Estimation of the Family and Community Unobserved Heterogeneity Effects on the Risk of Under-Five Mortality in Nigeria using Frailty Model

Anthony I. Wegbom[1,*], Isaac D. Essi[1] and Victor A. Kiri[1,2]

[1]*Department of Mathematics, Rivers State University, Port Harcourt, Nigeria*

[2]*Department of Mathematics, Physics & Electrical Engineering, Northumbria University, Newcastle Upon Tyne, UK*

Abstract: The Under-five mortality (U5M) rate is an important determinant of societal and national advancement- a key marker of wellbeing, value, and access. In spite of efforts to identify the predictors of U5M to reduce its high level in Nigeria, the problem remains a major cause for concern. This study estimated the potential role of unmeasured/unobserved factors at both family and community levels, using shared frailty models on the 2013 Nigeria Demographic and Health Survey (2013 NDHS) data. The Log-rank test was used to identify variables associated with U5M- hazard ratio estimates with P<0.05 were considered as statistically significant. Our findings suggested region, marital status, place of residence and place of delivery were significant determinants of U5M in both frailty models. We also found evidence of frailty effect on the risk, particularly at the community level- heterogeneity due to unmeasured/unobserved factors, which are generally ignored when we assess the risk using only observed variables. We, therefore, suggest that to achieve the sustainable development goals relating to child health in Nigeria, more significant efforts should be directed at identifying more determinants, such as to reduce the influence of unobserved factors and facilitate an extension of interventions to these factors.

Keywords: Under-five mortality, Unobserved heterogeneity, Frailty model, Determinants, Nigeria.

INTRODUCTION

The Under-five mortality (U5M) rate is an important determinant of societal and national advancement- a key marker of wellbeing, value, and access. The wellbeing and survival of children are essential measures of the social prosperity and wellbeing status of the community [1,2]. Although U5M levels continue to decline globally, those for Sub-Saharan Africa remain very high [3]. It was because of the lack of sufficient reduction in many developing countries during the era of Millennium Development Goals (MDGs), that the problem became one of the key focus areas of the Sustainable Development Goals (SDGs), to reduce under-five mortality to at most 25 deaths for every 1,000 live births by 2030; known as SDG 3.2 [4].

Nigeria is one of the countries in sub-Saharan Africa with high under-five mortality [5,6]. For instance, the under-five mortality rate in 1990 was 201 deaths per 1000, declining to 128 deaths per 1000 in 2013 [5] and increasing to 132 deaths per 1000 in 2018 [7]. This represented a 34% decline within the 28 years. Hence, Nigeria is still far short of achieving the SDG on under-five mortality.

Under-five mortality remains a daunting public health challenge in Nigeria. Several studies have been conducted to identify the factors that account for high rates of under-five mortality and to find the best strategies to adopt in combating the problem [8-13]. In spite of the concerted international and national efforts on reducing the undesirably high levels of under-five mortality, the issue of poor child health continues to be a significant cause for concern in Nigeria. Indeed, Nigeria may not be on course to achieving the SDG target. Hence, there is an urgent need to deploy appropriate techniques that will unravel the comprehensive determinants of under-five mortality in Nigeria, as this will guide policymakers in planning their interventions.

It is a known fact that not all covariates associated with child survival are usually captured in a Survey. Thus, using survey data to study the factors associated with under-five mortality without recourse to missing elements may produce biased inference [14-16]. In the applications of statistical techniques on survey data, usually, only a few covariates are measured or included in the models. It is known that many other factors that can influence child survival, such as those of biological, genetic, behavioural and environmental natures, as well as the quality of healthcare provisions, among others [2]. Most of these factors are often unquantifiable, and some may even be unknown, and

*Address correspondence to this author at the Department of Mathematics, Rivers State University, Port Harcourt, Nigeria; Tel: +1238032565971; E-mail: wegbomanthony@gmail.com

E-ISSN: 1929-4247/20

hence, they cannot be included in the analysis. However, when such important factors are ignored, the result may be a biased estimate.

There are very few documented studies on the likely influence of family and community-level unobserved factors on the risks of under-five mortality in Nigeria, and these are all based on survey data [8-10, 17-22]. In other words, the findings from such studies may be susceptible to bias due to the exclusion of key unquantified influential factors. Nevertheless, these studies can be useful in informing the decisions of policymakers in their efforts at developing appropriate public health interventions to implement. Our research aims to assess the influence of unobserved family and community-level factors on the risks of under-five mortality in Nigeria. Our hope is for results that would make a meaningful addition to the pool of information available to policymakers in their quest for effective strategies for achieving the Sustainable Development Goals.

METHODS

The 2013 Nigeria Demographic and Health Survey (2013 NDHS) dataset was used for this study. As a national representative data, the 2013 NDHS is cross-sectional and elicited information on demographic and health indicators both at State and national levels, such as, family planning, maternal and child health, fertility, gender, malaria, HIV/AIDS and nutrition [5]. The Demographic and Health Survey (DHS) is one that collects data on the assessment of the above indicators in developing countries, like Nigeria, where adequate and reliable vital registration system is missing [23].

The population (i.e. sample size) of our study data was 31,482 children born within the last five years before the survey (i.e. under-five children) in Nigeria. The information was derived from women age 15-49 years who had at least one live birth within this period in the 36 states of Nigeria. We used the Weibull frailty model which is a subset of the Weibull proportional hazards model from the family of parametric survival models, having been found as adequate for estimating the determinants of under-five mortality in the DHS dataset [15, 20-22, 24].

The Weibull Proportional hazard model expressed as:

$$h_i(t,X) = \lambda \exp(\beta' x_i) p t^{p-1} \quad (1)$$

Where,

$h_i(t,X)$ is the hazard of death for child *i* at time t;

P and λ are the shape and scale parameters respectively, estimated from the data,

β is the vector of unknown coefficients of the explanatory variables x_i

In this model, the hazard increases or decreases monotonically [25].

In the frailty model, frailty is a random factor designed to account for changeability due to unobserved factors that are unaccounted for by the other predictors in the model.

As stated in [14], the frailty α is an unobserved multiplicative effect on the hazard function that follows gamma distribution g(α) with α > 0 and unit mean. The variance of g(α) is a parameter θ (theta) that is usually estimated from the data. The model assumes that the individual risk of death is a function of known factors.

The frailty model expressed as:

$$h_{ij}(t, x_{ij}, \alpha_j) = \alpha_j h_{ij}(t, x_{ij}) \quad (2)$$

Children i in a family (or community j), are supposed to share the same frailty. If the variance estimate θ is not zero it shows that unobserved family (or community) factors affect the risk of death which implies that their survival risks are correlated; And if the variance estimate θ is zero, all families (or communities) have the same risk of death. Also, children with frailty α > 1 have a higher risk of death and hence, a lower chance of survival than those with frailty α = 1; whereas children with frailty α < 1 have a lower risk of death and therefore a higher chance of survival than those with frailty α = 1 [14, 25].

The hazard between two individuals with different values of predictors *x* is known as a hazard ratio. The hazard ratio (HR) is defined as the hazard for one individual divided by the hazard for a different individual. It expressed as:

$$HR = \frac{h(tx^*)}{h(t,x)} \quad (3)$$

Where x^* denotes the set of predictors for one individual, and x denotes the set of predictors for the other individual.

Table 1a: Log-Rank Test for Equality of Survival Time among the Demographic Covariate According to Death of Under-Five Children

Demographic Covariates	Number of Deaths (2886)	Percentage	P-value (X^2)
Sex of child			0.04 (3.93)
Male	1578	54.7	
Female	1308	45.3	
Region			0.00 (198.91)
North-central	328	11.4	
North-east	661	22.9	
North-west	1146	39.7	
South-east	263	9.1	
South-south	249	8.6	
South-west	239	8.3	
Maternal age at childbirth			0.00 (23.45)
<20 years	535	18.5	
20-34 years	1857	64.4	
35 and above	494	17.1	
Number of children ever born			0.00 (69.62)
≤2	668	23.2	
3-4	798	27.6	
5 and above	1420	49.2	
Preceding birth interval			0.00 (133.77)
First birth	607	21.1	
<24 months	803	27.8	
24-35 months	864	29.9	
>35 months	612	21.2	
Size of child at birth			0.00 (36.87)
Small	584	21.6	
Average	1110	41.0	
Large	1012	37.4	

Table 1b: Log-Rank Test for Equality of Survival Time among the Socioeconomic Variables According to the Death of Under-Five Children

Socio-economic covariate	Number of Deaths (2886)	Percentage	P-value (X^2)
Maternal educational level			0.00 (195.05)
No education	1657	57.4	
Primary education	596	20.7	
Secondary or higher education	633	21.9	
Wealth index			0.00 (276.22)
Poor	1722	59.7	
Middle	502	17.4	
Rich	662	22.9	

(Table 1b). Continued.

Socio-economic covariate	Number of Deaths (2886)	Percentage	P-value (X^2)
Marital status			0.41 (0.67)
Never married	160	5.5	
Married	2726	94.6	
Place of residence			0.00 (128.11)
Rural	2220	76.9	
Urban	666	23.1	
Type of toilet facility			0.00 (31.40)
Unimproved	1619	56.8	
Improved	1230	43.2	
Source of water supply			0.00 (26.22)
Unimproved	1419	49.9	
Improved	1427	50.1	

Table 1c: Log-rank Test for Equality of Survival Time among the Health Care Seeking Related Covariates According to Death of Under-Five Children

Health Care RelatedCovariate	Number of Deaths (2886)	Percentage	P-value (X^2)
Place of delivery			0.00 (88.49)
Home	1975	68.4	
Hospital/clinic	911	31.6	
Slept under Mosquito net			0.07 (3.35)
No	2303	79.8	
Yes	583	20.2	
Number of ANC visit			0.00 (46.39)
None	497	42.1	
1-3 times	130	11.0	
Four times and above	553	46.9	

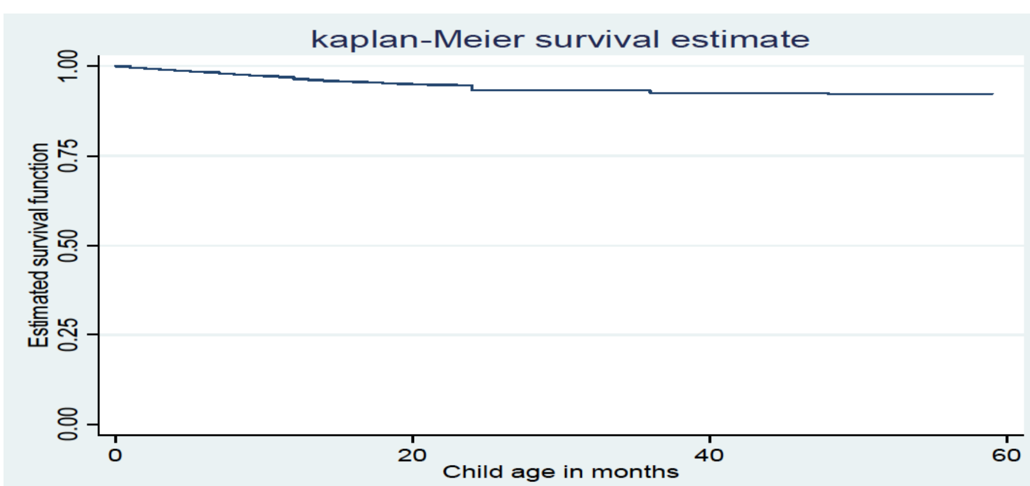

Figure 1: The plot of the overall estimate of Kaplan-Meier Survivor Function of under-five mortality in Nigeria.

All analyses were done using Stata (version 15). The log-rank test used to ascertain which variable is significantly related to U5M whereas, the frailty model using hazard ratio was used to assess the impact of the individual variable on the risk of under-five mortality moreover P<0.05 and 95% confident interval not including one was seen statistically significant.

RESULTS

Descriptive Analysis

To estimate the effects of unobserved heterogeneity on the risks of under-five mortality, it is important to examine the relationship between the selected variables and the risk of under-five mortality. Table **1a** to **1c** shows the results of the Log-rank tests on the lists of demographic, socio-economic and healthcare-related variables and their associations with under-five mortality in Nigeria based on the 2013 NDHS data. We found that all the variables except marital status (Table **1b**) and slept under a Mosquito net (Table **1c**) were significantly related to under-five mortality (p<0.05). However, the two variables were retained in our frailty models because earlier studies had reported on marital status and use of Mosquito net as significantly related to under-five mortality in Nigeria [8,13,17].

Figure **1** displays the overall Kaplan Meier estimate of the survival function. It shows that most deaths occurred in the early months of birth and the risk gradually declined as they aged, but which became less obvious as they approached the age of five- thus, justifying the choice of the Weibull model.

Frailty Model Results

Table **2** shows the fitted frailty models for both family and community-level variables. The models were fitted to assess not only the influence of the demographic, socio-economic and health care factors on the risk of under-five mortality in Nigeria but also those that were unobserved and unmeasured as family and community heterogeneity. In both models, the same sets of variables were used. The family frailty estimated the influence of unobserved/unmeasured variables on the risk among siblings, such as maternal care and genetic factors, while the community frailty estimated the influence of unobserved/unmeasured variables on the risk among children from the same community, such as cultural, climatic and environmental factors.

The results of the log-likelihood ratio tests suggested the community frailty model produced a better fit to the data than the family version. The ratio was -3103.09 for the family model whereas, that of the community was -3099.69. The frailty effect for under-five mortality at the family level was 0.035, and it was not statistically significant- suggesting the risk of under-five mortality between households in this data did not differ significantly even after adjusting for possible unmeasured/unobserved factors. In contrast, the community frailty effect was statistically significant at 0.175 and (P<0.05)- suggesting unobserved community factors might account for the risk of death among children aged under five by as much as 17.5%.

The study further identified the region, marital status, place of residence (urban or rural) and place of delivery as significantly associated with the risk of under-five mortality in both models. Also, we found no difference in the magnitude of the estimated risk from the two models. For instance, we obtained the same hazard ratios from both models for the South-East region of Nigeria (HR=2.18), married women (HR=0.68) and birth at hospital/clinic (HR=0.75). The ratios from the two models were also similar for the North-West region (HR=1.43 and 1.40) and rural versus urban residents (HR=1.47 and 1.46) from the family and community frailty models correspondingly.

DISCUSSIONS

The recently released 2018 NDHS reports suggest determinants of under-five mortality should be assessed beyond the observed pool of determinants, bearing in mind the lack of sufficient momentum in the declining trend of the risk between 1990 and 2013. The results from our study seemed to add weight to the suggestion by the finding of a possible association between the risk of under-five mortality and some unknown, unobserved/unmeasured factors at both family and community levels.

The frailty effect on under-five mortality at the family level was 0.035. Though, not statistically significant, this implied that the measured covariates accounted for 96.5% of the variation in under-five mortality at the family level. In contrast, the frailty effect on under-five mortality at the community level was statistically significant at 0.175- implying the measured covariates accounted for 82.5% of the variation in under-five mortality at the community level, thus leaving as much as 17.5% attributable to unknown, unmeasured factors. These results suggest unobserved/unmeasured

Table 2: Estimating the Effect of Family and Community Frailty on Under-Five Mortality

Covariates	Family Frailty (Model I)		Community Frailty (Model II)	
	RR	95% CI for RR	RR	95% CI for RR
Sex of child				
Male	1.00		1.00	
Female	0.92	0.78-1.08	0.92	0.78-1.08
Region				
North-central	1.00		1.00	
North-east	1.11	0.80-1.53	1.09	0.77-1.53
North-west	1.43*	1.05-1.95	1.40*	1.01-1.94
South-east	2.18*	1.49-3.20	2.18*	1.46-3.25
South-south	1.07	0.73-1.57	1.07	0.72-1.60
South-west	1.07	0.72-1.59	1.08	0.72-1.64
Maternal age at childbirth				
<20 years	1.00		1.00	
20-34 years	0.78	0.58-1.04	0.77	0.57-1.03
35 and above	0.91	0.63-1.31	0.90	0.62-1.29
Number of children ever born				
<=2	1.00		1.00	
3-4	0.82	0.62-1.09	0.83	0.62-1.10
5 and above	1.05	0.79-1.40	1.05	0.79-1.39
Preceding birth interval				
First birth	1.00		1.00	
<24 months	1.37	0.98-1.93	1.38	0.98-1.94
24-35 months	1.22	0.88-1.68	1.23	0.89-1.70
>35 months	0.94	0.67-1.32	0.95	0.68-1.33
Size of child at birth				
Large	1.00		1.00	
Average	1.01	0.84-1.21	1.01	0.84-1.21
Small	1.20	0.95-1.51	1.21	0.96-1.53
Maternal educational level				
No education	1.00		1.00	
Primary education	0.89	0.70-1.15	0.89	0.69-1.15
Secondary or higher education	0.75	0.56-1.02	0.75	0.55-1.02
Wealth index				
Poor	1.00		1.00	
Middle	0.79	0.62-1.02	0.79	0.61-1.02
Rich	0.78	0.57-1.07	0.77	0.56-1.06
Marital status				
Never married	1.00		1.00	
Married	0.68*	0.50-0.93	0.68*	0.50-0.93

(Table 2). Continued.

Covariates	Family Frailty (Model I)		Community Frailty (Model II)	
	RR	95% CI for RR	RR	95% CI for RR
Place of residence				
Urban	1.00		1.00	
Rural	1.47*	1.15-1.88	1.46*	1.13-1.88
Type of toilet facility				
Unimproved	1.00		1.00	
Improved	1.03	0.85-1.23	1.04	0.86-1.26
Source of water supply				
Unimproved	1.00		1.00	
Improved	0.95	0.80-1.13	0.95	0.79-1.13
Place of delivery				
Home	1.00		1.00	
Hospital/clinic	0.75*	0.59-0.96	0.75*	0.58-0.96
Slept under Mosquito net				
No	1.00		1.00	
Yes	0.83	0.67-1.03	0.82	0.66-1.03
Number of ANC visit				
None	1.00		1.00	
1-3 times	0.91	0.67-1.22	0.90	0.66-1.22
Four times and above	1.09	0.88-1.35	1.07	0.86-1.33
Frailty Effect	0.035		0.175*	
Log-likelihood	-3103.09*		-3099.69*	

*P<0.05.

factors, particularly at the community level might be responsible for the elevation and variations in the risk of under-five mortality in Nigeria. This is consistent with those reported by studies conducted in some other developing countries, such as Bangladesh, Kenya and Zimbabwe [2, 15, 26]. The unobserved heterogeneity effect summarizes the influences of a likely long list of various unobserved/unmeasurable candidates too numerous to specify, such as parental competence, genetic, behavioural and environmental factors, as well as quality of health facilities and professional care provisions at health facilities, among many others [2]. None of these could be accounted for at specific levels in our models since they were not captured in the survey.

Our findings also suggested that the risk of death before age five was significantly higher for those residing in the north-west, south-east and rural areas of Nigeria. At the same time, married women and women that gave birth at Hospital/clinic had a significantly lower risk of losing their children before the age of 5. Thus, confirming the finding of earlier studies [8, 12,23, 24, 27, 28].

The differentials on social factors, population density and regional economic resources might partly account for the higher risk of U5M in the north-west, south-east and rural areas of Nigeria [11, 13]. The reasons for higher risk of U5M in the rural areas than in the urban areas might also be due to improved water supply, improve sanitation facilities, healthcare and other social amenities which those residing in the rural areas might not have access to [12, 29]. Furthermore, delivery at a hospital/clinic would avail such women the opportunity of supervision by trained medical professionals which could enhance the chance of childhood survival outcomes [24, 30]. Also, as reported in a previous study, antenatal care visit to hospital/clinic could, at large extent, result in better delivery outcomes and reduction in the risk of childhood mortality [31].

CONCLUSION

This study has demonstrated the influence of family and community factors on the risk of under-five mortality. The results suggest that there are factors other than the observed covariates we usually include in our assessment models on survey data, which could affect under-five death among children at both family and community levels. That, there are some unobserved/unmeasured factors that could affect the risk at these levels- unknown factors that are generally ignored when we assess the risk using models that are based only on observed variables. Indeed, we found that unmeasured factors were significantly associated with high risks of children dying before reaching the age of five. We, therefore, suggest that to achieve the sustainable development goals relating to child health in Nigeria, substantial efforts should be directed at identifying more determinants, such as to reduce the influence of unobserved factors and facilitate an extension of interventions to these factors, particularly at the community level.

REFERENCE

[1] McGuire JW. Basic health care provision and under-5 mortality: a cross-national study of developing countries. World Dev 2006; 34(3): 405-25. https://doi.org/10.1016/j.worlddev.2005.08.004

[2] Khan JR, Awan N. A comprehensive analysis on child mortality and its determinants in Bangladesh using frailty models. Archives of Public Health 2017; 75: 58. https://doi.org/10.1186/s13690-017-0224-6

[3] UNICEF. Levels and Trends in Child Mortality Report 2017. Estimates Developed by the UN Inter-agency Group for Child Mortality Estimation [cited 2018 Oct 20]. Available from: http://www.childmortality.org/files_v20/download/igme%20report%202017%20

[4] United Nations. Transforming our World: the 2030 Agenda for Sustainable Development. United Nations. [cited 2018 Oct 20]. Available from: http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E.

[5] National Population Commission (NPC) [Nigeria] and ICF International. Nigeria Demographic and Health Survey, 2013. Abuja, Nigeria, and Rockville, Maryland, USA 2014.

[6] UNICEF. Levels and Trends in Child Mortality: Report 2014. Estimates Developed by the UN Inter-agency Group for Child Mortality Estimation [cited 2018 May 12]. Available from: https://www.unicef.org/media/files/Levels_and_Trends_in_Child_Mortality_2014

[7] National Population Commission (NPC) [Nigeria] and ICF International Nigeria Demographic and Health Survey 2018 Key Indicators Report. Abuja, Nigeria, and Rockville, Maryland, USA 2019.

[8] Wegbom AI, Essi ID, Kiri VA. Survival Analysis of Under-five Mortality and Its Associated Determinants in Nigeria: Evidence from a Survey Data. Int'l J of Stat and Appl 2019; 9(2): 59-66.

[9] 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. Afri Pop Studies 2013; 27(1): 25-42. https://doi.org/10.11564/27-1-5

[10] Adedini AA, Clifford O, Eunice NSI, Dorothy NO, Latifat I. Regional variations in infant and child mortality in Nigeria: A multi-level analysis. J Biosoc Sci 2015; 47: 165-87. https://doi.org/10.1017/S0021932013000734

[11] Adebayo SB, Fahrmeir L. Analyzing Child Mortality in Nigeria with Geoadditive Survival Models. Sonderforschungsbereich 2002; Paper 303.

[12] Kayode GA, Adekanmbi VT, Olalekan A, Uthman OA. Risk Factors and a predictive model for under-five mortality in Nigeria: evidence from Nigeria demographic and health survey. BMC Pregnancy and Childbirth 2012; 12(10): 1-10. https://doi.org/10.1186/1471-2393-12-10

[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 Pediatrics 2017; 17: 30. https://doi.org/10.1186/s12887-016-0742-3

[14] Wegbom AI, Akinyemi JO, Edet CK. The Influence of Frailty on Infant and Child Mortality in Rural Nigeria. American J of Public Health Research 2018; 6(1): 21-25. https://doi.org/10.12691/ajphr-6-1-5

[15] Omariba DWR, Beaujot R, Rajulton F. Determinants of infant and child mortality in Kenya: an analysis controlling for frailty effects. Popul Res Policy Rev 2007; 26(3): 299-321. https://doi.org/10.1007/s11113-007-9031-z

[16] Nasejje JB, Mwambi HG, Achia TN. 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. https://doi.org/10.1186/s12889-015-2332-y

[17] Akinyemi JO, Bamgboye EA, Ayeni O. Trends in neonatal mortality in Nigeria and effects of bio-demographic and maternal characteristics. BMC Paediatics 2015; 15: 36. https://doi.org/10.1186/s12887-015-0349-0

[18] Antai D. Regional Inequalities in Under-five Mortality in Nigeria: A Population-based Analysis of Individual - and - Community Determinants. Pop. Health Metrics 2011; 9(6): 1-10. https://doi.org/10.1186/1478-7954-9-6

[19] Antai D, Ghilagaber G, Wedrén S, Macassa G, Moradi T. Inequities in under-five mortality in Nigeria: differentials by religious affiliation of the mother. J of Relig Health 2009; 48(3): 290-304. https://doi.org/10.1007/s10943-008-9197-7

[20] Uthman OA. Effect of low birth weight on infant mortality: Analysis Using Weibull Hazard Model. The Int J of Epidemiol 2008; 6 (1): 8-16. https://doi.org/10.5580/fca

[21] Wegbom AI, Aboko IS, Mandah OCA. Multivariate Analysis of Child Mortality determinants in Rural Nigeria. Int. J of Multi Discipline in Ind and Appl Sci 2016; 1(8): 1-10.

[22] Wegbom AI, Wokoma DSA, Nnoka LC, Chibo O. What explains the high rate of infant mortality in rural Nigeria: biodemographic or socioeconomic factors? Int J Health Sci Res 2016; 6(8): 317-23.

[23] Pedersen J, Liu J. Child Mortality Estimation: Appropriate Time Periods for Child Mortality Estimates from Full Birth Histories. PLoS Med 2012; 9(8): e1001289. https://doi.org/10.1371/journal.pmed.1001289

[24] Wegbom AI, Kiri VA and Essi, ID. Comparison between Semi-Parametric Cox and Parametric Survival Models in Estimating the Determinants of Under-Five Mortality in Nigeria: Application in Nigerian Demographic and Health Survey. Afr J of Maths and Stat Stud 2019; 2(2): 1-12.

[25] Kleinbaum, D, Mitchel K. Survival Analysis: A Self-Learning Text.3rd ed. Springer Science + Business Media, Inc. 2012.

[26] Joshua K, Jeroen K. Determinants of infant and child mortality in Zimbabwe: Results of multivariate hazard analysis. Demographic Research 2009; 21(13): 367-384. https://doi.org/10.4054/DemRes.2009.21.13

[27] Morakinyo OM, Fagbamigbe AF. Neonatal, infant and under-five mortalities in Nigeria: An examination of trends and drivers (2003-2013). PLoS ONE 2017; 12(8): e0182990. https://doi.org/10.1371/journal.pone.0182990

[28] Kazembe L, Clarke A, Kandala NB. Childhood mortality in sub-Saharan Africa: cross-sectional insight into small-scale geographical inequalities from Census data. BMJ Open 2012; 2: 1-12. https://doi.org/10.1136/bmjopen-2012-001421

[29] Dejene T, Girma E. Social determinants of under-five mortality in Ethiopia: Event history analysis using evidence from Ethiopian Demographic and Health Survey (EDHS). Health (Irvine. Calif) 2013; 5: 879-84. https://doi.org/10.4236/health.2013.55115

[30] Tekelab T, Chojenta C, Smith R, Loxton D. The impact of antenatal care on neonatal mortality in sub-Saharan Africa: A systematic review and meta-analysis. PLoS ONE 2019; 14(9): e0222566. https://doi.org/10.1371/journal.pone.0222566

[31] Rahman A, Rahman S, Rahman A. Determinants of infant mortality in Bangladesh: a nationally surveyed data analysis. International Journal of Child Health & Nutrition 2019; 8(3): 93-102. https://doi.org/10.6000/1929-4247.2019.08.03.3

Received on 10-01-2020 Accepted on 24-01-2020 Published on 16-03-2020

https://doi.org/10.6000/1929-4247.2020.09.01.3