Modelling the survivorship of Nigeria children in their first 10 years of life

*Fagbamigbe, Adeniyi Francis[1,2] , Akinyemi, Joshua Odunayo[1]
[1]Department of Epidemiology and Medical Statistics, Faculty of Public Health, College of Medicine, University of Ibadan. Nigeria

[2]School of Research and Postgraduate Studies, HSS, North West University, Mafikeng, South Africa
Correspondence: *E-mail: franstel74@yahoo.com Phone: +2348061348165*

Conflict of Interest: Authors declared no conflict of interest
Acknowledgements: We acknowledge ICF macro and the National Population Council on behalf of the Federal government of Nigeria granting us access to the data used for this study

Abstract
Introduction: *Several studies have attributed social demographic and environmental characteristics to differentials in children mortality rates worldwide but there is paucity of information on modelling of children survival in Nigeria. In this study we modelled children survival in Nigeria and predicted their chances of survival in their first ten years of life.*

Methods: *We used the data from the 2013 Nigeria Demographic and Health Survey to carry out a retrospective analysis of children survival. We computed the probability of survival and mortality rates for the first five years and predicted survivals for 6th to 10th years of life using life table techniques and compared our estimates with Brass indirect techniques.*

Results: *The probability of a child surviving up to exact age 1 and 5 were 0.9212 (95% CI: 0.919-0.923) and 0.8583 (95% CI: 0.855-0.861) respectively. About 142 of every 1000 children would not make their tenth birthday in Nigeria. We found higher survivorship trend among female children than the males with higher rates in Southern Nigeria than in the Northern parts. The estimates of probabilities of survival from age 1 to 5 from the fitted curves agreed very closely with those obtained from Brass indirect techniques as the variability was less than 2%.*

Conclusion: *Child mortality is high in Nigeria with fewer children deaths among females. Probability of not attaining age 10 in South West is lower than chances of not marking first birthday in North West zone. Efforts must be concentrated in reversing the worrisome survival trend in Nigeria especially in the Northern parts of the country.*

Keywords: Survivorship, Nigeria, children mortality, Kaplan Meier, Brass Indirect method, Prediction

Introduction

Reduction of child mortality was one of the Millennium Development Goals (MDG). The target was to reduce by two-thirds, between 1990 and 2015, the under-five mortality rate. The indicators for tracking this goal are (i) Under-five mortality rate (ii) Infant mortality rate and (iii) Proportion of 1 year-old children immunized against measles.[1] The high importance attached to infant mortality and child mortality is due to its worldwide use in determining level of country's social economic development.[2,3]

The rate of children death in the first year and in the 1-4 years of life has attracted particular attention because: i) mortality is relatively high in these periods, the contribution of the probability of dying in the 0-4 years of human life is substantial, ii) impact on the average expectation of life and the art of population growth, iii) sensitivity to environmental and sanitary conditions and iv) usefulness of infant and child mortality as health indicator and living standard of a country.[4]

At the end of the 2015 deadline for the MDG, not much progress has been observed in Sub-Saharan Africa and Southern Asia. Unlike in most developing countries, the more developed world has made substantial progress by reducing the under-five mortality rate by 41 percent, from 87 (95% CI: 85, 89) deaths per 1,000 live births in 1990 to 51 (95% CI: 49, 55) in 2011.[2,5-6] Eastern Asia, with a 70 percent reduction, and Northern Africa, with a 68 percent reduction, achieved MDG 4. Similarly, Latin America and the Caribbean was close to doing so with a 64 percent reduction. However, sub-Saharan Africa with 39 percent and Oceania having a 33 percent lagged behind in under five mortality reduction.[6,7] The scourge of HIV/AIDS which sub-Saharan Africa is currently battling is a major challenge to reduction of children mortality in the region. Sub-Saharan Africa annual reduction rate increased slightly from 1.5% for 1990-2000 to 3.1% for 2000-201.1[6]

However despite reduction the World's Under Five (U5) mortality by 47%, current high children mortality are attributable to treatable and preventable causes.[8] The situation in Nigeria is more pathetic as the indicators are above the global average. Although U5 mortality and infant mortality has reduced over the years in Nigeria in the last decade, the country remained one of the worst hits as far as child mortality is concerned. For instance, the current infant mortality rate (75 per 1000 live births) is almost double the World's average (41 per 1000 live births) but at par with sub-Sahara Africa's rate of 72.[9]

According to UNICEF, in 2012, 6.6 million children died globally before reaching their fifth birthday.[10] Although this is a sharp decrease from 1990, when more than 12 million U5 children died, these numbers remain unacceptable. Several studies have attributed differentials in children mortality rates to some social demographic variables.[11-16]

A study on sex differentials in infant and child mortality in Egypt, found that regardless of region, socio-economic status, demographic variables or sex of older siblings, post- neonatal mortality is 12% higher and 2nd year mortality 60% higher for females. However, the study reported that mortality rates did not differ by gender among university-educated mothers.[11]

Relationship between maternal education and child survival in developing countries has been explored.[17,18] It was affirmed that on average, each one-year increment in mother's education corresponds with a 7–9% decline in U5 mortality. The study attributed influence of maternal education to reproductive health patterns, economic advantages associated with education (i.e. income, water and latrine facilities, housing quality, etc.). It is expected that maternal educational status should have a strong influence on infancy as well as early and later childhood mortality.

A Ghanaian study investigated the effects of polygynous marital structure on child survivorship and assessed whether the effect is uniform over the entire childhood period. The study found that children in polygynous marriages were found to have an elevated risk of death with older children experiencing the survival disadvantages associated with polygyny. They had opined that different marital arrangements in monogamous and polygynous might imply varying levels of parental support necessary for optimum child outcomes.[12]

The extensive use, elaboration, refinement, and application of the original Brass method for estimating infant and child mortality from child survivorship data in the last forty years is unprecedented and it has confirmed the overall usefulness of the methods beyond question. However, an earlier study on child survival estimation reported that estimates must be analyzed in relation to other relevant information before useful conclusions about the level and trend of mortality can be drawn.[14] The study suggested specific data maneuvers including plotting completed parity distributions and 'time-plotting' mean numbers of children ever born from successive censuses. We proffered logarithm model for understanding changes in mortality as a child grows older.

In recent decades, numerous studies have documented correlates, differentials as well as risk factors of infant and U5 children mortality rates in Nigeria but there is paucity of information on modelling of children survival pattern in Nigeria. In this study we estimated the children mortality rates at exact ages 1 to 5 for the country as a whole and further disaggregated the rates according to selected social-demographic factors earlier identified in previous studies and fitted a logarithm model for probability of survival in the first ten years of life.

Methodology

Data and Study Area

We used the data collected during the 2013 Nigeria Demographic and Health Survey (NDHS).[19] The sample for the 2013 NDHS was nationally representative and covered the entire population residing in non-institutional dwelling units in the country. The survey used as a sampling frame the list of enumeration areas (EAs) prepared for the 2006 Population Census of the Federal Republic of Nigeria, provided by the National Population Commission. The sample was designed to provide population and health indicator estimates at the national, zonal, and state levels. The sample design allowed for specific indicators to be calculated for each of the six zones, 36 states, and the Federal Capital Territory, Abuja.

Administratively, Nigeria is divided into states. Each state is subdivided into local government areas (LGAs), and each LGA is divided into wards. In addition to these administrative units, during the 2006 population census, each ward was subdivided into census enumeration areas. The primary sampling unit (PSU), referred to as a cluster in the 2013 NDHS, is defined on the basis of EAs from the 2006 EA census frame. The 2013 NDHS sample was selected using a stratified three-stage cluster design consisting of 904 clusters, 372 in urban areas and 532 in rural areas. A representative sample of 40,680 households was selected for the survey, with a minimum target of 943 completed interviews per state. A fixed sample take of 45 households were selected per cluster. All women age 15-49 who were either permanent residents of the households in the 2013 NDHS sample or visitors present in the households on the night before the survey were eligible. A total of 39,902 women age 15-49 were sampled, among which 98 percent were successfully interviewed. Other details of the survey methodology have been reported in 2013 NDHS.[19]

All data analysis were based on the recoded birth history data from the 2013 NDHS.[19] There were a total of 119,386 births data collected, of which 51.3% of the children were males and 32.5% of all the births were from urban areas. The 119,386 birth records were made up of 13.5% from North Central, North East 20.3%, North West 32.5%, South East 9.4%, South South 12.4% and 11.9% births from South West.

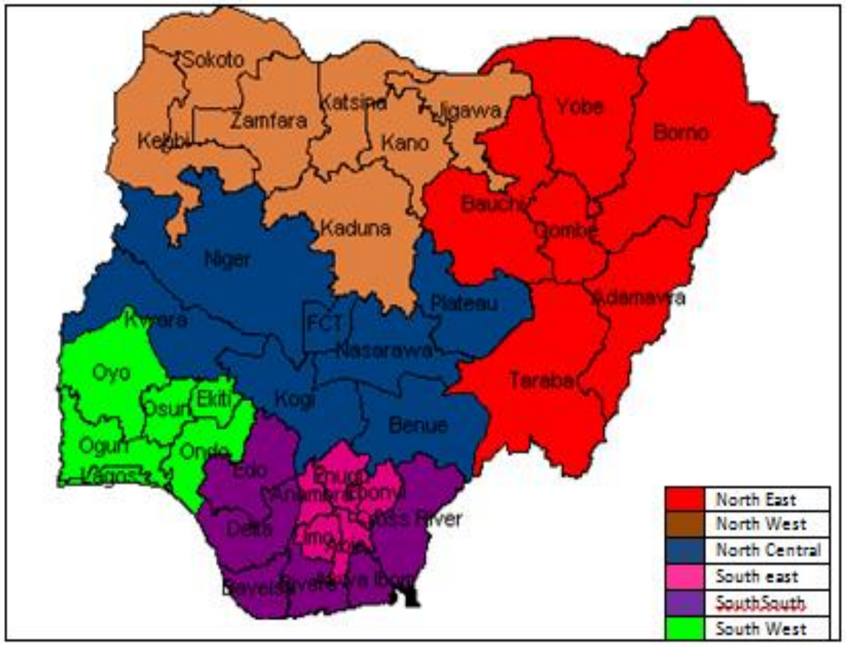

Figure 1. Map of Nigeria showing its 36 states, the federal capital territory and the geographical zones

Statistical Analysis: We obtained the date of birth of the children as detailed in the children birth recode NDHS data, irrespective of whether the child was dead or alive, age at death for those dead and current age for those alive were determined. We censored the children who were alive at the various ages as of the day of interview. We estimated both the failure time (the age when the child died) and the censoring time (the age of a living child as at the time of the survey). We then computed the probability of surviving and mortality rates (with 95% confidence interval) at the end of 1st year up to 10th year of life using life table techniques. We compared estimates of survival probabilities for exact ages 1, 2, and 3 with those obtained from Brass Indirect techniques.[20]

A life table is a useful tool for summarising event histories such as death rates in a given population over time. It works by dividing the study time to non-overlapping intervals and allows the examination of the empirical hazard function through aggregation. Assuming τ_i is the individual failure or censoring times. The data could be aggregated into intervals denoted by t_j , where j = 1; : : : ; k, and $t_{j+1} < \infty$ with each interval containing counts for $t_j < \tau < t_{j+1}$. If d_j and m_j are the number of failures and censored observations during an interval and N_j is the number alive at the start of a particular interval.

Then the adjusted number at risk (n_j)at the start of the interval could be obtained using

$$n_j = N_j - \frac{m_j}{2} \quad \text{...(1)}$$

The product-limit estimate of the survivor function is[21]

$$S(j) = \begin{cases} 1 & \text{if } j < t_1 \\ \prod_{t_i \le t} \left[\frac{n_k - d_k}{n_k}\right] & \text{if } j \ge t_1 \end{cases} \quad \text{...(2)}$$

And an asymptotic variance is

$$[s(j)] = \hat{S}(j)^2 \sum_{t_i \le t} \frac{d_k}{Y_k (Y_k - d_k)} \quad \text{...(3)}$$

This variance is not often used to compute the confidence interval as it may produce estimates outside the [0,1] constraints. An alternative is to use

$$\hat{s}_j = S_t \sqrt{\frac{\sum d_k/\{n_k(n_k-d_k)\}}{[\sum log\{n_k(n_k-d_k)\}]^2}} \quad \text{.................................(4)}$$

which produces an asymptotic standard error for the survival function *log(-logS*$_j$*)*. The corresponding confidence intervals are obtainable from $S_j^{\exp(\pm Z_{1-\alpha/2}\hat{S}_j)}$. The cumulative failure time (F_j) defined as additive complement of S_j have a confidence interval $1 - S_j^{\exp(\pm Z_{1-\alpha/2}\hat{S}_j)}$.

Assuming that the within-interval failure rate is defined as $f_j = d_j/n_j$, then the maximum likelihood estimate of the (within-interval) hazards is

$$\lambda_j = \frac{f_j}{(1-f_j/2)(t_{j+1}-t_j)} \quad \text{.................................5}$$

whose standard error is

$$S_{\lambda_j} = \lambda_j \sqrt{\frac{1-\{(t_{j+1}-t_j)\lambda_j/2\}^2}{d_j}} \quad \ldots\ldots\ldots\ldots 6$$

We fitted curve linear models using logarithm functions for all the estimated probabilities of survivorship disaggregated by selected socio-demographic variables. We used Microsoft Excel Office 2010, IBM PASW 20 and STATA 12 statistical analysis software for the data analysis.

Results

The estimated mortalities at each exact age were shown in Table 1 and Figure 1. The infant mortality rate (Exact age 1) was 79 which translated to survival probability of 0.9212 (95% CI: 0.9190-0.9233), under five mortality rate of 142 with 0.8583 (95% CI: 0.8552-0.8612) probability of surviving past age 5. By the tenth birthday of the children, an estimated 153 of a cohort of 1000 children would have died translating to probability of attaining age 10 as 0.8475 (CI 95% CI: 0.8438-0.8511).

Table 1. Distribution of Children survival in first ten years of life

Interval	Exact age	Probability of Survival (p_i)	Standard Error of p_i	95% CI of p_i	Deaths per 1000 live births
0 1	1	0.9212	0.0011	0.9190-0.9233	79
1 2	2	0.8933	0.0013	0.8908-0.8958	107
2 3	3	0.8736	0.0014	0.8708-0.8764	126
3 4	4	0.8632	0.0015	0.8602-0.8661	137
4 5	5	0.8583	0.0015	0.8552-0.8612	142
5 6	6	0.8553	0.0016	0.8522-0.8583	145
6 7	7	0.8530	0.0016	0.8498-0.8561	147
7 8	8	0.8511	0.0016	0.8479-0.8543	149
8 9	9	0.8493	0.0017	0.8459-0.8525	151
9 10	10	0.8475	0.0019	0.8438-0.8511	153

Figure 2 shows the survivorship pattern in the first ten years of life in Nigeria. The survivorship trend equation followed the logarithm function: y=0.9142 + 0.032ln(x) with R^2=0.9542 where y and x are the probability of survival and years after birth respectively.

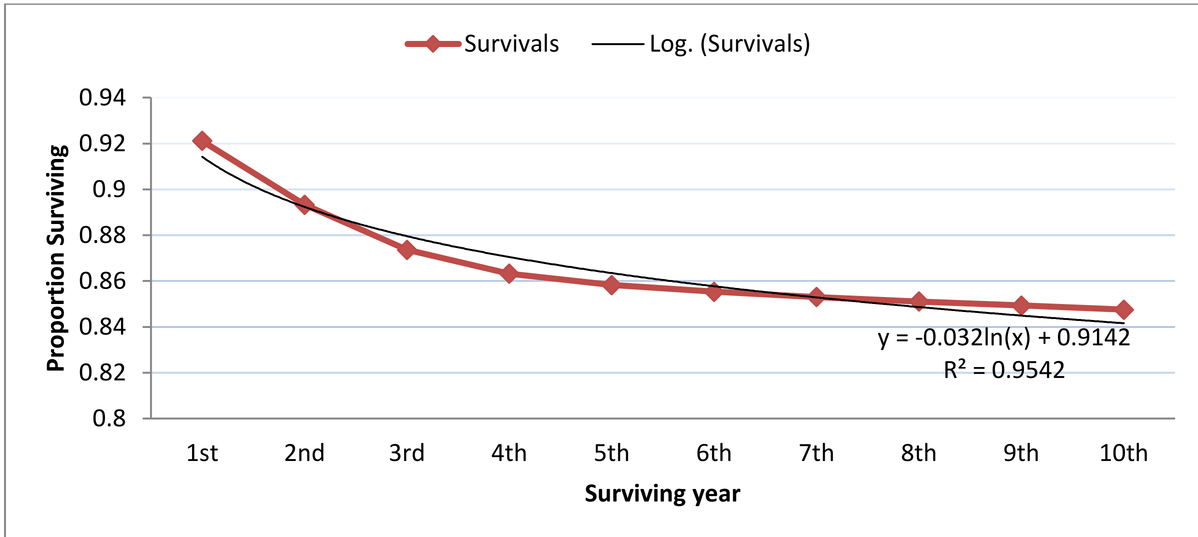

Figure 2. Surviving pattern of children in the first ten year of life

We explored a possible sex difference in the survivorship pattern of the children as shown in Figure 3. The graphs show the survivorship pattern in the first ten years of life for male and female Nigeria children. The male survivorship trend equation followed logarithm function of y = -0.032ln(x) + 0.9074 with R^2=0.9504 while the trend equation for the female children was y = -0.031ln(x) + 0.9213 with R^2=0.957 where y and x denotes probability of survival and years after birth respectively.

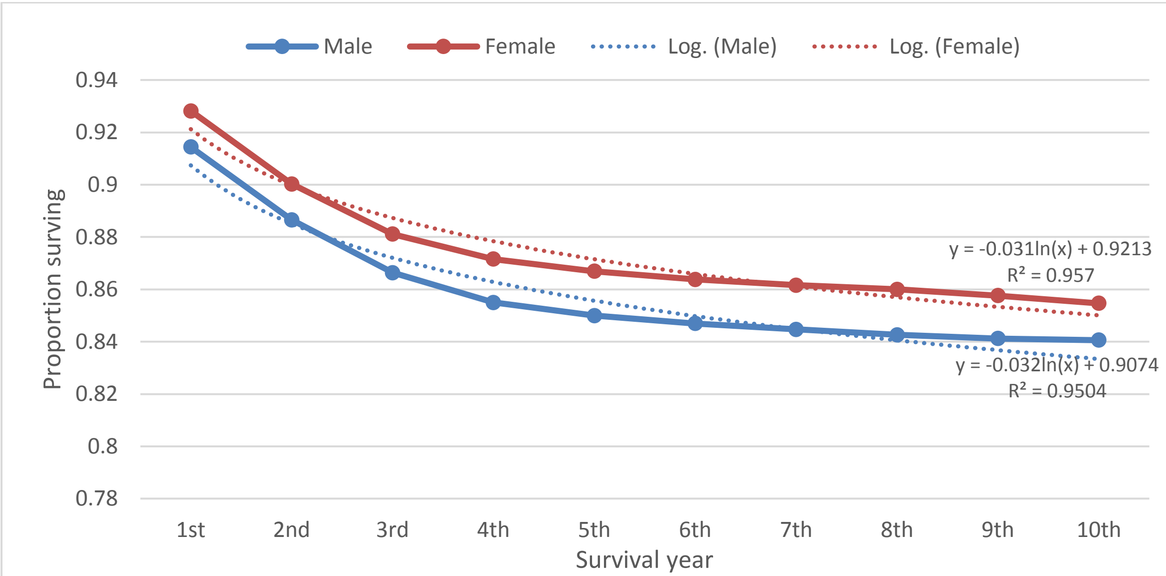

Figure 3. Surviving pattern of children in the first ten year of life by sex

Figure 4 shows the survivorship pattern in the first ten years of life for children from rural and urban Nigeria. The Urban survivorship trend equation followed logarithm function of $y = -0.018\ln(x) + 0.9348$ with $R^2=0.9645$ while the trend equation for the rural areas was $y = -0.038\ln(x) + 0.9045$ with $R^2=0.9507$ where y and x denotes probability of survival and years after birth respectively (Figure 4).

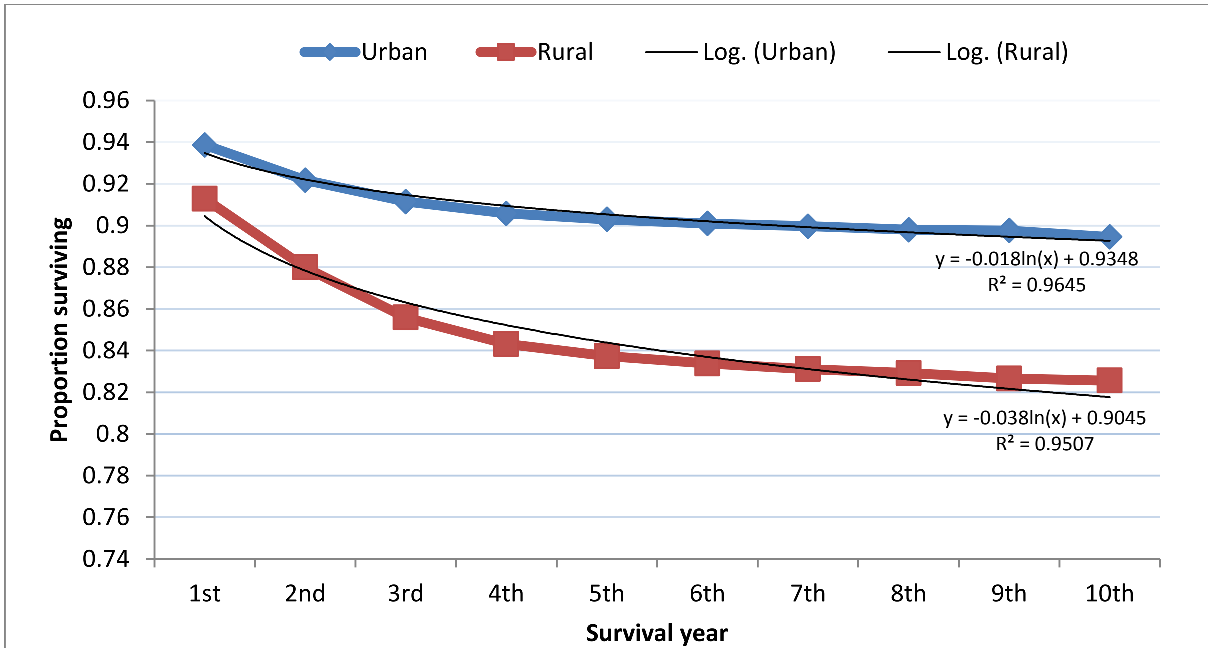

Figure 4. Surviving pattern of children in the first ten year of life by location of residence

The probabilities of survival among children in each of the six geopolitical zones constituting Nigeria were estimated alongside the 95% confidence interval as shown in Table 2. The chances of survival were found to be highest in the South South geopolitical zone (0.940) at each exact age 1 and highest from exact ages 2 to 10 in the South West while survival was lowest in the North West throughout the ten years. At the end of first ten years, 201 of 1000 North West children would have died, 181 in the North East, 136 in the South East, North central 103, South South 98 and 93 in the South West as shown in Table 2 and Figure 5.

Table 2. Distribution of Children survival in first ten years of life by Zones

Zone	North Cental		North East		North West		South East		South South		South West	
Exact age	Probability of survival (95% CI)	*Death /1000	Probability of survival (95% CI)	*Death /1000	Probability of survival (95% CI)	*Death /1000	Probability of survival (95% CI)	*Death /1000	Probability of survival (95% CI)	*Death /1000	Probability of survival (95% CI)	*Death /1000
1	0.936(0.930-0.941)	64	0.916(0.911-0.921)	84	0.906(0.902-0.909)	94	0.918(0.909-0.925)	82	0.940(0.934-0.945)	60	0.938(0.933-0.945)	62
2	0.923(0.917-0.928)	77	0.882(0.876-0.887)	118	0.865(0.860-0.869)	135	0.894(0.885-0.902)	106	0.922(0.916-0.929)	78	0.925(0.919-0.931)	75
3	0.914(0.907-0.919)	86	0.860(0.853-0.866)	140	0.832(0.826-0.837)	168	0.882(0.872-0.890)	119	0.913(0.906-0.919)	87	0.920(0.912-0.926)	81
4	0.909(0.901-0.915)	92	0.846(0.839-0.853)	154	0.816(0.810-0.822)	184	0.876(0.866-0.885)	125	0.909(0.902-0.916)	91	0.914(0.906-0.920)	86
5	0.904(0.897-0.911)	96	0.839(0.832-0.846)	161	0.810(0.804-0.816)	190	0.872(0.862-0.881)	128	0.907(0.899-0.914)	93	0.911(0.909-0.918)	89
6	0.902(0.895-0.909)	98	0.833(0.825-0.840)	167	0.807(0.801-0.813)	193	0.872(0.862-0.881)	128	0.905(0.898-0.912)	95	0.909(0.901-0.916)	91
7	0.900(0.893-0.907)	100	0.830(0.823-0.837)	170	0.804(0.798-0.811)	196	0.870(0.860-0.879)	130	0.903(0.895-0.910)	97	0.908(0.900-0.915)	92
8	0.898(0.891-0.905)	102	0.827(0.819-0.835)	173	0.802(0.796-0.809)	198	0.870(0.859-0.879)	130	0.902(0.894-0.909)	98	0.907(0.899-0.914)	93
9	0.897(0.889-0.904)	103	0.824(0.816-0.832)	176	0.800(0.794-0.807)	200	0.867(0.856-0.877)	133	0.902(0.894-0.909)	98	0.907(0.899-0.914)	93
10	0.897(0.889-0.904)	103	0.819(0.808-0.828)	181	0.799(0.792-0.806)	201	0.864(0.851-0.876)	136	0.902(0.894-0.909)	98	0.907(0.899-0.914)	93

*deaths per 1000 livebirths

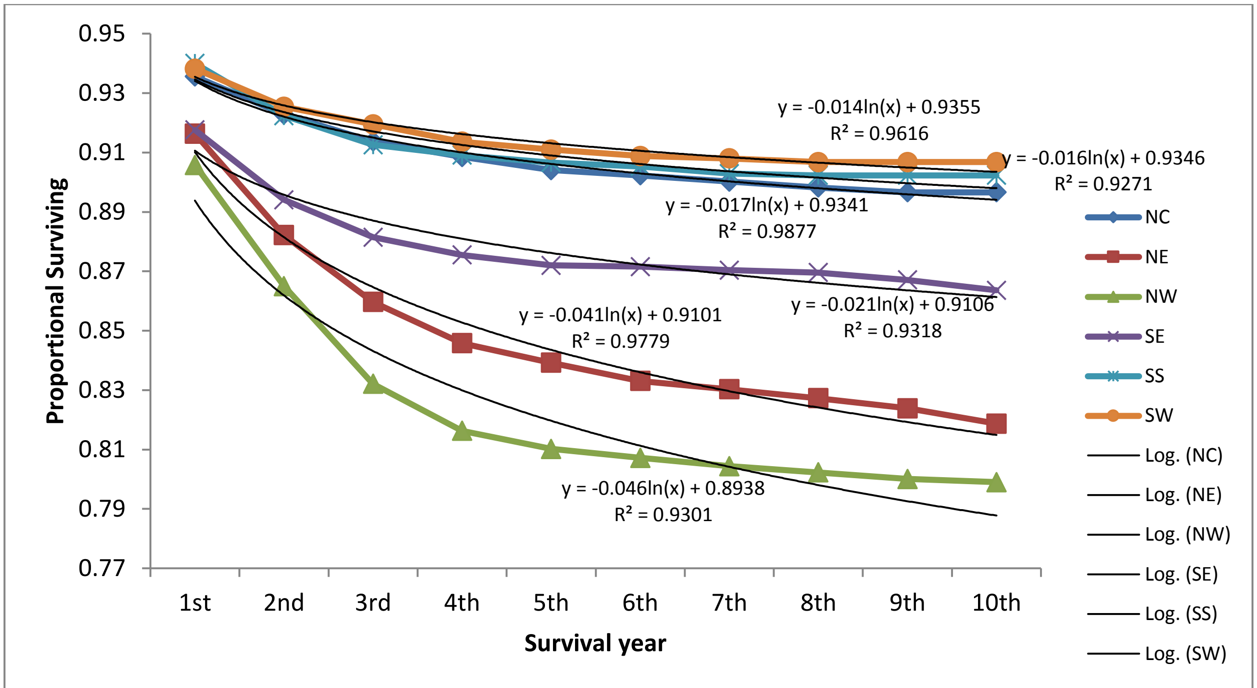

Figure 5. Surviving pattern of children in the first ten year of life by geo-political zones

Children whose mothers were teenagers had the lowest chance of survival than those from older mothers, ranging from 0.881 at exact age 1 to 0.781 at exact age 8 while 0.758 was the projected chance of survival beyond age 10 (Figure 6).

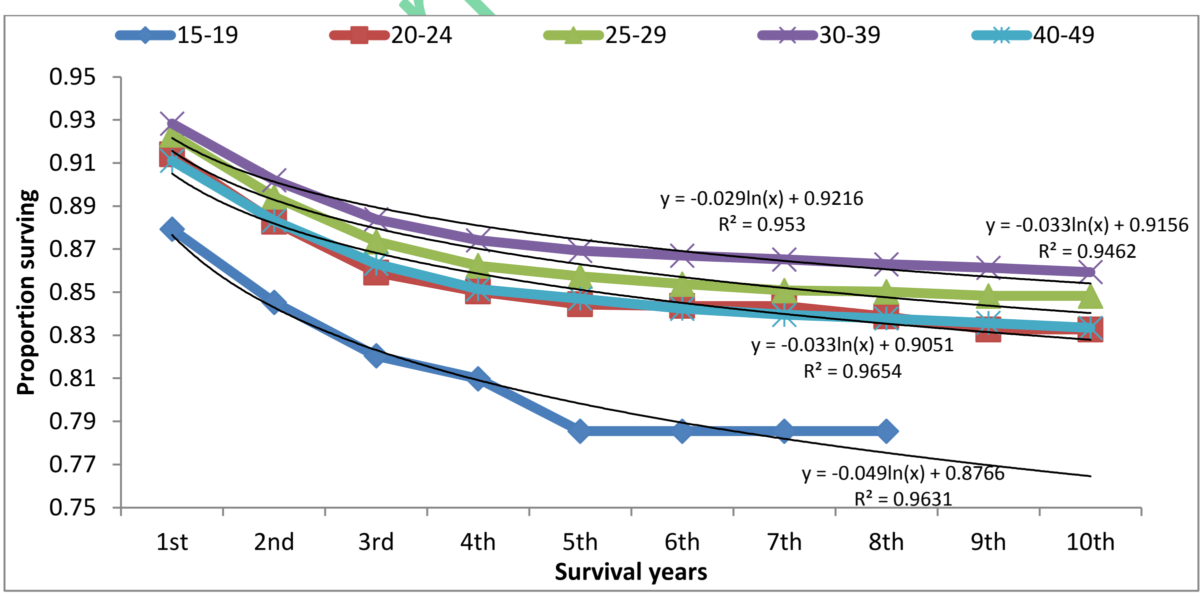

Figure 6. Surviving pattern of children in the first ten year of life by mother's age

Across wealth quintiles of children households, children survival was consistently lowest among children from lowest quintiles compared to those in the middle and highest quintiles with fitted survival curves y = -0.043ln(x) + 0.892; y = -0.028ln(x) + 0.9219 and y = -0.014ln(x) + 0.9377 respectively as shown in Figure 7.

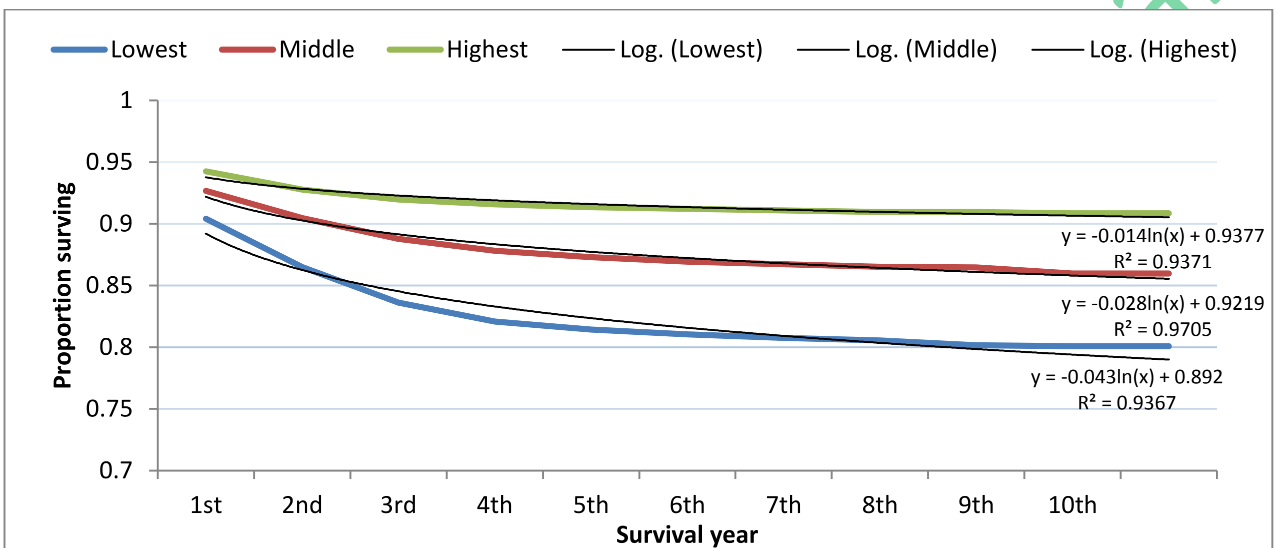

Figure 7. Surviving pattern of children in the first ten year of life by mother's wealth status

On the basis of mother's highest educational qualification, survival was lowest among children whose mothers had no formal education compared to those whose mothers had up to primary, secondary or tertiary education.

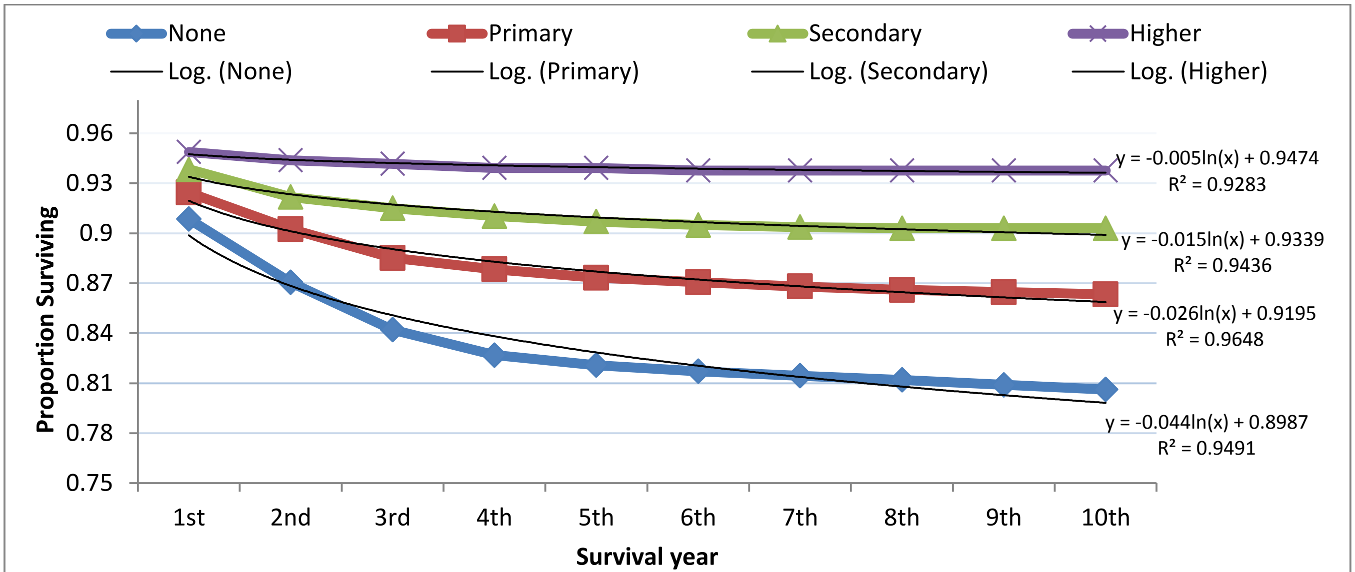

Figure 8. Surviving pattern of children by mother's education in the first ten year of life

Similarly, children of mothers who were widowed divorced or separated had lowest likelihood of surviving over the years compared with children whose mothers were either currently married or living with a sexual partner as shown in Figure 9.

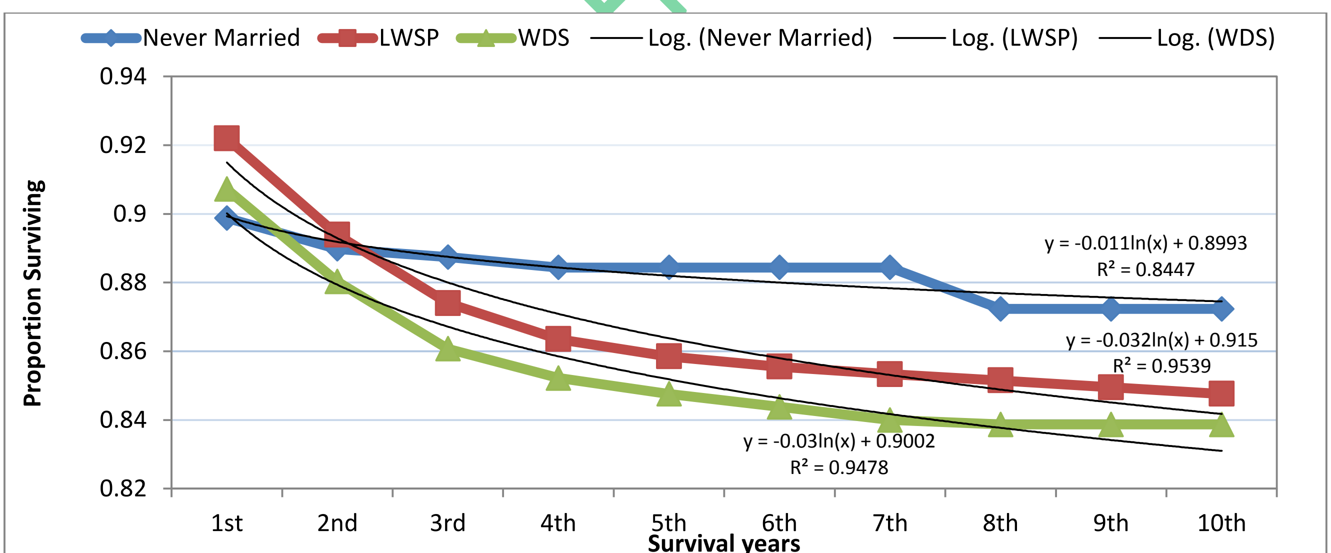

Figure 9. Surviving pattern of children in the first ten year of life by mother's marital status

Figure 10 shows the survivorship patterns of children by the main source of drinking water taken. Children who drank rain water had the highest chance of surviving, 0.941 at exact age 1 to 0.895 at exact age 10 compared with children who drank any of piped, well (either protected or not) or surface (stream, pond, river, spring etc) water with survivals ranging from 0.916 at exact age 1 to 0.840 at exact age 10.

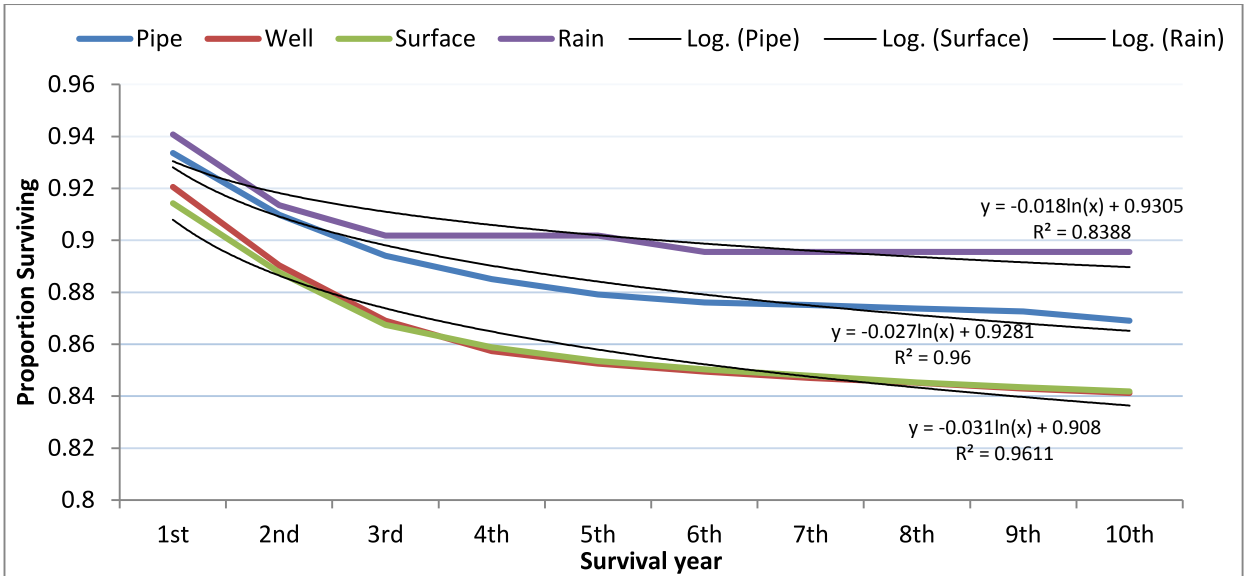

Figure 10. Surviving pattern of children in the first ten year of life by source of drinking water

Comparison with Brass indirect estimates

Table 3. comparison of estimates of probability of survival from Brass indirect and life table techniques

	Survivorship probability		
Age (yrs)	**Brass technique**	**Life Table**	**% difference**
1	0.9142	0.9212	0.8
2	0.8789	0.8933	1.6
3	0.8608	0.8736	1.5
5	0.8422	0.8583	1.9

Table 3 showed that estimates of probabilities of survival from age 1 to 5 agree very closely with those obtained from Brass indirect techniques. The percentage different ranged from 0.8% at age 1 to 1.9% at age 5 years.

Discussion

We found different degrees of variability in the survivorship pattern of the studied children across their socio-demographic characteristics. The fitted models further explained these variations. While 921 of every 1000 children will survive past their first birthdays only 858 and 848 will make 5th and 10th birthday respectively. This is very disturbing as it is far lower than the World's average. Huge regional variations were found in the survivorship patterns of the children. The highest survivorship estimates at exact age 1 were found in the South South zone, the South West had highest estimates at exact age 2 to 10, however, lowest survivorship estimates were found in the North West followed closely by the North East. It is very striking that fewer children would have died within first ten years of life in the South West than within 1st year of life in the North West zone.

The secondary nature of the data used for this study has limited the choice of our explanatory variable while been cross-sectional restrained us from establishing a causal relationship. Also the data might have suffered recall bias as there were no means of verifying the information provided by the respondents. However, the findings are valid as the survey instruments and personnel were pretested and validated for the large nationally representative data which consist of births from women of diverse background characteristics used in this study.

The wide rural-urban child survivorship differentials found in this study is similar to conclusions of others studies in many developing countries.[22] This is probably due to presence of better health facilities, trained health workers, better nutrition etc. As higher as children survivorship is in the urban areas compared with rural areas, many disadvantaged urban children would probably be worse off had their mothers been uneducated and remained in the lower wealth quintiles. Variability was also clearly observed in the survivorships of children in Nigeria across their household Wealth quintiles. Children in the higher wealth quintiles had the highest survival rates compared with children from the middle and lower wealth quintiles. This is at par with findings from a previous study on factors affecting differentials in infant mortality rates between South West and North East Nigerian.[23] The study had reported that "children from wealthiest homes in North East had lower infant mortality rates than children from wealthiest homes in the South West (37 vs 55) but wealth quintiles were not significant to infant mortality rates in the South West".

We found children survival to be consistently lower among male children than female children throughout the first ten years. This finding is at variance with an Egyptian study which reported higher mortality among female children.[11] The Egyptian study had associated the finding to poorer girls' nutritional status compared to boys' and also that breastfeeding period was shorter for girls. They had highlighted cultural evidences whereby parents unintentionally believe that boys are weaker and need more nurturing, and that social status and marital security for women was measured by bearing surviving sons. The lowest survivorship estimates were found among children whose mothers were teenagers. There were sharp decreases in this estimates compared with estimates from children from older mothers. Children of mothers aged 30-39 years had highest chances of survival across the years followed closely by those whose mothers were 20-29 years old.

Children survivorship differed along maternal educational attainments. Children of mothers with no formal education had the lowest chance of survival throughout the ten years as it fell consistently during the period. Compared to the nearly constant survivorship of children whose mothers had more than secondary education after the first three years, survivorship of children from other mothers fell throughout the ten years considered in this study. The associated advantages of mothers been educated cannot be exhausted. For instance, an educated mother would be more likely to be empowered, know importance as well as having better access to health facilities. These mothers are more likely to access and use both preventive and curative health services more than mothers with little or no education beside been able to administer drugs better. Our finding is similar to the reports in a previous study that maternal education and child survival are correlated.[17]

Children who were drinking piped/tap/borehole/bottled or rain water had higher survival rate than those who used well or surface water. This finding is consistent with findings of a Bangladesh study which found that Mothers who gave their children well water for drinking purposes reported 1.46 times more mortality rate than the mothers whose children were using piped water and that the rate increased for other sources of drinking water.[4] Children who drank surface or well water had the lowest chances of survival across the years considered in this study.

The close agreement of estimates of survival probabilities from our life table techniques with those from Brass indirect techniques attest to the robustness of the method. The indirect method is well known to provide plausible estimates of childhood mortality.[20] Even though, the indirect technique can provide estimates for ages 10, 15 and 20, however, beyond age 5, the method have the tendency to under-estimate survival due to a longer period of recall. The model proposed in this paper can thus help to overcome this weakness.

Study Implication

The findings of these study suggested poor survivorship and wide variation in children survivorship across different zones in Nigeria. This implied that efforts to combat children mortality in Nigeria should be geographical zone-specific rather than been treated as one cap fits all. There is need to improve environmental hygiene in most places and empower women as child survivorship is much higher among the better off women. Also, children from teen mothers and very old ones had lower chances of survival. This is a pointer that women should be encouraged to delay child birth till when they are mature both in mind and physically to nurture a child, although this should not be delayed for too long as evidenced in the findings. Overall, child health programmers should draw policies that will enable women to access and afford quality health care for their children. Identifying zonal-specific determinants of child survivorship in Nigeria is a gap for future studies.

Conclusion

Child survivorship is influenced by interrelated factors. The children constitute a large proportion of Nigeria population. These children are a vulnerable or special risk group, deserving special health care as the child mortality and morbidity risks are much higher at younger ages. Female education should be encouraged particularly in the rural areas since education gives mothers more decision making power and increase their knowledge about health services and health facilities for better survival of their children. Health programmes should give priority to hygiene and sanitation. Improving the household sanitation such as provision of portable water can help prevent diarrhea which is a renowned child killer in Africa. So, steps should be taken in this regard for a better survival of the children. Mass media promotion programme should be taken to understand morbidity in children and encourage treatments.

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