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Individual and Systemic Factors of Under-five Mortality in Nigeria: A Cox Proportional Hazard Model

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ABSTRACT

Despite considerable efforts to reduce under-five mortality nationwide, Nigeria has fallen short of achieving the Millennium Development Goals (MDGs) target of 67 deaths per 1,000 live births by 2015. Of all the documented factors of under-five mortality, little evidence exists on the impact of systemic barriers and individual factors (maternal health-seeking behaviour) on under-five mortality in Nigeria. The study used a nationally representative sample from Nigeria Demographic and Health Survey (NDHS) 2013 dataset. The target population was 20,192 women aged 15-59 years who had given birth to 31,480 children five years before the survey. Stata software was used for data analysis. The risk of death was estimated using Cox proportional hazard models and results are presented as hazards ratios (HR) with 95% confidence intervals (CI). Findings from the overall Model I-IV revealed individual factors (maternal health-seeking indicators) as significant factors of under-five deaths ($p < 0.05$). Children whose mothers received antenatal care coverage (ANC) outside health care facilities (HCF) (HR: 1.60, CI: 1.0-2.4, $p < 0.05$); or delivered outside HCF (HR: 1.02, CI: 0.7-1.5, $p < 0.05$) had elevated hazard risk of death before age five. Conversely, children who were presented for postnatal check within two weeks of delivery (HR: 0.60, CI: 0.5-0.8, $p < 0.05$), or delivered within the longer birth interval (HR: 0.67, CI: 0.6-0.8, $p < 0.001$) had significantly lower hazard risk of death before age five. As part of systemic factors, children whose mothers were covered by health insurance scheme had significantly (HR: 0.52, CI: 0.2-1.2, $p < 0.001$) lower risk of death when compared with their counterparts without health insurance coverage. The study emphasized the need to revitalize strategies and programs to improve women health seeking behaviour and investment in the health sector through health insurance, infrastructure, and supplies.

Keywords: Individual; Systemic; Under-five; Mortality; Cox-proportional; Hazards; Model; Nigeria

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ARTICLE INFO
Received: 19 May 2023 | Revised: 3 July 2023 | Accepted: 17 July 2023 | Published Online: 28 July 2023
DOI: https://doi.org/10.30564/mmpp.v5i3.5735

CITATION
Ojewumi, T.K., 2023. Individual and Systemic Factors of Under-five Mortality in Nigeria: A Cox Proportional Hazard Model. Macro Management & Public Policies. 5(3): 16-33. DOI: https://doi.org/10.30564/mmpp.v5i3.5735

1. Introduction

Nigeria, a country that contributes disproportionate 11% to the global burden of infant and child mortality [1], with an estimated infant mortality rate of 75 deaths per 1000 live births, child mortality rate of 88 deaths per 1,000 live births and under 5 mortality rates of 157 deaths per 1,000 live births [2], has achieved a slight decrease in the past ten years. Infant and under-5 mortality rates have declined to 69 and 128 deaths per 1,000 live births respectively. Considering the trend since 1999, under-5 mortality has declined by 31 percent over a period of about 15 years from 185 deaths per 1,000 live births to 128 deaths per 1,000 live births respectively. With both rates declining, Nigeria still falls short of achieving MDG 4, target of 67 deaths per 1,000 live births as of 2015 [3]. Based on past trajectory, one in every 15 Nigerian children still die before reaching age one, and one in every eight fail to survive their fifth birthday [4]. Meanwhile, vaccine-preventable diseases, such as pneumonia, diarrhoea, and measles, account for about 40% of all these deaths, while other significant causes of death were malaria and neonatal causes [5].

Over the years, the Nigerian government and its international partners have made considerable efforts to reduce infant and child mortality nationwide. As part of the efforts, the Nigerian government in 1988 adopted a primary health care (PHC) policy with the latest review in 2004. Also, in May 2008 [6], the national health bill was drafted and adopted with an attempt to clarify the structure, roles, and responsibilities of the different levels of government in the provision of adequate, effective and efficient health care services. In addition, health sector reform programme (2004-2007) [7], national health insurance scheme (NHIS) and a series of reproductive health programmes were introduced including national malaria control programme; national contraceptives commodities quantification programme; national HIV/AIDS programme and opportunistic infection (OI); national AIDS and sexually transmitted infections control programme (NASCP) [8-10]; and expanded programme on immunization (EPI) with support from United Nations International Children's Emergency Fund (UNICEF) and United States agency for international development (USAID) [4]. Each programme operated separate procurement, storage and distribution and logistics management information systems with a responsibility of reaching the poor and the hard-to-reach people nationwide. However, despite all these concerted efforts by the government, stakeholders and international partners to address the health issues in Nigeria, outcomes have remained sub-optimal.

As a result, researchers have made considerable efforts to understand influencing factors for high rates of child mortality and the best strategies to adopt in combating the problem. As part of the findings, NDHS 2013 revealed that the mother's education is inversely related to a child's risk of dying and established that childhood mortality generally decreases as wealth increases [3]. A number of studies have shown that infant and child mortality rates are influenced by socio-economic and bio-demographic characteristics [11-13], while others [14,15] have established the influence of increased access to health programmes and infrastructures on maternal and child mortality in developing countries. Several other studies on infant and child morbidity or mortality are mainly hospital-based [16,17], with little attention given to individual (No. of ANC visits, place of ANC visits, quality of ANC, place of delivery, delivery assistance and post-natal care) and systemic factors (cost of care, distance to health care facilities, attitude of the health workers and health insurance coverage) of under-five mortality in Nigeria.

Despite the benefits of maternal health care services, maternal health-seeking behaviour is still poor in Nigeria. While studies have shown that utilization of health care services by mothers during pregnancy and delivery is a precondition that mothers will seek subsequent care after delivery for both themselves and their children [18], still many women in Nigeria do not receive prenatal care at all, and the care that is received is often characterized by an insufficient number of visits [2]. Also, the delivery care utilization is dominated by home births while the proportion of

mothers accessing post-natal care is relatively low. Hence, high-risk pregnancies are often not identified, obstetric histories are ignored and important information on child health care and survival is missed by a large proportion of mothers [4]. Therefore, major treatment of childhood illness among mothers is often dominated by self-care with the use of home remedies or over-the-counter drugs [19]. Thus, mothers and caregivers usually visit a health care facility after the illness has failed to respond to several drugs and ineffective home treatment or self-treatment. These healthcare-seeking practices increase the possible emergence of drug resistance with high rates of morbidity and mortality among under-five children in Nigeria [20].

Other associated factors of under-five deaths also manifested in the form of systemic bottlenecks. Studies had revealed the availability of health workers as essential ingredients for quality health care service delivery, their shortage or absence threatens the health of individuals and populations, destabilises health systems, and further exacerbates the existing health inequalities, resulting in more unequal societies globally. The uneven distribution of health care facilities and a dearth and attitude of health personnel in many developing countries had been established as the inhibiting factors of demand for health care [21,22].

In Nigeria, the health system has been in a deplorable and degrading state with an overall health system performance ranking 187th out of 191 member states of the world health organization [23]. For instance, it was specifically reported that 'most of the 23,000 frontline primary health care facilities often lack skilled practitioners, and a large percentage of the facilities do not have basic pharmaceuticals and commodities consistently in stock' [24]. Health services delivery in Nigeria are delivered through a weak health care system [25], and other indicators such as waiting times, staff attitude to work and public confidence in the health sector had been a significant issues over the years. As a result, the health system has in the last 10 years unable to deliver basic and cost-effective services for the prevention and management of common health problems especially at the local government areas (LGAs) and Ward levels.

In addition, health systemic bottleneck via sector-specific is a factor inhibiting successful health care delivery and utilization of health care system. According to OSSAP-MDG 2013 report, this sector-specific manifested majorly in service delivery (supply-side) in terms of cost of care; shortage of skilled health care personnel; waiting time due to delays in getting treatment; shortage of emergency obstetric care services; inadequate critical supplies in PHCs; and lack of adequate attention to special (disadvantaged) groups of mothers particularly in the case of obstetric and childcare [26]. Most affected are patients in Nigeria's rural areas, as the majority of them lack access to health care facilities and health personnel [27].

Therefore, this study set to answer questions related to systemic and individual factors of under-five mortality in Nigeria by examining the influence of individual (No. of ANC visits, place of ANC visits, quality of ANC, place of delivery, delivery assistance and post-natal care) and systemic factors (cost of care, distance to health care facilities, attitude of the health workers and health insurance coverage) associated with under-five mortality in Nigeria.

Theoretical consideration

This study finds its theoretical construct within Tipping and Segall framework and Sheeran and Abraham's 'health believe model'. Tipping and Segall in 1995 demonstrated that 'the decision to engage with a particular medical channel is influenced by a variety of socio-economic variables, age, the social status of women, the type of occupation, place of residence, access to services and perceived quality of the service' [28]. Whereas Sheeran and Abraham's [29] "health believe model" focused on two elements: 'threat perception' and 'behavioural evaluation'. Threat perception is a function of perceived susceptibility to illness and anticipated severity; behavioural evaluation consists of beliefs concerning the benefits of a particular behaviour and the barriers to it—(*cost of service, perceived quality of service, distance to health care facilities and attitude of health*

personnel etc.). The two elements "threat perception and behavioural evaluation" interact to influence mothers' health-seeking behaviour towards their personal health and that of their children [29]. These two models are appropriate in explaining individual and systemic factors of under-five mortality in any community.

Based on the established theoretical models, this paper dwells much on the relationship between systemic (cost of care, accessibility to health care, perceived quality of service, availability of personnel and drugs) and individual factors (no. of ANC visits, place of delivery, place of postnatal care, etc.) of under-five mortality in Nigeria from the standpoint of literature. Recent estimates of the United Nations Inter-agency Group for Child Mortality Estimation (UN IGME) (2012) put the 2011 global under-five deaths at around 7 million [30]. Though childhood mortality is declining worldwide, but still relatively high in Sub-Saharan Africa. Meanwhile, infant and child deaths have also been known to vary substantially across different regions of the world. These variations between the developing and developed nations are slightly more than 85-fold from a high of 128 deaths per 1000 live births in Nigeria to low of 101 deaths per 1000 live births in the United State [31].

Whitworth et al. in 2002 [32] showed that two neonates with similar biological characteristics may experience different neonatal mortality risks if exposed to different antenatal and obstetric health care due to differences in access and quality of care. Also, Harttgen et al. [33] added that there would be differences in health outcomes of children from two communities with contrasting characteristics and community conditions that would have impacted on health outcomes of individuals [34] through physical structures, social structures, and service provisions [35]. For instance, children born or raised in communities that lack a health care facility are likely to suffer poorer health outcomes compared to those children from communities where good health facilities are available [36]. Meanwhile, Antai in 2010 [13] argued that "the number of health facilities notwithstanding, the use of maternal and child health services is largely determined by mother's indigenous religious affiliation, and this significantly influences the risk of infant and child mortality". Also, patients' waiting time in a health facility has long been established as a factor that affects the utilization of health care services [37,38].

Again, from a theoretical standpoint, the increase in the availability of health care personnel is expected to influence the reduction in infant and child mortality. Pison et al. in their 2013's study of mortality trends in Senegal noted that though trends in mortality declines were a result of the combined effects of socioeconomic conditions, improvements in health programmes and infrastructures (like vaccinations) and changing epidemiological situations (HIV/AIDS and resistance to antimalarial drug chloroquine), the isolated changes in socioeconomic conditions did not correspond to reduction in child mortality [15]. This is consistent with similar studies by Ahmad et al. (2000) [39], as their study showed improved population health outcomes resulting from targeted health interventions regardless of socioeconomic contexts. Therefore, it can be assumed that economic growth in isolation without deliberate public health actions (removal of health systemic bottlenecks) cannot lead to child mortality reduction [40].

2. Methodology

2.1 Data collection method

This study used a secondary dataset obtained from the NDHS 2013 birth recode dataset. The survey design was cross-sectional to provide specific information on population and health indicators at the national, zonal, and state levels. Information collected includes birth histories, in-depth demographic and socio-economic information on illnesses, medical care, immunizations, anthropometric details of children and retrospective history of infant and under-five death from mothers [2]. The total sample frame was 38,948 women aged 15-59 who had given birth to 31,480 children five years before the survey. The target population in this study was mothers of children aged 0-59 months with a sample size of 20,192 women who had given birth to 82,933 children within the five years preceding the 2013 NDHS

survey.

2.2 Data analysis

The data were analyzed using STATA 12 software. The analysis involved three stages namely: i) univariate analysis to examine the mother and child's background characteristics such as age, marital status, religion, education, place of residence, etc., The bivariate analysis involved the use of Pearson's Chi-square test to examine the statistically significant variable of child survival. In the third stage, Cox proportional hazards regression model was based on the selected significant variables at bivariate level to examine: 1) isolated effect of each of the independent variables on child survival; 2) combine effect of the selected independent variables on child survival.

2.3 Cox proportional hazards model

Cox proportional hazards model (survival analysis) is appropriate in analyzing time-to-event as an outcome variable where it can be assumed that the explanatory variables have a multiplying effect on the hazard rates. This means that using the Cox proportional hazards model, both the occurrence of under-five mortality and the time when the child died were combined to generate the outcome variable. In addition, Cox regression analysis handles the censoring problem and permits the inclusion of censored observation. In medical and social science research, an observation is said to be censored when the outcome of interest has not occurred [41]. Using the Cox proportional hazards model, the probability of under-five death was regarded as the hazard.

The hazard was modelled using the following:

$$H(t) = H_0(t) \exp. (b_1X_1 + b_2X_2 + b_3X_3 \_ \_ \_ b_kX_k) \quad (1)$$

where $X_1 \ldots X_k$ are a collection of explanatory variables and $H_0(t)$ is the baseline hazard at time t, representing the hazard for a person with the value 0 for all the explanatory variables. By dividing both sides of Equation (1) by $H_0(t)$ and taking logarithms, Equation (1) becomes:

$$\text{In } (H(t)/H_0(t)) = b_1X_1 + b_2X_2 + b_3X_3 + \ldots b_kX_k \quad (2)$$

where $H(t)/H_0(t)$ is regarded as the hazard ratio. The coefficients $b_1 \ldots b_k$ are estimated by Cox regression (*Cox DR. 1972*).

Therefore, multivariate Cox regression hazard models were used to examine 'individual, systemic and background factors that influence child survival in this analysis by fitting six different models. Model 1 examined the joint effect of individual factors (maternal health-seeking indicators) on child survival. Model II examined the joint effects of systemic factors on child survival. Model III examined the joint effects of background factors on child survival. At the second level, Model IV considered all the selected explanatory variables to examine their combined effect on child survival. The analysis was done using Stata software (version 12). For national representativeness, all analyses were weighted with the standard weighting factors constructed by the Measure DHS.

3. Findings from the study

3.1 Univariate analysis

Percentage distribution of respondents' maternal and systemic factors of under-five mortality in Nigeria

Table 1 below presents the percentage distribution of the respondents by selected individual, systemic and background factors. Analysis by maternal factors showed that the proportion of children whose mothers received more than 4 ANC visits is about 3.0% point higher than the proportion of their counterparts whose mothers received less than 4 ANC visits. More than half (59.7%) of the children are of mothers who did not receive any ANC care or received ANC care at home and other places. Of all, less than half (41.0%) of the children are from mothers who did not receive any tetanus injection during pregnancy. Meanwhile, about 63.8% of these children were from mothers who received ANC care from trained health providers, as more than half of them (64.2%) were delivered outside health care facilities. Also, 60.0% of the children were delivered with no assistance or assistance from relatives,

traditional birth attendant (TBA) and others. More than two-thirds (71.6%) of these children were not presented for post-natal check within two weeks of delivery. And lastly, more than one-fifth (23.2%) of these children were delivered within a short birth interval to the previous birth.

Analysis based on systemic barriers to accessing health care shows that more than one-fourth (25.5%) of the children belonged to mothers who reported the cost of health care service as barrier to accessing health care while about one-fifth (19.9%) and about one-tenth (9.7%) of their counterparts are from mothers who reported cost and distance as well as cost, distance and attitude of the health workers respectively as barrier to accessing health care facilities.

Results from **Table 1** showed that the majority of the children are from mothers within the age bracket 20-39 years with only 2.8 % of them are from mothers within aged 45-49 years. About 96 % of them are from mothers who are currently married or living with a spouse. Analysis by region shows that larger proportions of the children (37.0%) are from mothers in the Northwest region followed by those from the Southeast region (8.9%). More than half (65.0%) of the children belong to mothers from rural areas. Also, the majority (61.9%) of the children are from Muslim mothers while 36.6% of their counterparts are from Christian mothers. Almost half (49.2%) of the children are from mothers with no education. More than seventy percent (70.3%) of the children are from currently working mothers, while about half (46.7%) of them are from the poorest households. Considering the individual barrier, about two out of ten (15.6%) were children of mothers who reported getting permission from their spouse as a barrier to accessing health care, while about one out of ten (6.2%) reported getting permission and not wanting to go alone as a barrier to accessing health care.

3.2 Bivariate analysis

Interpretation of the relationship between selected variables and under-five mortality using Chi-square and Cox proportional hazard ratio (Independent effect)

Table 1 below also presents the chi-square bivariate relationship and independent hazard ratio of the children's survival status by the selected individual, systemic and background factors. The analysis showed that under-five mortality was significantly associated with selected maternal health-seeking indicators ($p < 0.001$). The percentage of under-five deaths was significantly higher for: children whose mothers received less than 4 ANC visits (6.7%); children whose mothers received ANC care at home or other places (11.8%); children whose mothers did not receive any tetanus injection during pregnancy (6.9%); children whose mothers received no ANC care or received ANC from TBA/others (10.5%); children whose mothers delivered at home or other places (10.3%); children of mothers who received no delivery assistance or received delivery assistance from TBA, relatives/others (10.5%); children whose mothers did not go for post-natal check within two weeks of delivery (6.7%) and children who were delivered within shorter birth interval to previous birth (13.6%).

We found no significant relationship between systemic barriers to accessing health care facilities and under-five deaths ($p > 0.05$). However, the result revealed that the proportion of under-five deaths increased monotonically with reported systemic barriers: The proportion of under-five deaths increased slightly from 9.4% among mothers who reported cost of service as problems to 9.6% among those who reported cost of service, distance and attitude of health workers as problems. Also, the proportion of under-five deaths was significantly higher among children whose mothers had no health insurance cover (9.1%, $p < 0.001$) compared with their counterparts whose mothers had health insurance cover (4.7%, $p < 0.001$).

Analysis based on background factors revealed that mothers' age is significantly associated with under-five mortality. The percentage of under-five deaths was significantly highest for children whose mothers are within the lower age group 15-19 (11.9%), and higher age groups 40-44 (10.0%) and 45-49 (13.6%) respectively. Also, there exists a significant regional variation in the proportion of un-

der-five death from a high of 11.0% in the Northwest to a low of 6.3% in the Southwest. The proportion of under-five death is about 4.0% significantly higher among women in the rural area and among women with Islamic faith (10.0%). Under-five deaths significantly vary with mothers' level of education. The proportion of under-five deaths among children whose mothers had no education is about 6.0% point greater when compared with their counterparts whose mothers had secondary or higher education. There is no significant difference in the proportion of under-five deaths by mothers' occupational status. However, the proportion of under-five deaths is significantly higher (11.7%) among children whose mothers are within the lower wealth status than their counterparts within the middle (7.6%) and higher (5.0%) wealth status.

We found no significant difference in the proportion of under-five deaths by mothers who reported individual barriers to accessing health care facilities. Our study revealed no significant variation in the proportion of under-five deaths among mothers who reported no barrier (9.0%) and their counterparts who reported problems getting permission (8.8%), and those who reported both problems of permission and not wanting to go alone (9.7%).

The results of the bivariate Cox proportional hazard ratio (independent effect) were also presented in **Table 1** below. The table presents the unadjusted hazard ratios showing the independent effects of each of the individual, systemic and background factors on child survival. Individual factors (maternal health-seeking indicators) were significantly associated with higher hazards of under-five death. The risk of death before age five was about twofold higher for children whose mothers display poor health-seeking behaviour during pregnancy, delivery and after delivery ($p < 0.001$). Children whose mothers receive: less than 4 ANC visits (HR: 1.35; CI: 1.2-1.5; $p < 0.001$); had no ANC care or received ANC at home/TBA/other places (HR: 2.43; CI: 2.2-2.7; $p < 0.001$); received no tetanus injection (HR: 1.36; CI: 1.2-1.6; $p < 0.001$); received ANC care from TBA/relatives/others (HR: 1.39: CI: 1.2-1.6; $p < 0.001$); delivered outside health care facilities (HR: 1.52; CI: 1.4-1.7; $p < 0.001$); received delivery assistance from TBA/relatives/others (HR: 1.53; CI: 1.4-1.7; $p < 0.001$); received no postnatal check within two weeks of delivery (HR: 2.00; CI: 1.7-2.4; $p < 0.001$); and children who were delivered within the short birth interval (HR: 1.90; CI: 1.7-2.1; $p < 0.001$) are at higher risk of death before age five when compared with their counterparts whose mothers display good health care seeking behaviour during pregnancy, delivery and after delivery.

Analysis based on systemic factors showed that children whose mothers reported cost of service (HR: 1.09: CI: 1.0-1.2; $p < 0.001$); cost and distance (HR: 1.06: CI: 0.9-1.2; $p < 0.001$); as well as cost, distance and attitude of health workers (HR: 1.11: CI: 1.0.9-1.3; $p < 0.001$); as a barrier to accessing health care had higher risk of death before age five than their counterparts whose mothers reported no problem. Also, children without health insurance coverage had a 100% significantly higher hazard risk of death before age five (HR: 2.00: CI: 1.7-2.4; $p < 0.001$) compared to their counterparts with health insurance coverage.

Analysis based on background factors of under-five death revealed that mothers' age, region of residence, place of residence, religious affiliation, level of education and wealth status significantly predict child survival to age five ($p < 0.05$). For instance, children whose mothers' ages were between 15-44 years had a lower hazard risk of death compared to their counterparts whose mothers' ages were between 45-49 years. Also, children from other regions had a significantly higher hazard risk of death than their counterparts from the southwest region. Children from rural area (HR: 1.62: CI: 1.4-1.8; $p < 0.001$), those of Islamic (HR: 1.35: CI: 1.2-1.5; $p < 0.001$) or other faiths had elevated hazard risk of dying before age five compared to their counterparts in the urban centers or of Christian faith respectively. Also, children whose mothers had no education (HR: 2.28: CI: 1.7-3.0; $p < 0.001$), had primary education (HR: 1.92: CI: 1.4-2.5; $p < 0.001$) or secondary education (HR: 1.29: CI: 0.9-1.1; $p < 0.001$) as well as children from poor (HR: 2.37: CI: 2.0-2.8; $p < 0.001$)

or relatively poor (HR: 1.52: CI: 1.3-1.8; p < 0.001) households had a higher hazard risk of death before age five than those whose mothers had tertiary education and from wealthy households respectively.

Though not statistically significant, findings still revealed that children whose mothers reported problem of permission (HR: 1.07: CI: 0.8-1.3; p > 0.05) has relatively higher hazard risk of dying before age five, whereas, children whose mothers reported no problems in accessing health care facilities has lower hazard risk (HR: 0.87: CI: 0.9-1.1; p > 0.05) of dying before age five when compared with their counterparts whose mothers reported joint problem of permission and not wanting to go alone.

Table 1. Percentage distribution of respondents' background factors and under-five mortality in Nigeria.

Variables	**Total (n = 31,828) N (%)**	**Child survival status (%)**		**Chi-Square/ p-value**	**Independent hazard ratio (C.I)**
		Alive	Dead		
Maternal factors					
Number of ANC visits				26.61***	
< 4 visits	10,010 (48.9)	93.3	6.7		1.35 (1.2-1.5)***
4 visits+	10,457 (51.1)	95.0	5.0		RC
ANC Places				426.44***	
ANC/home/other places	19,000 (59.7)	88.2	11.8		2.43 (2.2-2.7)***
Within HCF	12,828 (40.3)	95.0	5.0		RC
ANC Quality				28.57***	
NO Tetanus injection	8,394 (41.0)	93.2	6.9		1.36 (1.2-1.6)***
Receive tetanus injection	12,073 (59.0)	94.9	5.1		RC
ANC Provider				31.89***	
No ANC/TBA/VHW/Others	7,366 (36.2)	89.5	10.5		RC
Doctor/Nurse/Auxi/Midwives	12,981 (63.8)	93.0	7.0		1.39 (1.2-1.6)***
Place of delivery				104.1***	
Home/Other places	20,442 (64.2)	89.7	10.3		1.52 (1.4-1.7)***
within HCF	11,387 (35.8)	93.2	6.8		RC
Delivery assistance				117.8***	
Doctor/Nurse/Auxi/Midwives	12,719 (40.0)	93.1	6.9		RC
No assist/TBA/Rel/Others	19,108 (60.0)	89.5	10.5		1.53 (1.4-1.7)***
Post natal check within 2 weeks				83.18***	
No	14,661 (71.6)	93.3	6.7		2.00 (1.7-2.4)***
Yes	5,806 (28.4)	96.6	3.4		RC
Birth interval				220.26***	

Table 1 continued

Variables	**Total (n = 31,828) N (%)**	**Child survival status (%)**		**Chi-Square/ p-value**	**Independent hazard ratio (C.I)**
Short birth interval	5,935 (23.2)	86.4	13.6		1.90 (1.7-2.1)***
Long birth interval	19,608 (76.8)	92.6	7.4		RC
Systemic barrier				5.48	
No problem	14,316 (45.0)	91.4	8.6		RC
Problem—cost	8,104 (25.5)	90.6	9.4		1.09 (1.0-1.2)
Problem—distance	6,331 (19.9)	90.8	9.2		1.06 (0.9-1.2)
Problem—cost and distance	3,076 (9.7)	90.4	9.6		1.11 (0.9-1.3)
Insurance cover				10.71***	
No	31,353 (98.5)	90.9	9.1		RC
Yes	475 (1.5)	95.3	4.7		0.51 (0.3-0.8)***
		Alive	Dead		
Age group				49.00***	
15-19	1,597 (5.0)	88.1	11.9		0.87 (0.6-1.2)
20-24	6,237 (19.6)	90.9	9.1		0.65 (0.5-0.8)***
25-29	8,893 (27.9)	91.7	8.3		0.60 (0.5-0.8)***
30-34	6,974 (21.9)	91.4	8.6		0.62 (0.5 -0.8)***
35-39	4,926 (15.5)	91.1	8.9		0.65 (0.5-8.3)***
40-44	2,317 (7.3)	90.0	10.0		0.73 (0.6-1.0)*
45-49	885 (2.8)	86.4	13.6		RC
Marital status				1.847	
Never married/not living with spouse	1,337 (4.2)	89.9	10.1		1.13 (0.9-1.4)
Married/living with spouse	30,491 (95.8)	91.0	9.0		RC
Region				129.09***	
North Central	4,340 (13.6)	92.6	7.4		1.17 (0.9-1.5)
North East	5,578 (17.5)	90.3	9.7		1.55 (1.2-2.0)***
North West	11,775 (37.0)	89.0	11.0		1.75 (1.4-2.2)***
/South East	2,840 (8.9)	91.0	9.0		1.43 (1.1-1.9)*
South South	2,935 (9.2)	93.4	6.6		1.04 (0.8-1.4)
South West	4,360 (13.7)	93.7	6.3		RC
Residence				133.28***	
Urban	11,126 (35.0)	93.5	6.5		RC
Rural	20,702 (65.0)	89.6	10.4		1.62 (1.4-1.8)***
Religious affiliation				56.24***	
Christian	11,647 (36.6)	92.6	7.4		RC

Table 1 continued

Variables	Total (n = 31,828) N (%)	Child survival status (%)		Chi-Square/ p-value	Independent hazard ratio (C.I)
Islam	19,689 (61.9)	90.0	10.0		1.35 (1.2-1.5)***
Others	492 (1.6)	90.6	9.4		1.26 (0.9-1.7)
Level of education				182.22***	
No education	15,657 (49.2)	89.1	10.9		2.28 (1.7-3.0)***
Primary	6,127 (19.3)	90.8	9.2		1.92 (1.4-2.5)***
Secondary	8,211 (25.8)	93.4	6.3		1.29 (0.9-1.7)
Higher	1,834 (5.8)	95.1	4.9		RC
Occupational status				0.911	
Not working	9,463 (29.7)	90.7	9.3		RC
Working	22,365 (70.3)	91.1	8.9		0.96 (0.9-1.1)
Wealth status				256.51***	
Lower status	14,851 (46.7)	88.3	11.7		RC
Middle status	11,657 (36.6)	92.4	7.6		1.52 (1.3-1.8)***
Upper status	5,320 (16.7)	95.0	5.0		2.37 (2.0-2.8)***
Individual barrier				1.273	
No problem	24,918 (78.3)	91.0	9.0		0.87 (0.9-1.1)
Pro permission	4,949 (15.6)	91.2	8.8		1.07 (0.8-1.3)
Permission/not to go alone	1,962 (6.2)	90.3	9.7		RC

Note: * = p-value < 0.05, *** = p-value < 0.001.

3.3 Multivariate analysis

Cox proportional hazard regression model of the individual and systemic effect on under-five mortality in Nigeria (Model I-IV)

Table 2 below presents the Cox proportional hazard regression analysis of the effect of individual, systemic and background factors on under-five mortality in Nigeria (Model I-VI). The Model I-III examined the combined hazard effect of individual, systemic and background factors on under-five mortality having controlled for at most two of the factors in each separate model. Model IV however examined the combined hazard effect of all the selected variables on under-five mortality.

Having controlled for systemic and background factors in model I, results established individual factors (maternal health-seeking behaviour) as important predictors of under-five mortality in Nigeria. Results showed that the risk of death before reaching age five for children whose mothers received at least 4ANC visits is 20.0% point lower than the risk experienced by their counterparts whose mothers received less than 4ANC visits. Likewise, children whose mothers received: no ANC or received ANC from Home/TBA/Others (HR: 1.60: CI: 1.1-2.4; $p > 0.05$); no tetanus injection (HR: 1.05: CI: 0.8-1.3; $p > 0.05$); ANC from Non-Skilled providers (TBA/ Relative/Others) (HR: 1.14: CI: 0.7-1.8; $p > 0.05$); and delivered outside health care facilities (HR: 1.05: CI: 0.7-1.5; $p > 0.05$) had higher hazard risk of death before reaching age five. However, children whose delivery were assisted by trained health professionals (HR: 0.89: CI: 0.6-1.3; $p < 0.05$); who were presented for postnatal check within two weeks of delivery (HR: 0.57: CI: 0.5-0.7; $p < 0.001$); and those who were delivered within longer birth interval (=>24 months) to previous birth (HR: 0.70: CI: 0.6-0.8;

$p < 0.0001$) had lower hazard risk of dying before age five when compared with their counterparts whose delivery were not assisted by trained health professionals, were not presented for postnatal check and delivered within short birth interval respectively.

Our findings revealed no significant hazard ratio between systemic factors and under-five deaths ($p > 0.05$) in model II after controlling for selected background and maternal factors. However, findings showed that the risk of death before reaching age five were slightly higher for children whose mothers reported cost of service (HR: 1.08, CI: 1.0-1.2, $p > 0.05$), cost and distance (HR: 1.06, CI: 0.9-1.2, $p > 0.05$), as well as cost, distance and attitude of health workers (HR: 1.10, CI: 0.9-1.3, $p > 0.05$) as systemic barrier to accessing health care compared to their counterparts whose mothers reported none of the systemic barriers. In addition, children of mothers with health insurance coverage had a significantly lower hazard risk of dying before age five (HR: 0.52, CI: 0.3-0.8, $p < 0.001$), relative to children whose mothers had no health insurance coverage.

Having controlled for the selected maternal and systemic factors in Models III, our findings still established mothers' age, region, place of residence, level of education, wealth status, and individual barriers as significant predictors of risk of death before age five ($p < 0.05$). Whereas the hazard ratio of death due to marital status, religion and occupational status are less significant in predicting a child's death before age five ($p > 0.05$).

Analysis of the joint hazard effect of the individual (maternal) and background factors, having controlled for systemic factors in model IV, revealed place of ANC care, place of delivery, postnatal check and birth interval as significant predictors of hazard of death before age five ($p < 0.05$). The result affirmed that children whose mothers received ANC care outside HCF (HR: 1.61, CI: 1.1-2.4, $p < 0.05$), or delivered outside HCF (HR: 1.03, CI: 0.7- 1.4, $p < 0.05$) had relatively higher hazards of death before age five compared with their counterparts whose mothers received ANC within HCF or delivered within HCF. Also, children who received postnatal check within two weeks of delivery (HR: 1.10, CI: 0.9-1.3, $p > 0.05$) and were delivered within longer birth interval (=> 24 months) (HR: 0.61., CI: 0.5-0.8, $p < 0.001$) had about 10%-40%-point lower hazard risk of death before age five.

Model VI (final model) examines the joint influence of individual factors (maternal health care seeking indicators), systemic factors and background factors on child survival. Results, as presented in Model VI, still affirm a significant relationship between child survival and ANC places, place of delivery, postnatal check, and birth interval. Children whose mother received ANC care outside health care facilities (HR: 1.60, CI: 1.0-2.4, $p < 0.05$) or delivered outside health care facilities (HR: 1.02, CI: 0.7-1.5, $p < 0.05$) have relatively higher risk of dying before age five than their counterparts. Whereas, children who received postnatal check within two weeks of delivery (HR: 0.60, CI: 0.5-0.8, $p < 0.05$), or delivered within longer birth interval (HR: 0.67, CI: 0.6-0.8, $p < 0.001$) had about 40% point lower hazard risk of death in their first five years of life compared to their counterparts who were not presented for postnatal check or were delivered within short birth interval (< 24 months) to the preceding birth.

In addition, our analyses from this model VI still affirmed that there is no significant relationship between Systemic factors and child survival ($p > 0.05$). The result, however, showed that children whose mothers reported cost of service (HR: 1.50, CI: 1.0-2.2, $p > 0.05$), cost and distance to HCF (HR: 1.47, CI: 1.0-2.1, $p > 0.05$) as well as combined problems of cost, distance and attitude of health workers (HR: 1.22, CI: 0.9-1.7, $p > 0.05$) as a systemic barrier to accessing health care services are at higher risk of dying before age five compared to their counterparts whose mothers reported none of these systemic problems. Consistently, our findings still showed that children whose mothers had insurance coverage (HR: 0.52, CI: 0.2-1.2, $p < 0.001$) have a lower hazard risk of death before age five than their counterparts without insurance cover.

Analysis of the background variables in this final model VI showed that the age of mothers, place of

residence, level of education, wealth index and individual barriers consistently and significantly predict child survival ($p < 0.05$). For instance, being a child of a mother within the age bracket 20-44 years significantly have a lower risk of death before age five compared to their counterparts in the older age group (45-49). Also, being a child of a mother who had no education (HR: 1.26, CI: 0.7-1.7, $p < 0.05$) or had primary education (HR: 1.12, CI: 0.7-1.8, $p < 0.05$), or a child of mother from very poor household (HR: 1.39, CI: 1.0-2.0, $p < 0.05$) or relatively poor household (HR: 1.17, CI: 0.8-1.6, $p < 0.05$), or a child of mother residing in a rural area (HR: 1.25, CI: 1.0-1.5, $p < 0.05$) was associated with higher risks of under-five mortality. Also, being a child of a mother who reported individual problem with permission (HR: 1.24, CI: 0.8-1.9, $p > 0.05$), or permission and not wanting to go alone as individual barrier to access health care facilities was associated with higher risks of death before age five compared with their counterparts whose mothers reported none of the individual barriers (HR: 0.86, CI: 0.7-1.1, $p < 0.05$).

Model I = joint effect of Maternal factors; Model II = joint effect of the Systemic factors: Model III = joint effect of socio-demographic variables: Model IV = joint effect of both Maternal and Socio-demographic variables: Model V = joint effect of both Systemic factors and Socio-demographic variables: Model VI = joint effect of all the variables (Maternal, Systemic & Socio-demographics factors) = Full Model.

Table 2. Cox proportional hazard regression model of the individual and systemic effect on under-five mortality in Nigeria (Model I-IV).

Selected variables	**Model I Maternal factors**	**Model II Systemic factors**	**Model III Background factors**	**Model IV Overall effect of all the variables**
Maternal factors	Hazard ratio (CI)			
Number ANC visits				
< 4 visits	RC			RC
> 4 visits	0.79 (0.8-1.3)			0.99 (0.8-1.3)
ANC Places				
Within HCF	RC			RC
No ANC/Home/TBA/Others	1.60 (1.1-2.4)*			1.60 (1.0-2.4)*
ANC Quality				
Received tetanus injection	RC			RC
No tetanus injection	1.05 (0.8-1.3)			1.08 (0.8-1.4)
ANC Providers				
Trained health professionals	RC			RC
TBA/Relatives/Others	1.14 (0.7-1.8)			1.18 (0.8-1.8)
Place of delivery				
Within HCF	RC			RC
Outside HCF	1.05 (0.7-1.5)			1.02 (0.7-1.5)*
Delivery assistance				
TBA/Relatives/Others	RC			RC
Trained health professionals	0.89 (0.6-1.3)*			0.84 (0.6-1.8)
Postnatal check within 2 weeks				
No	RC			RC
Yes	0.57 (0.5-0.7)***			0.60 (0.5-0.8)***

Table 2 continued

Selected variables	Model I Maternal factors	Model II Systemic factors	Model III Background factors	Model IV Overall effect of all the variables
Birth Interval				
Short birth interval	RC			RC
Long birth interval	0.70 (0.6-0.8)***			0.67 (0.6-0.8)***
Systemic Factors				
No Problem		RC		RC
Problem-cost		1.08 (1.0-1.2)		1.50 (1.0-2.2)
Problem-cost/Distance		1.06 (0.9-1.2)		1.47 (1.0-2.1)
Problem-cost/Distance/Attitude		1.10 (0.9-1.3)		1.22 (0.9-1.7)
Insurance Cover				
No cover		RC		RC
Yes cover		0.52 (0.3-0.8)***		0.52 (0.2-1.2)***
Age group				
15-19			0.87 (0.6-1.2)	0.59 (0.3-1.1)
20-24			0.72 (0.6-0.9)*	0.39 (0.3-0.5)***
25-29			0.68 (0.5-0.9)*	0.43 (0.3-0.6)***
30-34			0.72 (0.6-0.9)*	0.45 (0.3-0.6)***
35-39			0.73 (0.6-0.9)*	0.60 (0.5-0.8)***
40-44			0.77 (0.6-1.0)	0.63 (0.5-0.8)***
45-49			RC	RC
Region				
North Central			1.85 (0.6-1.1)	1.73 (0.5-1.0)
North East			1.98 (0.7-1.3)	1.86 (0.6-1.3)
North West			1.09 (0.8-1.4)	1.91 (0.6-1.3)
South East			1.37 (1.0-1.8)*	1.16 (0.8-1.7)
South South			0.91 (0.7-1.8)	0.84 (0.6-1.2)
South West			RC	RC
Marital Status				
Never married/no spouse			1.23 (1.0-1.5)	1.35 (0.9-1.9)
Married/ with spouse			RC	RC
Residence				
Urban			RC	RC
Rural			1.24 (1.1-1.4)*	1.25 (1.0-1.5)*
Religious Affiliation				
Christian			RC	RC
Islam			1.00 (0.8-1.2)	0.90 (0.7-1.2)
Others			0.97 (0.7-1.3)	0.72 (0.4-1.2)
Level of Education				
No education			1.42 (1.0-1.9)*	1.26 (0.7-1.7)*
Primary			1.37 (1.0-1.9)*	1.12 (0.7-1.8)*
Secondary			1.08 (0.8-1.4)	0.87 (0.6-1.4)
Higher			RC	RC
Occupational Status				

Table 2 continued

Selected variables	Model I Maternal factors	Model II Systemic factors	Model III Background factors	Model IV Overall effect of all the variables
Working			RC	RC
Not Working			1.04 (0.9-1.2)	1.04 (0.9-1.2)
Wealth Status				
Upper Status			RC	RC
Middle status			1.23 (1.0-1.5)	1.17 (0.8-1.6)
Lower status			1.64 (1.3-2.1)*	1.39 (1.0-2.0)*
Individual Barrier				
No problem			0.81 (0.7-0.9)*	0.86 (0.7-1.1)*
Pro permission			0.84 (0.7-1.0)	1.24 (0.8-1.9)
Permission/Not wanting to go alone			RC	RC

Note: * = p-value < 0.05, *** = p-value < 0.001.

4. Discussion and conclusions

Understanding the impact of the individual (maternal health-seeking behaviour) and systemic factors (cost of care, distance to HCF, and attitude of health care providers) in determining childhood survival status is important to reduce childhood mortality in Nigeria through improved maternal health-seeking behaviour and easy access to health care facilities. Our findings revealed individual, systemic and background factors as important predictors of childhood survival status in Nigeria.

As shown from the findings, under-five mortality is relatively lower among children whose mothers display good maternal health-seeking behaviour during pregnancy, delivery and after delivery. Under-five deaths were significantly higher for: children whose mothers received less than 4 ANC visits; children whose mothers received ANC care at home or other places; children whose mothers did not receive any tetanus injection during pregnancy; children whose mothers received no ANC care or received ANC from TBA/relatives; children whose mothers delivered at home or other places; children of mothers who received no delivery assistance or received delivery assistance from TBA, relatives or others; children whose mothers did not go for post-natal check within two weeks of delivery and; children who were delivered within shorter birth interval to previous birth.

To achieve the full life-saving potential that ANC promises for women and babies, four visits providing essential evidence-based interventions—a package often called focused antenatal care—are required. Essential interventions in ANC include identification and management of obstetric complications such as preeclampsia, tetanus toxoid immunisation, intermittent preventive treatment for malaria during pregnancy (IPTp), and identification and management of infections including HIV, syphilis, and other sexually transmitted infections (STIs). As affirmed by this study, ANC care is an important pregnancy related care with life-saving potential for both mothers and babies as achieving at least 4 ANC visits is significantly associated with lower childhood mortality.

Also, quality of ANC care (proxy by receipt of tetanus injection), assisted delivery within health care facilities, early post-natal care and healthy behaviour of optimal pregnancy spacing have been established as significant factors associated with lower hazard risk of childhood mortality in this study. It can therefore be said that the quality of ANC care, delivery within health care facilities, the use of skilled attendants at birth and healthy behaviours towards early postnatal care and planning for optimal pregnancy spacing provides the windows of opportunities to improve childhood survival status in

Nigeria.

These findings are consistent with the study conclusion by Whitworth et al., in 2002 [32], which concluded that two neonates with similar characteristics may suffer different neonatal mortality risks if they are exposed to different antenatal and obstetric health care as a result of differences in access and quality of care. Also, Phathammavong et al., in 2010 [18], noted that mothers' utilization of health care services during pregnancy and delivery is a precondition that mothers will seek subsequent care after delivery for both themselves and their children. Therefore, effort should be geared at all levels towards strategies and programs to improve ANC care attendance, access to quality of care, delivery within health care facilities and healthy behaviour towards early postnatal care and long births interval as these will expose them to knowledge on all pregnancy-related risks and subsequent utilization of health care facilities.

Systemic barriers, though not statistically significant, have been identified as impacting negatively on the survival status of under-five children in Nigeria. Our study revealed that cost of service, distance to health care facilities and attitude of health workers stands as barriers inhibiting women from accessing health care services. Our findings revealed that the proportion of under-five deaths is higher among children whose mothers had systemic barriers in accessing health care facilities and relatively lower among children whose mothers reported no barriers in accessing health care services. This finding is consistent with findings by Adedini et al., in 2014 which pointed out resource-related barriers to health care utilization as an important factor driving high under-five mortality in Nigeria [36]. Health sector initiatives & investments through health infrastructure and supplies in all rural areas to reduce the distance to health care facilities as well as improvement in health service delivery through behavioural change communication approach (BCC) by the health care service providers will go a long way in increasing health care utilization and subsequently reduce childhood mortality.

Decrease in out-of-pocket expenditure through alternative health care financing mechanisms will also serve as an alternative approach in hastening progress towards reducing childhood mortality in Nigeria. For instance, our findings revealed that being covered by health insurance scheme ameliorate the cost of accessing health care, give mothers the confidence to access health care facilities and thereby reduce under-five mortality. However, the result further revealed that larger proportions of mothers were not covered by health insurance scheme with a higher proportion of under-five mortality. Therefore, efforts should be geared towards broader national coverage of health insurance scheme to accelerate progress in reducing under-five mortality in Nigeria. These can be achieved via an integrated health insurance routine system through provinces, districts, and health centres to reach all communities and hard to reach populations.

In concordance with previous findings which established that infant and child mortality rates are influenced by socio-economic and bio-demographic characteristics [11-13,42], this study also established that socio-economic inequalities are significant factors of under-five mortality. The study revealed that under-five mortality rates among children of mothers with no schooling are approximately six percentage points greater than among children of mothers with a secondary education. In addition, the proportion of under-five deaths is significantly higher among children whose mothers are within the lower wealth status than their counterparts whose mothers are within the middle and higher wealth status. Therefore, policy options to reduce socio-economic inequalities through women's education and empowerment will go a long way in improving national childhood survival status.

Implications for practice

Based on the findings, this study established that systemic factors contribute to childhood mortality as attitudes of health care workers often inhibit access to services among others. Thus, improving health care workers' attitudes towards health care infrastructure development will enhance and improve under-five health outcomes in Nigeria.

Limitations of the study

The limitation of this study emanated from the survey design as predetermined which did not include capturing the related systemic factors/variables at the facility levels. Subsequent studies should include triangulation of facility level survey data to wholistically measure the influence of systemic factors on childhood mortality.

Conflicts of Interest

The author declared no conflict of interest.

Data Availability Statement

The dataset for the study was 2013 NDHS accessible at https://www.dhsprogram.com/data/dataset_admin/login_main.cfm.

Funding

There was no funding for this research.

Ethical Approval

The study used a secondary data from 2013 NDHS dataset for which ethical approval had been obtained by ICF International from the Institutional Review Board (IRB) and Nigeria National Health Research Ethics Committee (NHREC) at the time the study was conducted, and data use access was granted by the dhsprogram https://www.dhsprogram.com/data/dataset_admin/login_main.cfm

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