https://doi.org/10.46344/JBINO.2025.v14i03.20

MODELLING SURVIVAL ANALYSIS ON DEMOGRAPHIC AND HEALTH SURVEY ON UNDER FIVE CHILDREN MORTALITY THROUGH COX PROPORTIONAL HAZARD MODEL AND LOG RANK TEST

Shammasu Sidi[1], Bilkisu Maijama'a[2], and Shammah Emmanuel Chaku[2], and M. O Adenomon[2]

[1]Research Student Department of Statistics and Data Analytics, Nasarawa State University, Keffi.
[2]Lecturer, Department of Statistics and Data Analytics, Nasarawa State University, Keffi, Nasarawa State.

maijamaab@nsuk.edu.ng

ABSTRACT

Child Mortality is the factor that decides the well-being of a population and also serves as a key to the socio-economic status and the development of a nation. This study examined the factors that strongly lead to child mortality rate (Under-five mortality) in Nigeria. The study used data from the Nigeria Demographic and Health Survey(NDHS) of 2018, which reported that about 33,924 children where reported death prior to their fifth birth day. This places Nigeria among the Sub Sahara African country that still recorded the highest absolute number of child deaths. This study is aimed at Modeling the Nigeria Demographic and Health Survey on under-five children Mortality, using Survival Analysis and Log rank test.We used the non-parametric Kaplan-Meier survival method to assess the influence of the sets of candidate factors on the survival of children aged under-five (U5) and the Log rank test to test for the significant difference between the levels of the factors in terms of the distribution of time until the event occurs (death). The result from the Log rank test also shows that Mothers educational level, Parents wealth status, Nutritional Status, and Birth interval all shows a significant difference between their levels in terms of the distribution of time until the event occurs since the p value is less than 0.05. While factors like Birth order shows no significant difference in the level of first birth, second to third birth, fourth to sixth birth and the seventh and above birth in terms of the distribution of time until the events occurs since the p value is greater than 0.05. Residence of parents also shows no significant difference in the level urban and rural area to the distribution of time until the events occurs since the p value is greater than 0.05.The study found evidence that Under five mortality in Nigeria is relatively high in the North western part of the country and suggested that may be under-five mortality in Nigeria is more associated with social, economic, environmental and demographic factors, than the health related factors. We conclude that for Nigeria to achieve the Sustainable Development Goals, its public health interventions may need to take into account, the factors we have identified.

Keywords: Cox-proportional hazard model, Log rank test. Survival Analysis, Under five Mortality, Health Survey.

1. INTRODUCTION

Under-five mortality is defined as the death of a child between birth and age of five Bamigbala & Ojetunde (2023). Though most of the deaths that occurred at the early stage of life are known to be preventable Yaya, Ahinkorah, Ameyaw, Seidu & Adjeji (2020), yet under- five mortality continued to be a tropical in the world. The issue of under five mortality was the goal number four (4) in the Millennium Development Goals (MDGs), aimed at reducing under five deaths to 25 of fewer per 1,000 in 2030 (Yaya et al, 2020).

Among the countries in sub-Saharan Africa with high under five mortality rate is Nigeria. The mortality rate in the country in 2013 was 128 per 1000 (Samuel, 2015). Nigeria therefore was far too short of achieving the MDG goal of reducing under- five death. However, the progress being made in reducing under-five mortality in Nigeria will continue to be intensified and monitored in the post-2015 Sustainable Development Goals (SDG) global agenda (Samuel, 2015).

The survival analysis is used to model the distribution of survival times and estimate the effect of riskfactorsofthesurvivorship (Mokgoropo&Walace,2014).Thefunctionconsidertheinformationregardinglostinfollow-upandthoseexperiencinganeventagainstoneswhowere at risk and then build a connection of survival probabilities at each time interval till the end ofobservationperiod.

2. STATEMENT OF THE PROBLEM

According to the recent Nigeria Demographic health survey of 2018 it has come to conclusion that under-five mortality in Nigeria are still very high and need further intervention therefore This research is unique and different in the sense that, it examines the link between the direct and indirect factors in understanding and explaining the causes of under-five mortality among the Nigerian children using Cox Proportional Hazard model of survival analysis because there are scarcity of studies that have used direct and indirect factors in survival analysis.

Thesewillenableformulationofeffectivepoliciesandprogramsthathasthecapacitytoreduceunder-fivemortalityin Nigeria. For example, policies that are directed to influence the direct factors are breastfeeding, birth spacing, immunization, etc. are more likely to cost less, make greater andquicker impact in reducing under-five mortality than policies that are exclusively directed toinfluencethe indirect factors suchaswomen'sformal education and also contribute to meet the SDG target for Nigeria.

The aim of this research is to Model Demographic Health Survey on under-five child Mortality in Nigeria, using Survival Analysis through the following objectives.To assess the influence of the sets of factors and their hazard ratio on the survival of the under five children using non parametric survival analysis.To compare and check for

the significant level of each of the factors contributing to Under-five mortality in Nigeria using the Log rank test.

3. LITERATURE REVIEW

Although there are many empirical review on the issues of Under-five mortality and some of the factors that lead to children death at the age of five years are reveled. This research contribute to knowledge with the use of data from the Nigeria Demographic Health Survey of 2018 on Under-five mortality where so many covariate such as socio-economic, demographic, cultural and health factors are been used in the research work to test for those factor that have a positive effect on Under- five mortality.

Egbon, Bogoni, Babalola, & Louzade, (2022). Found that Nigeria is among the top five countries in the world with the highest Under-five mortality rates. His study has shown that disparity in socio-cultural values and practices across ethnic group in Nigeria influence child survival. The study quantified the survival probabilities and the impact of socio-economic and demographic factors, proximate and biological determinants, and environmental factors on the risk of Under-five mortality in Nigeria.

Azuike, Onyemachi, Amah, Okafor, Anene, Enwonwu, & Ilika (2019). On their study, they revealed several determinants of Under-five mortality in the south-east geo-political zone of Nigeria. They found that children who reside in Anambra state had lower odds of under –five mortality compared with the children who reside in the four states. They also found that factors like female gender, maternal education, maternal age less than 35 years, maternal use of modern family planning, family belonging to middle and rich wealth index reduce the odds of under-five mortality.

Bamigbala, Ojetunde, (2023). Found that maternal age, regions (North East and North West) maternal education (no education), wealth index (poorest households) and size of Nigeria child at birth (very small birth size) are the significant factors associated with under-five mortality in Nigeria. The results also showed that the odds of under- five mortality increase as the age of mother increases. Therefore, the Nigeria government should understand the poverty is not just an economic problem but also a significant factor in health: as a result, the battle against poverty needs to receive the necessary attention.

Wegbom, Essi, & Kiri. (2019). In their work they established that assessing the effect of socio-economic bio-demographic and health related factors on mortality risk among under-five of Nigeria children using the 2013 Nigeria demographic and health survey data. They also added that they used Keplan-Meier survival method to assess the influence of the set of candidate factors on the survival of children aged under- five and also used the Cox proportional hazard model to access the form of the influence on mortality risk. Those found to have a significant influence on the risk in Nigeria were: mother's educational level, wealth index, marital status, place of residence, sex of the child, region, maternal age at

child birth number of children ever born, birth interval, and child size at birth. He added that they also found evidence that under five mortality in Nigeria may be associated with socio-economic, environmental and demographic factors, than with health related factors. They concluded that for Nigeria to achieve the Sustainable Development Goals, its public health interventions may need to take into account the factors we identified.

4 Research Methodology

This study examines the factors that lead to the death of Under-five children in Nigeria using the 2018 Nigeria Demographic and Health Survey. This study uses the survival analysis technique and it begins with Kaplan-Meier test, to give the graphical summary of the non parametric survival analysis and the Cox proportional hazard Model to estimate the parameters of the model and also the Log rank test is also computed. This research utilized the used of secondary data obtain from 2018 Nigeria Demographic and Health Survey (NDHS).

5.1 Population, Sample and Sampling Techniques

Target population also known as universe population it can be seen as a measurement of a group of elements such as individuals, objects or items from a sample. A population refers to the totality or group of persons from which a sample are taken for measurement. A population ought to share at any rate one thing for all intents and purpose Mohajan, (2018). However, a sample is a subset of individuals, items, or object from a population that a researcher collected in other to analyze, predict and make inferences. This research utilized the experience of some well trained lecturers, doctors and some medical personnel, parents and the children under discussion. Data from DHS are used for this research , and it is from this data the population of children are known and it is from this population that sample of study was drawn from profound investigation on the Under-five mortality in Nigeria.

5.2.1 Technique For Data Analysis And Model Specification

This study used the Survival analysis as the data analysis technique. The Cox proportion helps in estimating the model of the data and check which of the factors have either an increasing or decreasing influence on under-five children in the country.

The log rank test also tries to check if there is any relationship and significant difference between the level of factors in terms of the distribution of time until the event occurs.

5.2.2 The Keplan - Meier Estimator

TheKaplan-Meierestimatoralsoknownastheproductlimitestimatorwaspresentedby Kaplan and Meier (1958).It gives a simple and quick estimate of the survival function in thepresenceofcensoring.Itusestheexactfailuretime.

Thestandarderroristhereforegivenby:

$$s.e\left(\hat{S}(t)\right) = \hat{s}(t)\left[\sum_{i=1}^{k}\frac{d_i}{n_i(n_i-d_i)}\right]^{\frac{1}{2}} \quad (3$$

5.2.3 The Cumulative Hazard Function

from equation (1.4) if $\hat{s}(t)$ is the Keplan-

meier estimate to the survival function, then:

$$\hat{H}(t) = -\sum_{i=1}^{k} In\left(1 - \frac{d_i}{n_i}\right). \quad (3.7)$$

is an estimate to the cumulative hazard function.

From Taylor series expansion

$$In\left(1 - \frac{d_i}{n_i}\right) = -\frac{d_i}{n_i} - \left[\frac{d_i}{n_i}\right]^2 + \cdots \approx -\frac{d_i}{n_i}, \quad (3.8)$$

By ignoring higher order terms. The estimate to the cumulative hazard function is therefore given as

$$\hat{H}(t) = \sum_{i=1}^{k} \frac{d_i}{n_i}. \quad (3.9)$$

5.2.4 LogRankTest

Thelogranktestisthemostcommontechniqueofcontrastingthesurvivalcurvesbetweendifferentdirect and indirect factors of under-five mortalitywhichtakesthewhole observationperiod into account. The logranktestfollowedthesame assumptions ofKaplan–Meier method hence it would be an appropriate test forthisstudy.Thelog-ranktestaddressesthenullhypothesisof the probability of an event is same for any timepoint. These exposures can help in define whether thereis significance difference between two factors.Thelogrank statisticis approximately distributed aschi-square test statistic and the formula is as follows:

$\square^2\square$

$$\sum \frac{(\sum o_{ij} - \sum E_{jt})}{\sum E_{ij}} \quad (3.22)$$

Where

$\sum O_{ij}$ Totaloftheobservednumberofevents(deaths) inthe*j*thgroupoftreatmentovertime

$\square E_{jt}$-Total ofthe expectednumberofevents (deaths)inthe*j*thgroupoftreatmentovertime

j=1,2

Theobservedandexpectednumbersofeventsateverysingle event time in each group need to calculate beforecalculatethetessstatistic.Theexpectednumberofevents issolvedateacheventtimeineachgroupaccordingtothefollowingequation:

$$E_{jt_i} = N_{jt_i} * \left[\frac{O_{t_i}}{N_{t_i}}\right] \quad (3.23)$$

N_{jt_i}- Number at risk in the j^{th} group of treatment at i^{th} ordered time .

O_{t_i}- Number of observed events (deaths) at i the ordered time

N_{t_i}- Total the number at risk at i^{th} ordered time

j= 1,2

i=1,2,3…,*n*

The test statistic is approximately distributed as chi square with k-1 degree of freedom, where k is the number of comparing groups. The critical value for the test $\square^2_{a,v}$ can be learning in the table of percentage points of the $\square^2$ Distribution at 0.05 significant level.

5.2.5 Model Estimation

To investigate the death of Under-five children. This study adapt the used of Cox (1972) to estimate the model of the data and the factors to be investigated upon are the birth interval, nutritional

status, Birth Order, Place of Delivery, health Size of Birth, wealth status, mother's education, Sex of child, fathers education, Region, Place of residence, Age of child, Marital Status and the overall sudden event which is death. The study utilized the used of Cox proportional hazard model and Log rank test. The Cox model estimated this investigation is given below

$$h(t, \boldsymbol{X}) = h_0(t)\exp(X^T\beta) \quad (3.38)$$

Where β is regression parameter and $h_0(t)$ is the baseline hazard function at the time and X is the covariate.

The Cox model for all the factors is written below.

$$h_i(t_i, under-five\ mortality) = h_0(t_i)exp\beta_1(Mothers\ Age)^T + \beta_2(Sex\ of\ Child)^T + \beta_3(Region)^T + \beta_4(Fathers\ Education)^T + \beta_5(Marital\ Status)^T + \beta_6(wealth\ status)^T + \beta_7(mothers\ education)^T + \beta_8(Place\ of\ Residence)^T + \beta_9(Age\ of\ Child)^T$$

and the relative risk is given below

$$\frac{h_i(t_i, under-five\ mortality)}{h_0(t_i)} = e^{\beta_1(Mother's\ Age)\times\beta_2(Sex\ of\ child)\times\beta_3(Region) + (Antenatal\ care\times\beta_5(Health\ Behaviour\times\beta_6(wealth\ status)\times\beta_7(m}$$

5.3 Justification Of Methods

The Cox proportional hazard and Log Rank test which was estimated, was used in the study to estimate equation (3.16), (3.18) and (3.22) the approach was used because the model can be used to estimate other variable that may led to the death of Under- five children. This will help give a detailed result as this research makes use of both survival and Log rank test in the 2018 Nigeria Demographic and Health data. The Log Rank test was also used to determine whether there is significance difference between the distributions of the level of the factor that led to under- five mortality rate in Nigeria.

6. Data Analysis and Result

Table 4.1 Number of under -5 mortality

Number of deaths	Frequency	Percentages
0 -1 Under-5 Mortality	28607	84.3
2 -3 Under-5 Mortality	4332	12.8
4 -5 Under-5 Mortality	773	2.3
6 and above Under-5 Mortality	212	0.6
Total	33924	100

Table 4.2:FrequencyDistribution oftheIndirectfactors

Variables	Freq.	Percent	Variables	Freq.	Percent
Mother'sEducation			**Mother'sAge**		
NoEducation	15391	45.4	Below 20 years	1434	4.2
Primary	5274	15.5	20-29 years	16096	47.4
Secondary	10623	31.3	30-39 years	13094	38.6

More than Secondary	2636	7.8
Total	**33924**	**100**
Sex of Child		
Male	17257	50.9
Female	16667	49.1
Total	**33924**	**100**
Region		
NorthCentral	5875	17.3
NorthEast	7211	21.3
NorthWest	10305	30.4
South East	3798	11.2
South South	3202	9.4
SouthWest	3533	10.4
Total	**33924**	**100**
WealthStatus		
Poor	15809	46.6
Middle	7171	21.1
Rich	10944	32.3
Total	**33924**	**100**

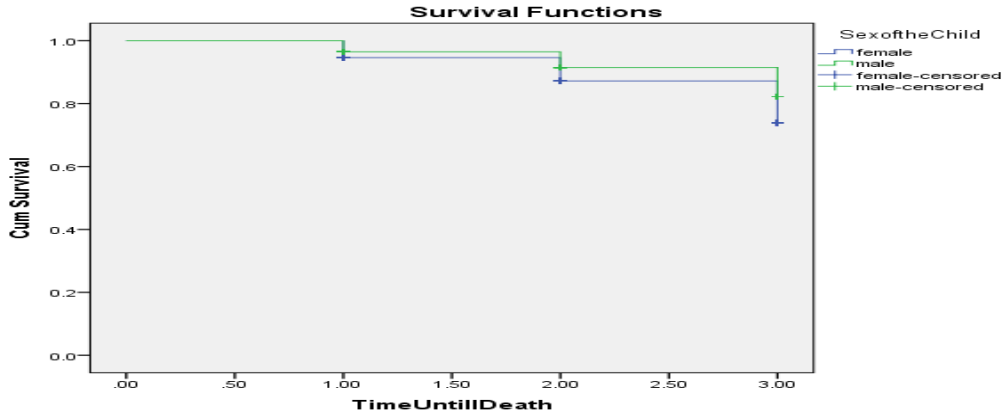
40+years	3300	9.8
Total	**33924**	**100**
PlaceofResidence		
Urban	11699	34.5
Rural	22225	65.5
Total	**33924**	**100**
Age of Child		
Less than 12 Months	6759	19.9
12–36months	13750	40.5
37–59months	13415	39.5
Total	**33924**	**100%**
Father'sEducation		
NoEducation	11610	38.0
Primary	5985	19.6
Secondary	9009	29.5
Higher	3981	13.0
Total	**30585**	**100**
MaritalStatus		
Currentlymarried	29990	95.3
Notcurrentlymarried	1492	4.7
Total	**31482**	**100**

Table 4.3:FrequencyDistribution oftheDirectFactors

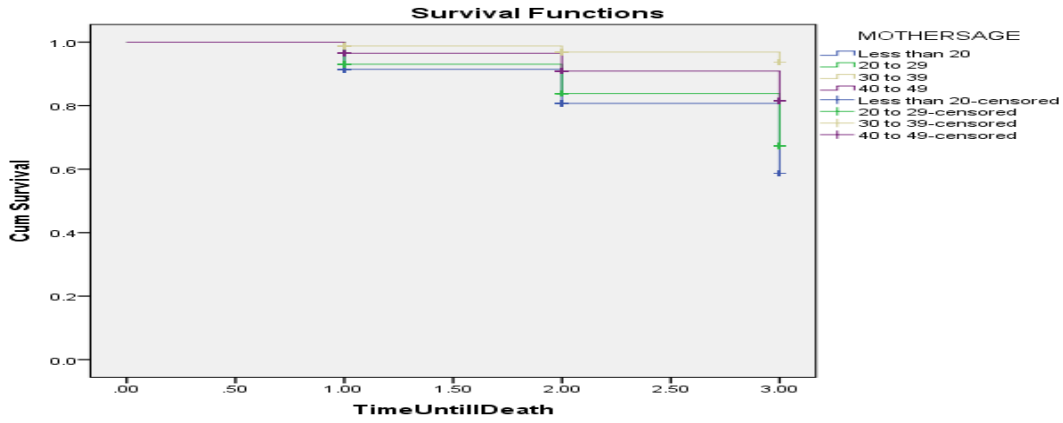
Variables	Freq.	Percent	Variables	Freq.	Percent
Nutrition			**Place of Delivery**		
Breastfed	7184	27.7	Home	7652	37.2
Never breastfed	18347	70.7	Hospital	4535	62.7
Missing	430	1.7	Others	15	0.1
Total	**25961**	**100**	**Total**	**12202**	**100**
			Size of Birth		
Birth Interval					
First birth	4670	19.1	Very small	860	2.5
< 24 months	4382	17.9	Small	3436	10.1
24-47 months	11722	48.0			
48 months	3671	15.0	Average or larger	30186	87.3
			Total	**33924**	**100**
Total	**24445**	**100**			
Birth Order					
1 birth	464	21.3			
2 -3 births	440	20.2			
4-6 births	516	23.7			
7+ births	760	34.9			
Total	**33924**	**100**			

The graph produce below are Keplan-Meier and cumulative hazard plots for a few selected factors affecting under-five Childs \survival in Nigeria from NDHS 2018 data set.

(a) Sex of the child



(b) Mothers age at first birth



(c) Mothers Education level

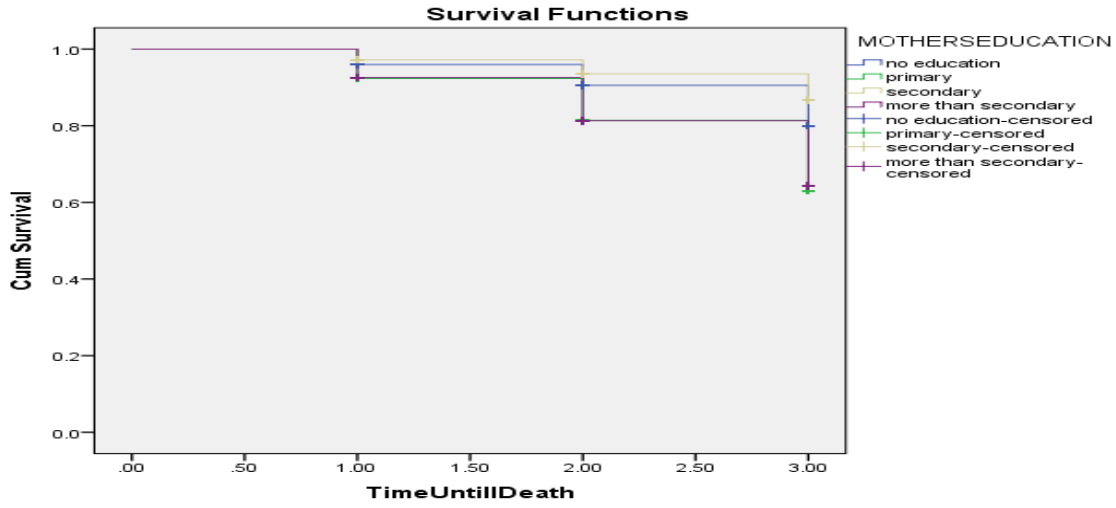
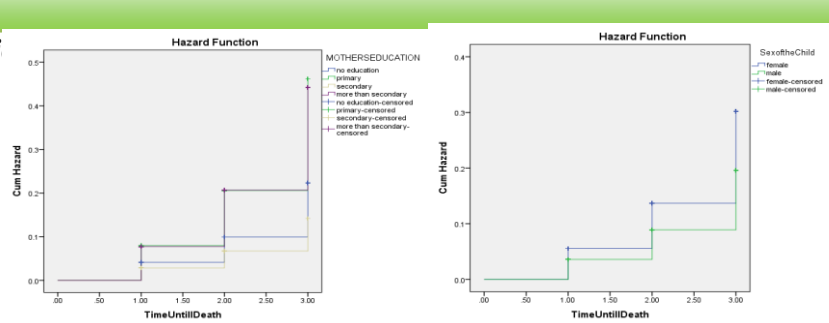


Figure (4.1a) shows that a male child is at higher chance of survival than a female child. From figure (4.1c) one can see that children born of mother with secondary school are at higher chance of surviving to the age of five years than children born of mother with more than secondary, primary or no education. The survival curve for children with mothers who have acquired secondary is above the survival curve of those children of mother who have more than secondary, primary and no education. From Figure (4.1b) one sees that mothers whose age at first birth was below 20 years were at a higherprobabilityofhavingtheirchildrendeadbefor ereachingtheageoffiveyears,this is because the survival curve of this category of children was below the one for children whosemother'sage at first birth was between the age of 30-39 years, 20−29years and 40 – 49 years.This is probably due to the ill preparedness of these mothers on parenting plus birth complications.The probability of surviving becomes less for children born of mothers whose age at first birth is between 20−29years, this is probably due to the birth complications involved with mothers of this age group.



(d) Cummulative Hazard function of Mothers education

(e) Cumulative Hazard function of sex of child

Figure (4.1d) shows the cumulative hazard curve for the children mother's level of education.Thecumulativehazardcurveforchildrenwhosemothershavemore than secondary and secondaryeducationisbelowtherestoftheotherchildrenwhosemothershavea lower education level which indicates a lower probability of death for children from such mothers and an increased probability of death for the rest of the other children whose mothershadprimaryornoeducationatall.The femalechildhadanincreasedprobability ofdeath,andthiscanbeseenfromthecumulativehazardcurvebeinghigherthanthat of the male child under the age of five see Figure (4.1e).

(f) Parents wealth status

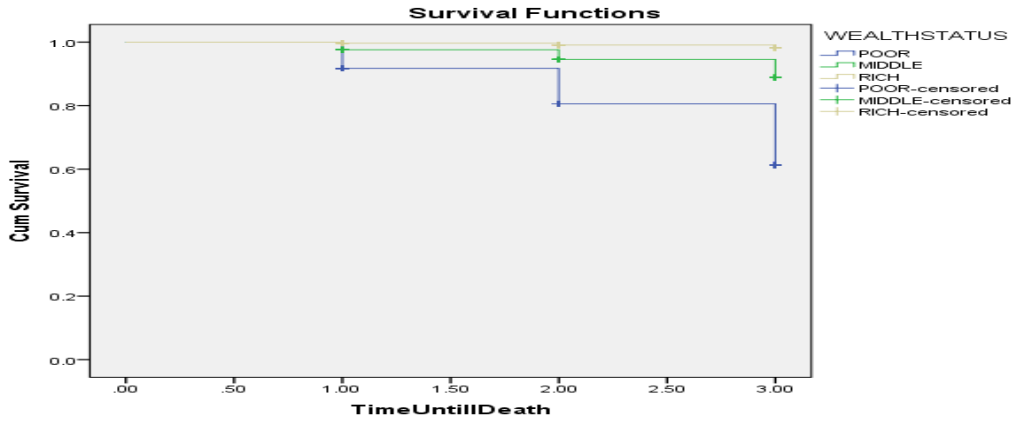


Figure (4.1f) shows that children born from wealthy and rich home are at higher chance of surviving to the age of five years than children born in the middle and poor home of mother with more than secondary, primary or no education. The survival curve for children from wealthy home is above the survival curve of those children middle and poor home.

(g) Cumulative Hazard function for Wealth Status

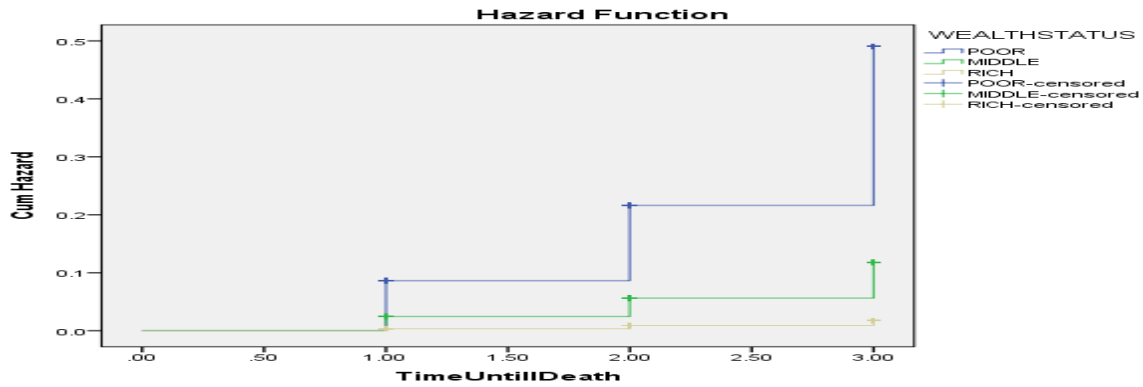


Figure (4.1g) indicated that childrenbornfromtherichestfamilieswereexposedtoalowerprobabilityofdeath before reaching the age of five compared to the rest of the children from richer, middle, poorerandpoorfamilies.Figure(4.1g) showsthatthecurveforthecumulativehazard ofdeathforchildreninrichfamiliesisbelowalltheothercurves.

(h) Place of Delivery

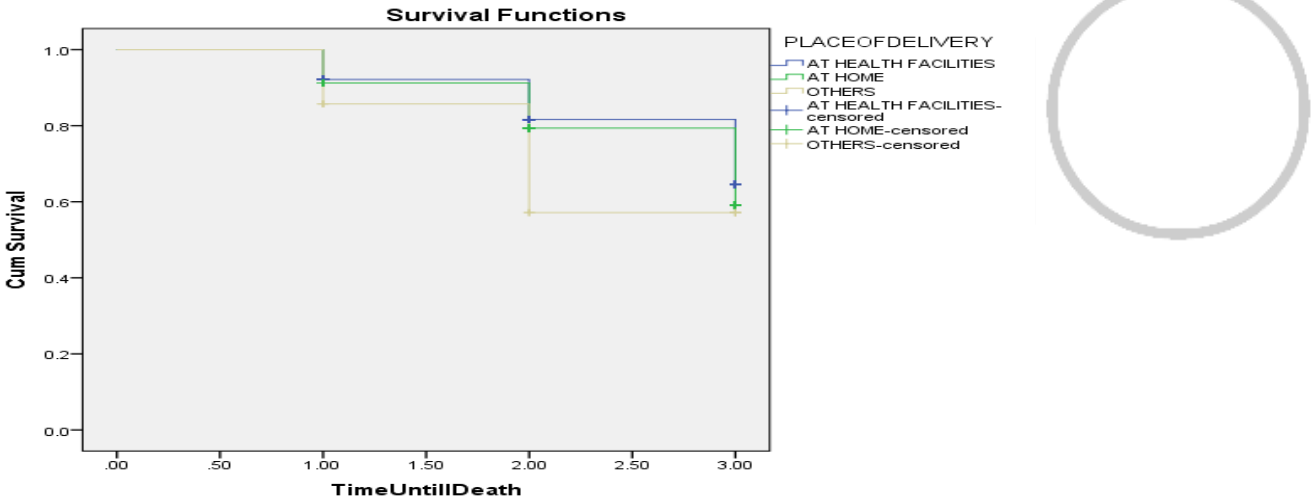


Figure (4.1h) indicated that children that are born at health centre wereexposedtoalowerprobabilityofdeath before reaching the age of five compared to the rest of the children that were born at home.

The Log Rank Test

Thelog-ranktest addressesthenull hypothesis that the probability of an event is same for any timepoint.

This test compares the entire survival experience among the groups and can be used to determine if the survival curves from each sample are the same, overlapping or neither

H1: There is a significant difference between the sex of child in terms of the distribution of time until the deaths occurs.

Table 4.4: Log rank test of sex of child

Log Rank (Mantel-Cox)

	Chi-Square	df	Sig.
Sex of Child	194.615	1	.000

Test of equality of survival distributions for the different levels of Sex of the Child.

From table 4.1; The Log rank test shows that there is a significant difference between the sex of child in terms of the distribution of time until the event occurs since the p value is less than 0.05.

H1: There is a significant difference between the levels of Mothers education in terms of the distribution of time until death occurs.

Table 4.5: Log rank test for Mothers education

Log Rank (Mantel-Cox)

	Chi-Square	Df	Sig.
MOTHERS EDUCATION	889.853	3	.000

Test of equality of survival distributions for the different levels of Mothers education.

From table 4.2

The Log rank test shows that there is a significant difference between the levels of mother education in terms of the distribution of time until the event occurs since the p value is less than 0.05.

H1: There is a significant difference between the levels of the selected factors in terms of the distribution of time until death occurs.

TABLE 4.6: log rank test for some others factors of under five mortality

LOG RANK (Mantel-Cox)

FACTORS	**CHI-SQUARE** χ^2	**Df**	**SIG.**	**DECISSION**

MOTHERS AGE	1,202.148	4	0.000	The test shows that there is significant difference in the level of mothers age
WEALTH STATUS	3189.342	2	0.000	There is also a difference in the level of wealth status of parents.
NUTRITIONAL STATUS	389.167	2	0.000	Nutritional status also shows a significant difference on it levels
RESIDENCE	1.547	1	0.214	There is no significant difference in the level of urban and rural residence
PLACE OF DELIVERY	17.295	2	0.000	There is a significant difference in the level of place of delivery
BIRTH ORDER	2.069	3	0.558	The test shows that the level of birth order has no significant difference in terms of the event that has occurs.
BIRTH INTERVAL	716.066	3	0.000	Birth interval also shows a significant difference in the levels of the intervals.

From table 4.6; Mothers educational level, Parents wealth status, Nutritional Status, and Birth interval all shows a significant difference between their levels in terms of the distribution of time until the event occurs since the p value is less than 0.05. While factors like Birth order shows noi. significant difference in the level of first birth, second to third birth, fourth to sixth birth and the seventh and above birth in terms of the distribution of time until theii. events occurs since the p value is greater than 0.05. Residence of parents also shows no significant difference in the level urban and rural area to the distribution of timeiii. until the events occurs since the p value is greater than 0.05

6.1 Recommendations

In the light of the above, the following**iv.** recommendation are made, more efficient interventions are needed may be those that target individual households rather than communities. Mothers should be made more aware about modern family planning methods to enables them plan for their families' well being and also short preceding and succeeding birth intervals. Parents should also make aware that all children require equal treatment regardless of their sex. Therefore the following recommendation are postulated

From the result obtain it shows that there is a need for the provision of extensive method on how to extract and organize any form of data of under- five mortality

The analysis also shows that serious interventions are needed in the North Western part of Nigeria as the under-five death is high in the region.

Hospital personnel's can also make use or seek the assistance of a statistician on how to use the estimated Cox proportional model postulated in this research.

Medical personnel should also teach parents on some basic technique to arrest any minor or major event that may occur to children of such age limit.

7. CONCLUSION

Theresultsindicatethatsexofthechild,Region, wealth status, Age of mother, Age of child,

fathers educational qualification, Marital status are strongly associated to the survival of children under the age of five. The results also indicated that children born in poor families were exposed to a higher risk of death than those in rich and families that had both the parents and the father as the family head. According to the non parametric plot a male child was a lower risk of death than a female child and this is attributed to the value most of the tribes in Nigeria attach to the male child. The male child is seen as a source of wealth to the family, thus the male child is preferentially given more care or attention.

This covariate also shows that short Nutritional Status, Place of delivery birth intervals and Size of birth are associated with a high child mortality rate. The short birth intervals portrayed by the results can also be as a result of the low use of modern method of birth control such as family planning methods.

The result from the Log rank test also shows that Mothers educational level, Parents wealth status, Nutritional Status, and Birth interval all shows a significant difference between their levels in terms of the distribution of time until the event occurs since the p value is less than 0.05. While factors like Birth order shows no significant difference in the level of first birth, second to third birth, fourth to sixth birth and the seventh and above birth in terms of the distribution of time until the events occurs since the p value is greater than 0.05. Residence of parents also shows no significant difference in the level urban and rural area to the distribution of time until the events occurs since the p value is greater than 0.05

REFERENCES

Aalen, O. O., Borgan, O., & Gjessing, H. K. (2008). An introduction to survival and event history analysis. Survival and event history analysis: A process point of view, 1-39.

Aboagye, R.G., Ahinkorah, B. O., Seidu, A. A., Frimpong, J. B., Archer, A. G., Adu, C., & yaya, S. (2022).Birth weight and nutritional status of children and under five in sub – Saharan Africa. Plos one, 17(6), e0269279.

Adebowale, S. A., Morakinyo, O.M., &Ans, G.R.(2017). Housing materials as predictors of under-five mortality in Nigeria. Evidence from 2013 demographic and health survey. BMC pediatrics, 17, 1-13.

Antai, D. (2010). Social Context, social position and child survival: Social Determinants of ChildHealth Inequities in Nigeria. University of Stocklohm, Karolinska Institutet. A DoctoralThesissubmittedtotheDepartmento fEnvironmentalMedicine,Pp.1-86.

Antai, D. (2011). Regional Inequalities in Uder-five Mortality in Nigeria: A Population-basedAnalysis of Individual - and - Community Determinants. Population Health Metrics, 9(6).Retrievedfrom .http://www.pophealthmetrics.com/content/9/1/6.

Aheto, J. M. K. (2019). Predictive model and determinants of under five child mortality: evidence from the 2014 Ghana demographic and health survey. BMC Public health 19, 1-10

Azuike, E. C., Onyemachi, P. E. N., Azuike, C. C., Okafor, K.C., Anene, J.O., Enwonwu, K.G.,&Ilika, A.L. (2019). Determinant of under-five mortality in south eastern Nigeria. J community Med Public Health care, 6,049

Bamigbala, O.A., & Ojetunde, A. O. (2023). Identifying Factors Contributing to under-five Mortality in Nigeria. Tanzania journal of Science, 49(2), 322-331.

Bewick, V., L. Check, & Ball, J. (2004) ''Statistics Review 10: Further Non-Parametric methods. Critical Care, Vol. 8, 1-4.

Budu, E., Ahinkorah, B. O., Ameyaw, E. K., Seidu, A. A, Zegeye, B., & Yaya, S. (2021). Does Birth interval Matter in Under-Five Mortality? Evidence from Demographic and Health surveys from Eight countries in West Africa. BioMed Research International, 2021(1), 5516257.

Balan, T.A., & Putter, H. (2020). A tutorial on frailty models. 'Statistical methods in medical research 29(11), 3424-3424.

Egbon, O.A., Bogoni, M.A, Babalola, B.T., & Louzade, F. (2022). Under age five children survival times in Nigeria: a Bayesian spatial modeling approach. BMC public health, 22(1), 2207

Fagbamigbe, A. F., Adeniji, F. I. P., & Morakinyo, O. M. (2022). Factors contributing to households wealth inequality in under-five deaths in low-and middle income countries: decomposition analysis. BMC Public health, 22(1), 769

Gatachew, Y., and S. Bekele (2016) ''Survival analysis of under-five mortality of children and its associated risk factors in Ethiopia.'' J Biosens Bioelectron 7.213:2.

Hangal, David D, (2011). Modelling Survival data using frailty models. Boca Roton: Chapman &Hall//CRC.

Jones, G. L., & Qin, Q. (2022). Markov Chain Monte Carlo in practice. Annual Review of Statistics and its Application, 9(1), 557-578.

Kazembe, L.,Clarke, A., & Kandala, N.B. (2012). Childhood mortality in sub- Sahara Africa cross sectional insight into small-scale geographical inequalities from census data. BMJ open, 2(5), e001421

Kombo, D. K., & Tromp, D. L. (2006). Proposal and thesis writing: An Introduction. Nairobi:Paulines Publications, Afric, 5(1), 814-30.

Makgaba, M.E.W.(2014). Survival analysis with applications to Ga-Dikgale children (Doctoral dissertation)

Mulaudzi, T.B. (2022). Modeling children under-five mortality in South Africa using coupula and Frailty survival models(Doctoral dissertation).

Miller, K. T. (2011). Bayesian nonparametric latent feature models. University of calfornia, Berkeley.

Muzari, T., Sheva, G. N., & Shonhiwa, S. (2022). Qualitative research paradigm, a key research design for educational researchers, process and procedures: a theoretical overview. Indiana journal of Humanities and Social Sciences, 3(1), 14-20.

Mohajan, H. K. (2018. Qualitative research methodology in social sciences and related subjects. Journal of economic development, environment and people, 7(1), 23-48

Nasejje, J. (2013). Application of survival analysis methods to study under-five child

mortality in Uganda (Doctoral dissertation).
Oduse, S., Zewotir, T., North, D. (2021). The impact of antenatal care on under-five mortality in Ethopia: a difference –in-differences analysis. BMC pregnancy and Childbirth, 21, 1-9
Quattrochi, J. P., Hill, K., Salomon, J. A., & Castro, M.C. (2020). The effects of changes in distance t nearest health facility on under-five mortality and health care utilization in rural Malawi, 1980-1998. BMC health services research, 20, 1-12
Samel, G. W. (2015). Underlying and proximate determinants of under-five mortality in Nigeria: understanding the pathways of influence (Doctoral dissertation, Covenant University)
Schober, P. & Vetter, T.R. (2018). Survival analysis and interpretation of time to event data: the tortoise and the hare'' Anesthesia & Analgesia 127(3), 792-798
Ssengonzi, R. De Jong, G.F., & Shannon Stokes, C. (2002). The effect of female nigration on infant and child survival in Uganda. Population Research and policy Review 21, 403-431.
Trochim, W., Kane, C., Graham, M. J., & Pincus, H.A. (2011). Evaluating translational research: a process marker model. Clinical and translational science, 4(3), 153-162.
Wegbom, A. I., Essi, I. D., & Kiri, V.A. (2019). Survival analysis of under-five mortality and its associuated determinants in Nigeria: evidence from a survey data. International journal of Statistics and Applications, 9(2), 59-66.
Yay, S., Ahinkorah, B. O., Ameyaw, E. K., Seidu, A. A., Darteh, E. K. M., & Adjei, N.K (2020). Proximate and socio economic determinants of under-five mortality in Benin, 2017/2018. BMJ global health, 5(8), e002761
Qiao, Y., Labi, S., & Fricker, J.D. (2019). Hazard-based duration models for predicting actual duration models for predicting actual duration models of highway projects using nonparametric and parametric survival analysis. Journal of Management in engineering, 35(6), 04019024.