Modelling regional differentials in childhood and adult mortality in Nigeria

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Abstract

Context: Nigeria is one of the countries yet to undergo demographic transition in sub-Saharan Africa. This study provided estimates of childhood and Adult mortality across geopolitical zones in Nigeria.

Data Source and Method: The parameters used in this study were estimated from 2013 Nigeria Demographic and Health Survey. Child and adult mortality were estimated using Brass logit system and siblings survival method respectively and then linked using the logit life tables. Heligman pollard model was used to generate estimates of probability of death.

Findings: There were regional variations in the levels of infant and under-five mortality in Nigeria, mortality was highest in the North West and least in South West. Survivorship probabilities decreased as age increased. The age patterns of childhood and adult mortality were similar across all regions. Life expectancy from birth in Nigeria was 58 years.

Conclusion: The estimated mortality rates were high and varied across the regions in Nigeria. While government should not relent its efforts in childhood mortality reduction in Nigeria, more attention should be focused on children who live in the Northern part of Nigeria.

Keywords: Childhood mortality, Survivorship probability, Nigeria.

Introduction

Mortality remains an issue of public health concern. Going by the present demographic indices in Nigeria, it can be affirmed that Nigeria is at the onset of demographic transition with persistent high level of childhood and adult mortality and fertility. Study has revealed that half of under-five deaths in the globe occur in Nigeria and four other countries. After India (21%), Nigeria contributes 13% to under-five deaths globally (United Nations, 2014). In Nigeria, infant and under-five mortality have been estimated to be 69 deaths per1000 live births and 128 deaths per 1000 live births respectively (NPC & ICF Macro, 2014). Although, there has been disparity in the level of mortality across the geo-political zones (Aigbe and Zannu, 2012, Adedini et al, 2015), lack of accurate statistics and method surrounds the earlier estimates of mortality in Nigeria. The most reliable means of tracking number of deaths in any society is vital registration system (Verhulst, 2016) and such system is either not in existence or incomplete in many developing countries including Nigeria. Estimates of mortality often rely on hospital records and on few occasions, the accident records. Deaths that occur at homes are likely not to be reported and this leads to gross under-estimation of deaths in most developing countries.

Consequently, several methodologies have been devised to provide mortality estimates for countries with limited data and poor data quality. For childhood and adult mortality the Brass logit system, life table approach and other methods are being used. Among the studies previously conducted on infant and childhood mortality in Nigeria, literature is scarce on the use of Heligman Pollard model. The model is mathematically represented as $qx/px = A^{(x+B)^c} + De^{-E(\ln x - lnF)^2} + GH^x$ (Heligman and Pollard, 1980). The model consists of eight-parameter (A, B, C, D, E, F, G and H), that graduates a set of age-specific probabilities of dying from the standard set of five-year age groups into a set of single-year probabilities of dying which makes it suitable for mortality analysis and forecasting (Rogers and Gard, 1991). This model also has three components that reflect the age pattern of mortality in childhood, young adulthood and older ages (Booth and Tickle, 2008). Heligman Pollard model has been cited as the best existing demographic model for estimating mortality at all ages due to its strength of using several parameters (Sharrow et al, 2013). The Heligman Pollard model was one of the indirect methods used to provide childhood mortality estimate in this study. Heligman Pollard model has provided mortality estimates in some countries. In Australia, it was used to graduate post-war national mortality (Heligman and Pollard, 1980). In the United States, it was used to smooth combined death rates at ages 66 to 100 years, while preparing the 1999 to 2001 decennial life tables (Wei et al, 2008). In Malaysia, the model was used to estimate one year probability of dying from the five year probabilities given in the abridged life table (Ibrahim 2008). The Heligman pollard model was used by Ozeki in 2005, to fit eighteen Japan Life tables from 1891 to 2000 (Ozeki, 2005, in Jos, 2014). Emilidha and Danardono in 2017 used the Heligman-Pollard model to model hospital mortality data.

As for the adult mortality, siblings survival method was used (Moultrie, et al, 2013). The method described the relationship between the proportions of surviving siblings and life table probabilities of surviving from age 15 to adult ages. The method has been used to provide estimates of adult mortality in some countries with limited data and those where the vital registration system is not sufficient enough to produce direct estimate. The siblings survival method was used by Obermeyer et al, 2010 and Gakidou et al, 2006 to estimate adult mortality for different populations. Thereafter, a complete life table was fitted by linking the childhood and adult survivorship probabilities estimate using the Brass logit system as obtained in the literature (Lopez et al, NBS 2014).

In this study, the methods described above were used to provide childhood and adult mortality estimates across the six geopolitical zones in Nigeria. Different approaches have been used in the past to estimate childhood and adult mortality in Nigeria. For instance, Adebowale et al., 2010 estimated maternal mortality using sisterhood method from a nationally representative survey data. Ogunbiyi and Bamgboye in 2011 estimated adult mortality using Timaeus variant of Brass' Orphanhood method from single round cross sectional survey data. It is also worthwhile to note that the estimate of childhood and adult mortality often published by international agencies are not supported with the methodologies involved in generating the estimates which appears to be a strong limitation of their reliability. The current study has addressed this limitation through the provision of concise and detailed account of the methodology in order to facilitate replication of the method in other studies. Aside its high sense of accuracy, the approach used in the present study is still a grey area for research on child and adult mortality in Nigeria. The study also generated a complete life table with the estimates of life expectancy and survival probability provided for each of the six geo-political zones in Nigeria. The study outcomes will help the population planners in their quest for mortality statistics in Nigeria.

Method

Study area

According to the 2006 population and housing census, Nigerian's population is 140,431,790 (NPC & ICF Macro, 2009). Nigeria has 6 geo-political zones. Nigeria is a country with diverse religions, ethnic groups, ecology, believes and values. There are discrepancies in exposures and health outcomes in various regions of the country. The northern region is marked with low literacy level and poor standard of living. Several factors like poverty, lack of potable water supply, poor road networks, unstable electricity supply, poor access to modern health facility, lack of essential drugs at the public health facilities and lack of strong political support that have tendencies to contribute to high mortality are found in every parts of Nigeria. Early marriage and childbearing are more practiced in the north-west and north-east than other regions in Nigeria (Adedokun et al, 2016) and some regions are HIV prone than others. The feeding pattern is different across the region and almost homogenous within the region.

Data collection

The 2013 Nigeria Demographic and Health Survey was used in this study and it is the most recent of such surveys in Nigeria. The survey was designed to provide population and health indicators estimates at the national, zone and state levels. The sample was selected using a stratified three-stage cluster design consisting of 904 clusters, 372 in urban areas and 532 in rural areas. The rural-urban selection reflects the rural urban composition of Nigeria (NPC & ICF Macro, 2014). During the survey, all regular households were listed. The data contains information that are needed for the provision of childhood and adult mortality estimates using indirect method.

Data analysis

Childhood mortality estimation

The estimate of childhood mortality was derived by indirect method through the adoption of procedures in Manual X as adjusted in tool for demographic estimation (Moultrie et al., 2013; United Nations, 1983). Also the Heligman Pollard and life table approaches were used to provide childhood mortality estimates. The Heligman Pollard model has eight parameters. Parameter A represents the level of child mortality, B is the probability of dying between age 0 and 1, C measures the rate of mortality decline during childhood period. D represents the level of mortality hump, E is inversely related to the width of the mortality hump, F depicts the location of mortality hump on the age axis, Parameter G measures late life mortality and parameter H is the slope of Gompertz curve (Sharrow et al, 2013; Heligman and Pollard, 1980).

Adult mortality estimation

The method used data on survival of siblings as indicated in the tool for demographic estimation (Moultrie, et al, 2013). This method is known to be reliable for the estimation of adult mortality having known the survival probability to age 15 years. The model is expressed mathematically as; $l_x/(l_{15}=a(x)+b(x)S(x-5,5))$. Where S(x-5, 5) is the proportion of brothers (or sisters) who, having survived to age 15, are still alive among those reported by respondents aged (x-5,x). Thus, the adult mortality is estimated using the equation $l_n/(l_{15}=a(n)+b(n)\ 〖(_5^.)S〗_{(n-5)})$. Where l_n/l_{15} is the probability of survival to age n, given that the individual has survived to age 15; a(n) and b(n) are estimation coefficients (Timeus et al, 1997) and $〖(_5^.)S〗_{(n-5)}$ is the proportion of siblings who survived to their 15th birthday but were still alive at the time of interview.

Linking childhood and adult mortality estimates

The estimate of adult mortality provided using the previous method is in the form of conditional survivorship probability, but an unconditional probabilities is more preferred, since the later define a conventional life-table. Therefore, the adult survivorship was linked in the form l(x)/l(y), with childhood survivorship. The procedure would make possible the derivation of a complete life table and also incorporates smoothing the range of available survivorship estimates. In the two-parameter logit life-table system, any pair of survivorship probabilities, one from birth and another conditional on attaining a certain age, uniquely determine values of the parameters α and β defining the life table system. However, since one of the probabilities is conditional, the values of the parameters were estimated iteratively because algebraic approach is not plausible. The logit system which provides a convenient basis for such a procedure can be found in tool for demographic estimation (Moultrie et al.,2013). Other functions of the life table were derived from the estimated l_x^* (x) function by linking of child and adult mortality.

Ethical approval

This study is based on secondary analysis of an existing dataset. Ethical approval to conduct the study was received from the National Health Research Ethics Committee in the Federal Ministry of Health, Abuja, Nigeria, and from the Ethics Committee of the Opinion Research Corporation of Macro International Inc., Calverton, MD, USA. The inform consent was sought from the study participants and granted during the survey. Permission to use the data was obtained from ICF Macro Inc.

Results

Table 1 shows child mortality estimates for Nigeria. The Coale Demeny West Model Life table was used as the standard. Infant mortality (1q0) in Nigeria is 0.102, under-five mortality rate is 0.147. The probability of death obtained for Nigeria indicates high mortality at childhood ages. Tables 1 also show child mortality estimates for the six geopolitical zones in the country. There is disparity in infant mortality rate with the highest infant mortality rate of 0.126 in the North Western region and lowest infant mortality rate of 0.067 in South South region. The infant mortality rates of North Central, North East, South East and South West regions are 0.076, 0.106, 0.079 and 0.069 respectively. In all the regions, the probability of dying after infancy increased gradually with increase in age. Under-five mortality rates for the regions are 0.105, 0.156, 0.188, 0.114, 0.091 and 0.096 for North Central, North East, North West, South East, South South and South West regions respectively. Under-five mortality was highest in North West with mortality rate of 0.188 and lowest in South South with child mortality rate of 0.091. There is also disparity in under-five mortality level in the respective regions of the country.

Table 1: Child mortality estimates

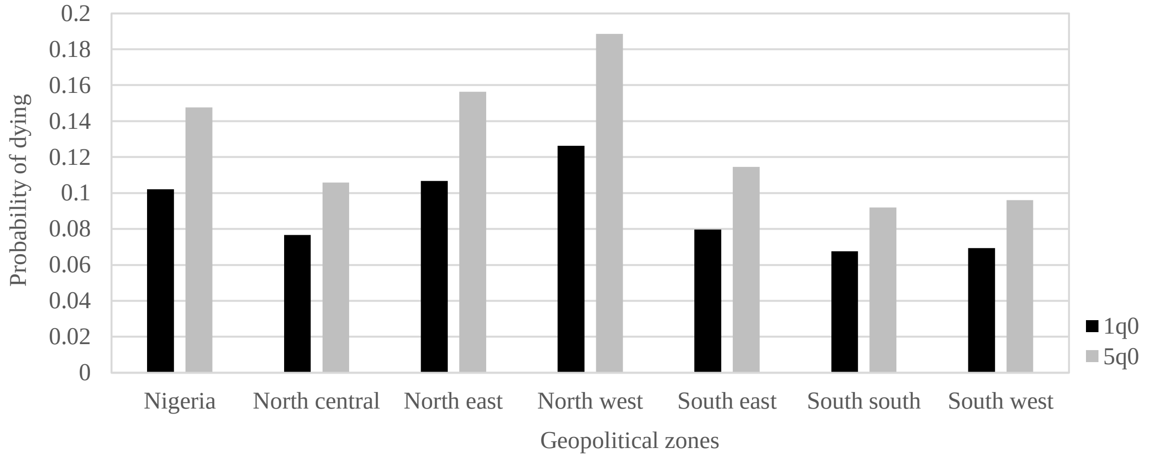
Age group	*Average parity*	*Di*	*Ki*	*qx*	*Lx*	*logit(lx)*	*logit(ls)*	*lx(ref)*	*q(x)ref*	*tx*
Nigeria:	Level =14.86; α = -0.0123									
15-19	0.2111	0.1230	1.0265	0.1262	0.8738	-0.9674	-1.0749	0.8979	0.1021	2012.3
20-24	1.2103	0.1159	1.0395	0.1205	0.8795	-0.9939	-0.9590	0.8746	0.1254	2011.0

25-29	2.5963	0.1380	1.0014	0.1382	0.8618	-0.9152	-0.9132	0.8642	0.1358	2009.1
30-34	3.9580	0.1487	1.0137	0.1508	0.8492	-0.8643	-0.8643	0.8524	0.1476	2007.0
35-39	5.2537	0.1620	1.0327	0.1673	0.8327	-0.8024	-0.8127	0.8389	0.1611	2004.6
40-44	5.9017	0.1837	1.0209	0.1876	0.8124	-0.7330	-0.7766	0.8289	0.1711	2001.9
45-49	6.7530	0.2296	1.0128	0.2326	0.7674	-0.5969	-0.7271	0.8144	0.1856	1999.0
North central: Level =17.62; α =0.0360										
15-19	0.1577	0.0934	1.1061	0.1033	0.8967	-1.0804	-1.2804	0.9233	0.0767	2012.4
20-24	1.1103	0.0924	1.0597	0.0979	0.9021	-1.1103	-1.1874	0.9091	0.0909	2011.2
25-29	2.4368	0.0964	1.0038	0.0967	0.9033	-1.1169	-1.1480	0.9024	0.0976	2009.3
30-34	3.8708	0.0981	1.0106	0.0992	0.9008	-1.1032	-1.1032	0.8942	0.1058	2007.0
35-39	4.9413	0.1037	1.0274	0.1065	0.8935	-1.0635	-1.0541	0.8845	0.1155	2004.5
40-44	5.5800	0.1201	1.0150	0.1219	0.8781	-0.9874	-1.0193	0.8772	0.1228	2001.7
45-49	6.1503	0.1448	1.0071	0.1459	0.8541	-0.8837	-0.9696	0.8661	0.1339	1998.8
North east: Level =14.0718, α =-0.0383										
15-19	0.3346	0.1482	0.9988	0.1481	0.8519	-0.8750	-1.0236	0.8932	0.1068	2012.2
20-24	1.6580	0.1191	1.0089	0.1202	0.8798	-0.9953	-0.9024	0.8678	0.1322	2010.8
25-29	3.1489	0.1509	0.9779	0.1476	0.8524	-0.8767	-0.8548	0.8565	0.1435	2008.8
30-34	4.6607	0.1678	0.9943	0.1668	0.8332	-0.8042	-0.8042	0.8436	0.1564	2006.4
35-39	6.1345	0.1958	1.0142	0.1986	0.8014	-0.6976	-0.7520	0.8293	0.1707	2003.8
40-44	6.9959	0.2165	1.0026	0.2170	0.7830	-0.6415	-0.7155	0.8187	0.1813	2001.1
45-49	7.1386	0.2665	0.9947	0.2651	0.7349	-0.5098	-0.6659	0.8035	0.1965	1998.2
North west: Level =12.6123; α =-0.0379										
15-19	0.3262	0.1275	0.9805	0.1250	0.8750	-0.9728	-0.9295	0.8738	0.1262	2012.2
20-24	1.6728	0.1405	1.0252	0.1441	0.8559	-0.8910	-0.7981	0.8418	0.1582	2010.9
25-29	3.4949	0.1777	0.9975	0.1773	0.8227	-0.7674	-0.7467	0.8277	0.1723	2009.0
30-34	4.9938	0.1978	1.0132	0.2004	0.7996	-0.6919	-0.6919	0.8115	0.1885	2006.9
35-39	6.6634	0.2199	1.0335	0.2272	0.7728	-0.6120	-0.6385	0.7946	0.2054	2004.5
40-44	6.9463	0.2574	1.0221	0.2630	0.7370	-0.5151	-0.6013	0.7822	0.2178	2002.0
45-49	8.2199	0.3042	1.0138	0.3084	0.6916	-0.4037	-0.5523	0.7650	0.2350	1999.1
South east: Level =15.7966; α =-0.0834										

15-19	0.0727	0.0923	1.0900	0.1006	0.8994	-1.0952	-1.1396	0.9203	0.0797	2012.3
20-24	0.6044	0.0868	1.0972	0.0952	0.9048	-1.1258	-1.0303	0.9027	0.0973	2011.3
25-29	1.6894	0.0887	1.0433	0.0926	0.9074	-1.1413	-0.9867	0.8947	0.1053	2009.8
30-34	3.1040	0.1265	1.0473	0.1325	0.8675	-0.9395	-0.9395	0.8855	0.1145	2008.0
35-39	4.1635	0.1221	1.0643	0.1300	0.8700	-0.9506	-0.8887	0.8748	0.1252	2005.9
40-44	5.1119	0.1395	1.0521	0.1468	0.8532	-0.8800	-0.8530	0.8668	0.1332	2003.4
45-49	6.2653	0.1902	1.0436	0.1985	0.8015	-0.6977	-0.8036	0.8549	0.1451	2000.4
South south: Level = 18.2613; α = 0.0244										
15-19	0.1259	0.0692	1.0594	0.0733	0.9267	-1.2682	-1.3369	0.9325	0.0675	2012.3
20-24	0.7639	0.0860	1.0424	0.0896	0.9104	-1.1591	-1.2506	0.9207	0.0793	2011.0
25-29	1.6088	0.0787	0.9972	0.0785	0.9215	-1.2314	-1.2130	0.9151	0.0849	2009.1
30-34	2.9943	0.0873	1.0077	0.0879	0.9121	-1.1696	-1.1696	0.9081	0.0919	2006.8
35-39	4.2164	0.1098	1.0259	0.1127	0.8873	-1.0319	-1.1212	0.8997	0.1003	2004.3
40-44	5.2603	0.1044	1.0138	0.1058	0.8942	-1.0672	-1.0867	0.8933	0.1067	2001.6
45-49	5.5498	0.1174	1.0059	0.1181	0.8819	-1.0054	-1.0368	0.8834	0.1166	1998.7
South west: Level = 17.6116; -0.0177										
15-19	0.0732	0.1098	1.1549	0.1268	0.8732	-0.9650	-1.2802	0.9306	0.0694	2012.5
20-24	0.7248	0.0679	1.1033	0.0749	0.9251	-1.2572	-1.1872	0.9176	0.0824	2011.4
25-29	1.9369	0.0911	1.0352	0.0943	0.9057	-1.1310	-1.1478	0.9114	0.0886	2009.8
30-34	2.9545	0.0958	1.0358	0.0992	0.9008	-1.1030	-1.1030	0.9039	0.0961	2007.7
35-39	3.9261	0.0934	1.0510	0.0982	0.9018	-1.1087	-1.0539	0.8950	0.1050	2005.4
40-44	4.5870	0.1215	1.0383	0.1262	0.8738	-0.9675	-1.0191	0.8883	0.1117	2002.8
45-49	5.0632	0.1347	1.0302	0.1387	0.8613	-0.9130	-0.9694	0.8781	0.1219	1999.8

Figure 1 shows the comparison of infant mortality rates among the six geopolitical zones, infant mortality rate varied among the zone with North West having the highest infant mortality rate of 0.126. South South had the lowest infant mortality rate of 0.067. Infant mortality rate in North central is 0.076, 0.106 in the North east, 0.079 in South East region and 0.069 in the South West.

Figure 1: Comparison of infant and under-five mortality estimates in the six geopolitical zones using Life table approach



Adult mortality rate estimate

Table 2 shows the adult mortality estimates for Nigeria derived from information on Siblings provided by respondents aged 15-49 years. The Coale Demeny West Model Life table was used as the standard. The column 2 of the table (proportion of siblings still alive) reduced as age increased. The 4th column which estimates the survivorship between exact age 15years and 15+n, also showed a downward trend. The probability of dying for Nigeria showed a trend reduction as age increases from 25 to 50. For Nigeria, The probability of a 15 year old person dying before age 40 (25q15) was 0.084 and the probability of a 15 year old person dying before reaching age 45 (30q15) was 0.0693.

The adult mortality index that is the probability of a 15 year old person dying before age 50 (35q15) was 0.0611, the probability of a 15 year old person dying before reaching age 55 (40q15) was 0.0593, the probability of a 15 year old person dying before reaching age 60 (45q15) was 0.0517 and probability of a 15 year old person dying before reaching age 65 (50q15) was 0.0528.

Tables 2 also show the adult mortality estimates for North Central, North East and North West Nigeria (the Northern geopolitical zones). The probability of a 15 year old person dying before age 40 (25q15) among the Northern zones are 0.081, 0.119 and 0.068 for North Central, North East, North West zones respectively, it is highest in North East (0.119) and lowest in North West (0.068). The probability of a 15 year old person dying before reaching age 45 (30q15) was 0.053, 0.099 and 0.059 for the respective zones.

The adult mortality index that is the probability of a 15 year old person dying before age 50 (35q15) was 0.0605, 0.085 and 0.0507 in North Central, North East, North West zones respectively. The probability of a 15 year old person dying before reaching age 55 (40q15) was 0.055, 0.075 and 0.048 in North Central, North East, North West zones respectively, the probability of a 15 year old person dying before reaching age 60 (45q15) was 0.053, 0.073 and 0.039 for North Central, North East, North West zones respectively. The probability of dying is highest in the North East (0.073) and lowest in North West (0.039). Probability of a 15 year old person dying before reaching age 65 (50q15) are 0.050, 0.066, 0.048, for North Central, North East, North West, regions respectively. In all the Northern regions of the country, the proportion of siblings still alive decreased as age increased.

The probability of a 15 year old person dying before age 40 (25q15) among the Southern zones (South East, South South and South West regions respectively) are 0.090, 0.083 and 0.069 for South East, South South and South West regions respectively, it is highest in South East (0.090) and lowest in South West zone (0.069). The probability of a 15 year old person dying before reaching age 45 (30q15) in the 3 zones are 0.078, 0.076 and 0.0568.

The adult mortality index that is the probability of a 15 year old person dying before age 50 (35q15) are 0.069, 0.055 and 0.057 in South East, South South and South West regions respectively. The probability of a 15 year old person dying before reaching age 55 (40q15) was 0.060, 0.074 and 0.0513 in South East, South South and South West regions respectively, the probability of a 15 year old person dying before reaching age 60 (45q15) was 0.055, 0.056 and 0.0471 for the respective zones and the probability of a 15 year old person dying before reaching age 65 (50q15) are 0.068, 0.051 and 0.0433 for South East, South South and South West regions respectively. In all the Southern regions of the country, the proportion of siblings still alive decreased as age increased.

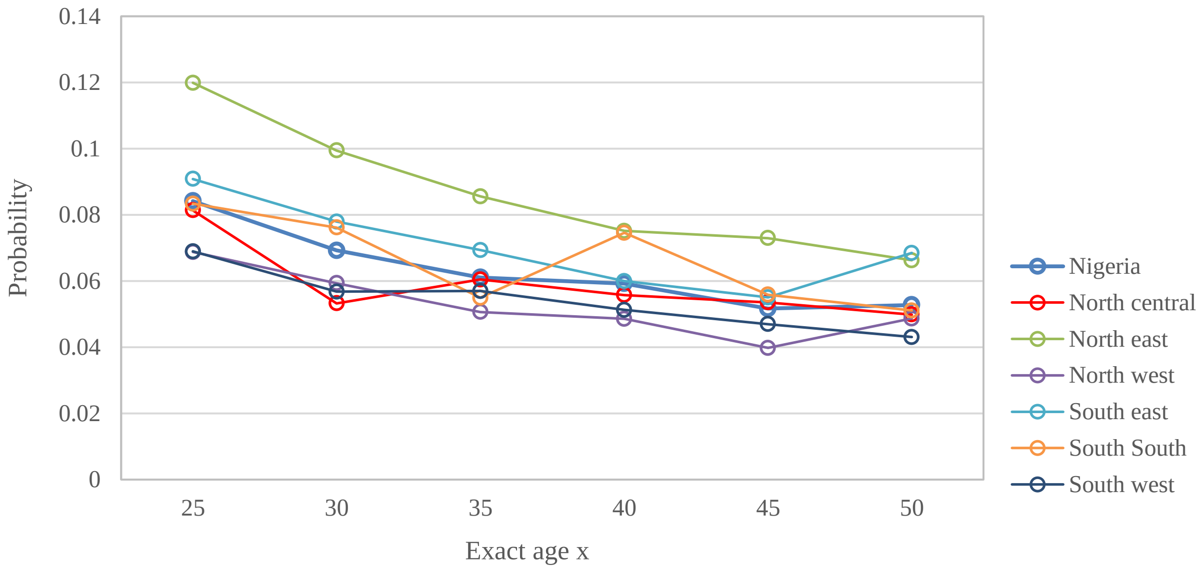
Table 2: Adult mortality estimates

Age group	Proportion still alive	N	$l_{(n)}/l_{(15)}$	$l_s(n)$	$l_s(15)$	logit(ls)	$\lambda_s(15)$	${}_xq_{15}$
Nigeria								
15-19	0.9788							
20-24	0.9729	25	0.9736	0.7909	0.8253	-0.6652	-0.7764	0.0842
25-29	0.9683	30	0.9647	0.7695	0.8253	-0.6028	-0.7764	0.0693
30-34	0.9603	35	0.9551	0.7459	0.8253	-0.5383	-0.7764	0.0611
35-39	0.9464	40	0.9407	0.7191	0.8253	-0.4699	-0.7764	0.0593
40-44	0.9361	45	0.9314	0.6880	0.8253	-0.3953	-0.7764	0.0517
45-49	0.9127	50	0.9082	0.6510	0.8253	-0.3117	-0.7764	0.0528
North central								
15-19	0.9787							
20-24	0.9736	25	0.9744	0.8659	0.8898	-0.9326	-1.0445	0.0814
25-29	0.9755	30	0.9730	0.8509	0.8898	-0.8708	-1.0445	0.0533
30-34	0.9607	35	0.9557	0.8340	0.8898	-0.8070	-1.0445	0.0605
35-39	0.9495	40	0.9442	0.8140	0.8898	-0.7383	-1.0445	0.0558
40-44	0.9333	45	0.9283	0.7894	0.8898	-0.6608	-1.0445	0.0536
45-49	0.9148	50	0.9105	0.7577	0.8898	-0.5700	-1.0445	0.0499
North east								
15-19	0.9666							
20-24	0.9606	25	0.9613	0.7909	0.8253	-0.6652	-0.7764	0.1199
25-29	0.9543	30	0.9485	0.7695	0.8253	-0.6028	-0.7764	0.0995
30-34	0.9445	35	0.9367	0.7459	0.8253	-0.5383	-0.7764	0.0856
35-39	0.9325	40	0.9247	0.7191	0.8253	-0.4700	-0.7764	0.0752
40-44	0.9114	45	0.9038	0.6880	0.8253	-0.3953	-0.7764	0.0730
45-49	0.8926	50	0.8859	0.6510	0.8253	-0.3117	-0.7764	0.0663
North west								
15-19	0.9815							
20-24	0.9781	25	0.9789	0.7350	0.7756	-0.5101	-0.6202	0.0688

25-29	0.9730	30	0.9701	0.7101	0.7756	-0.4479	-0.6202	0.0594
30-34	0.9670	35	0.9630	0.6826	0.7756	-0.3829	-0.6202	0.0507
35-39	0.9558	40	0.9514	0.6521	0.7756	-0.3142	-0.6202	0.0486
40-44	0.9500	45	0.9470	0.6177	0.7756	-0.2400	-0.6202	0.0398
45-49	0.9196	50	0.9158	0.5787	0.7756	-0.1587	-0.6202	0.0487
South east								
15-19	0.9781							
20-24	0.9705	25	0.9713	0.8168	0.8477	-0.7473	-0.8585	0.0909
25-29	0.9643	30	0.9601	0.7975	0.8477	-0.6852	-0.8585	0.0780
30-34	0.9550	35	0.9490	0.7760	0.8477	-0.6211	-0.8585	0.0694
35-39	0.9459	40	0.9400	0.7513	0.8477	-0.5528	-0.8585	0.0600
40-44	0.9319	45	0.9268	0.7221	0.8477	-0.4776	-0.8585	0.0551
45-49	0.8886	50	0.8815	0.6866	0.8477	-0.3922	-0.8585	0.0685
South South								
15-19	0.9818							
20-24	0.9729	25	0.9737	0.8892	0.9096	-1.0412	-1.1543	0.0834
25-29	0.9651	30	0.9611	0.8763	0.9096	-0.9791	-1.1543	0.0762
30-34	0.9643	35	0.9599	0.8618	0.9096	-0.9152	-1.1543	0.0550
35-39	0.9330	40	0.9254	0.8444	0.9096	-0.8457	-1.1543	0.0746
40-44	0.9301	45	0.9247	0.8223	0.9096	-0.7661	-1.1543	0.0559
45-49	0.9115	50	0.9069	0.7929	0.9096	-0.6711	-1.1543	0.0511
South west								
15-19	0.9829							
20-24	0.9777	25	0.9785	0.8659	0.8898	-0.9326	-1.0445	0.0690
25-29	0.9739	30	0.9712	0.8509	0.8898	-0.8708	-1.0445	0.0568
30-34	0.9630	35	0.9584	0.8340	0.8898	-0.8070	-1.0445	0.0570
35-39	0.9535	40	0.9487	0.8140	0.8898	-0.7383	-1.0445	0.0513
40-44	0.9410	45	0.9369	0.7894	0.8898	-0.6608	-1.0445	0.0470
45-49	0.9253	50	0.9222	0.7577	0.8898	-0.5700	-1.0445	0.0431

Figure 2 shows comparison of Adult mortality estimates obtained for the six geopolitical zones, probability of dying was highest in North east (0.119), followed by the South East region(0.090). Adult mortality rate was lowest in North West region with a mortality rate of 0.068. The Adult mortality estimates obtained for North Central was 0.081, 0.083 in South South and 0.069 in South west.

Figure 2: Comparison of probability of dying from age 15 to age x across the six geopolitical zones



Life table estimation based on Linking of child and adult mortality

Life table estimates for Nigeria were derived by estimates from linking of Childhood and Adult mortality using the Coale Demeny West Model Life table as the standard. It summarizes the mortality experience at all ages with particular reference to age 20, 50 and 65 respectively. The survivorship functions (lx) show the number of persons alive at above reference ages are 83112.57, 70852.11 and 56099.29 which means 83.112%, 70.852% and 56.099% live to age 20, 50 and 65 respectively and 1525, 3679 and 8230 died prior to age 25, 55 and 70 respectively, probability of dying (qx) for those ages are 0.018, 0.0519 and 0.146 respectively with expectation of life at 49.22, 24.8 and 14.09 years respectively. The expectation of life from birth in Nigeria was 58 years.

Figure 3: Life table estimates for lx

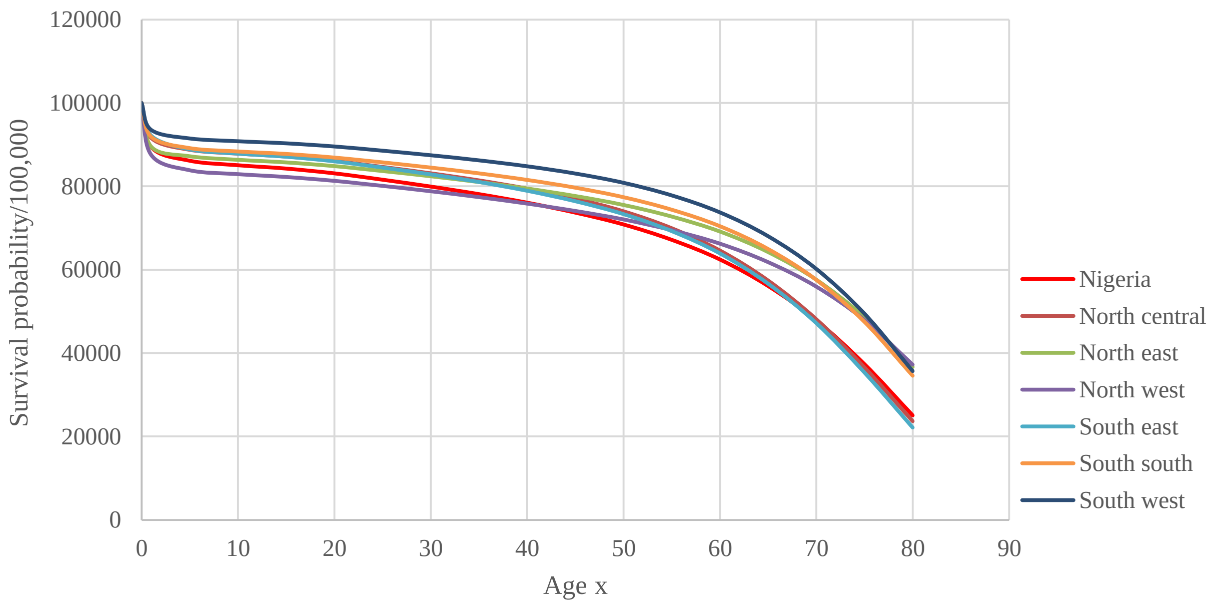
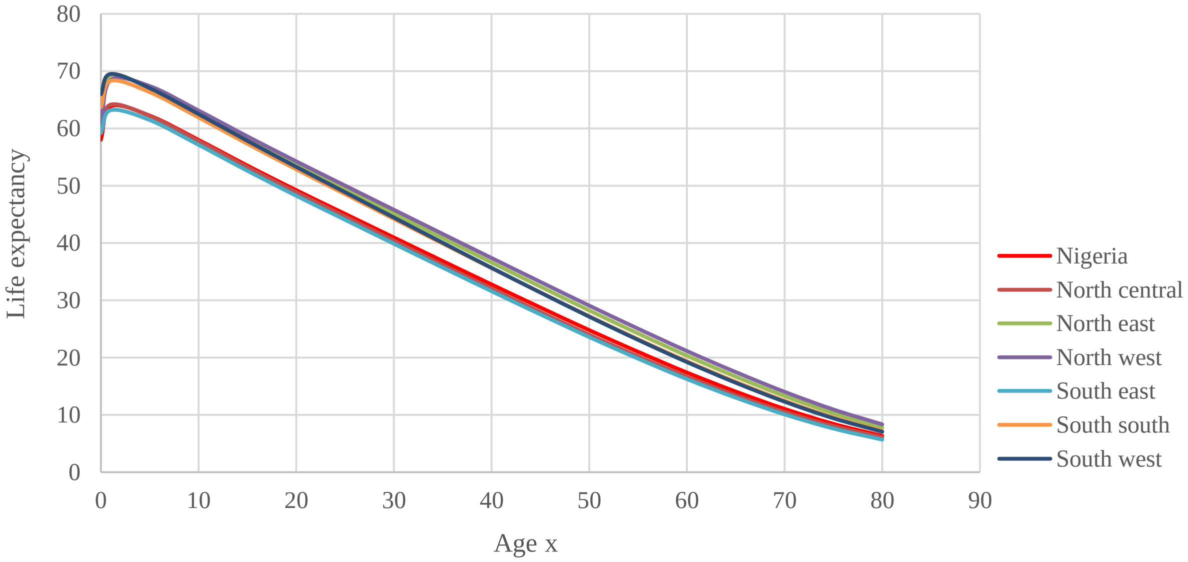


Figure 4: Life table estimates for ex



Estimation of probability of death at childhood using the Heligman Pollard Model

Table 3 shows estimates of child mortality obtained using the Heligman Pollard Model for Nigeria and the six geopolitical zones. The Heligman Pollard Model showed infant mortality rate of 0.092 and under-five mortality rate of 0.102 for Nigeria. The infant and under-five mortality estimates for Nigeria indicates a high level of childhood mortality in the country. The Heligman Pollard Model showed infant mortality rate of 0.075, 0.089 and 0.106 for North Central, North East and North West zones respectively. Infant mortality rate is highest in North Western Nigeria with an infant mortality rate of 0.106 and lowest in North central Nigeria with an infant mortality rate of 0.075. The infant mortality estimates for Northern Nigeria indicate a high prevalence of infant mortality in these regions. The under-five mortality rates given by the model in the regions are 0.081, 0.098 and 0.120 for North Central, North East and North West regions respectively.

The Heligman Pollard Model showed infant mortality rates of 0.072, 0.072 and 0.058 for South East, South South and South West regions respectively. South West has the lowest infant mortality rate in the Southern region of the country. The under-five mortality estimates given by the model in the regions are 0.077, 0.078 and 0.062 for South East, South South and South West regions of Nigeria respectively.

Table 3: Infant probability of dying

Region	Infant					Under-five				
	Parameters					*Parameters*				
	q(x,n)	A	B	C	$_1q_0$	q(x,n)	A	B	C	$_5q_0$
Nigeria	0.106	0.105	0.070	0.990	0.092	0.138	0.105	0.070	0.990	0.102
North Central	0.083	0.083	0.050	0.990	0.075	0.112	0.083	0.050	0.990	0.081
North East	0.105	0.105	0.080	0.990	0.089	0.127	0.105	0.080	0.990	0.098
North West	0.125	0.124	0.080	0.992	0.106	0.161	0.124	0.080	0.992	0.120
South East	0.079	0.078	0.043	0.991	0.072	0.111	0.078	0.043	0.991	0.077
South South	0.081	0.081	0.052	0.993	0.072	0.108	0.081	0.052	0.993	0.078
South West	0.065	0.064	0.043	0.995	0.058	0.085	0.064	0.043	0.995	0.062

Figure 5:

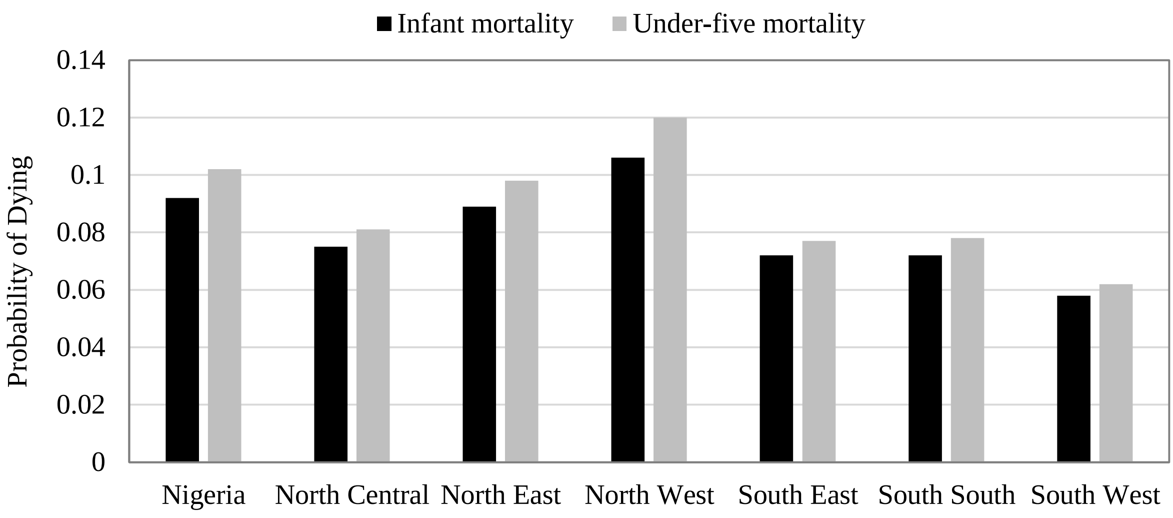


Figure 6 compares the relationship between infant mortality estimates obtained from Brass method, Life table method, Heligman Pollard model and NDHS report across the six geopolitical zones. Infant mortality estimates obtained from Brass method was higher than estimates obtained from the other methods. North West region had the highest infant mortality rates from all the methods examined. Infant mortality rate was lowest in South South from NDHS and Brass methods and lowest in South West from the Life table method and Heligman Pollard model.

Figure 7 shows the comparison of under-five mortality estimates obtained from Brass method, Life table method, Heligman Pollard model and NDHS report across the six geopolitical zones. Under-five mortality estimates obtained from Brass method was higher than estimates obtained from the other methods in most regions. North West region had the highest under-five mortality rates from all the methods examined. Under-five mortality rate was lowest in South South from Brass methods and lowest in South West from the Life table method and Heligman Pollard model.

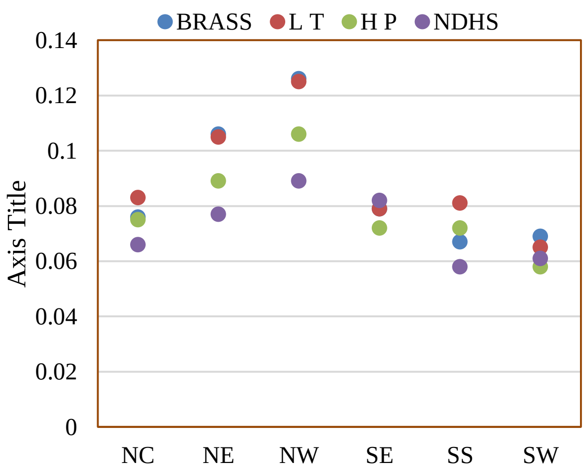


Figure 6:
Comparison of infant mortality estimates from Brass, Life table, Heligman Pollard model and NDHS across the six geopolitical zones

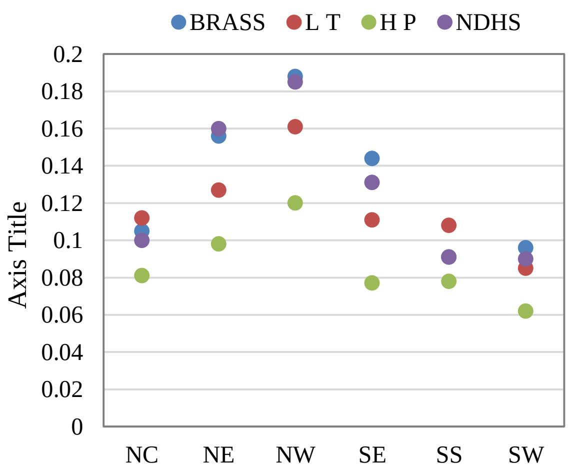


Figure 7:
Comparison of under-five mortality estimates from Brass, Life table, Heligman Pollard and NDHS across the six geopolitical zones

Discussion

The study revealed variations in infant and under-five mortality rates among regions in the country and this was in agreement with the findings of the study by Adedini et al, 2015 on the regional variations in infant and child mortality in Nigeria. Infant and under-five mortality rates were highest in the North western region and lowest in South Western region. Generally the Northern regions were at higher risk of infant and under-five mortality among all regions examined. This could be attributed to poor socioeconomic status and poor community level characteristics in these areas (Adedini et al, 2015).

They were also variations in expectation of life across the regions, life expectancy from birth (e^0) was highest in South West and lowest in North Central, the probabilities of surviving from birth was highest in South West and lowest in North west while probability of dying (qx) was higher in the North than the Southern regions. The mortality table functions showed higher mortality levels and lower survival rates in the North than the Southern regions. The study also revealed that the probability of surviving slightly increases after infancy till age ten and then drops gradually as age increases till the end of the life table and same trend applies to expectation of life.

The Heligman Pollard model was considered because recent studies with the model in other populations have shown that it is the best existing demographic model for estimating mortality at all ages (Ibrahim 2008, Sharrow et al, 2013) Furthermore, the model possess parameters which have demographic interpretation (Heligman and Pollard 1980, Rogers and Gard 1991). In estimating mortality rates using the Heligman pollard model, mortality estimates were first obtained using Brass method, Siblings method and Life table methods. Although the Brass and Life table methods yielded plausible results, the estimates obtained were different from estimates obtained using the Heligman Pollard model. The mortality estimates obtained using the Heligman pollard model was also different from the estimates obtained from the Demographic and health survey of 2013. Infant and under-five mortality given by the Heligman Pollard model was highest in North West and lowest in South West region.

The Brass estimates of child mortality showed that Nigeria has high infant and child mortality rates proved by the high probability of death prevalent in most zones. These high mortality rates were also present in all the methods applied and are in agreement with the study by Adebowale et al, 2017 on Predictors of under-five mortality in Nigeria. The study also found a similarity in the age pattern of mortality among the methods used. In most of the zones examined; the probability of dying decreased after the first year of life and survival rates fall noticeably as age increases. In the adult mortality estimation, the proportion of siblings still alive and proportion that survived to age 15 who are still alive at age n decreased with increase in age. Furthermore, the estimated survival probabilities derived from estimates of under-five mortality rates were approximately similar to the life table survivorship probabilities. The probability of dying at infancy is lower in the National Demographic and Health Survey report than in the methods of estimation examined.

In all zones, most children were exposed to high mortality rates through the childhood ages. The Heligman Pollard model shows estimates that varies with the Brass model of child mortality estimation, mortality estimates of Brass method was higher than the Heligman Pollard model estimates. Recent studies on childhood mortality modeling using the Heligman Pollard model that used Health Survey data showed that there was vivid increase in child mortality but that was attributed to high prevalence of HIV (Sharrow et al. 2013). Also from recent studies and reports on the Heligman Pollard model, the model provides more reliable estimates of the risk of death in the study populations. Thus, results of this study have shown that the Heligman Pollard model is efficient when used with secondary data and it provides accurate estimates of mortality at early life.

Limitations and strengths of the study

The reporting of under-five mortality by women may include omission of few deaths since child deaths are seen as bad events that they do not want to remember. Inability of the respondents to report deaths correctly may lead to response and recall bias since the records of death are based on reports given by sampled respondents. These biases may affect the true level and pattern of mortality in the population. Also misclassification of and infant deaths and stillbirths is also possible, particularly in settings where misclassification was purposeful in order to avoid death registration. Due to security challenges, some clusters in the Northern part of Nigeria were omitted during the 2013 demographic and health survey. These factors outlined could collectively distort the true pattern of mortality in recent times in the population under study. But this study utilizes indirect techniques of demographic estimation which minimize such errors.

A major strength of this study is that it utilizes a nationally representative dataset which accounts for sampling design effects (the study samples were effectively selected from the larger population). This study derived life tables for Nigeria and its geopolitical zone and presents the true infant mortality situation in the country, an indices useful for efficient planning of health and development to improve general wellbeing of the citizens of the country particularly the vulnerable population.

Conclusion

It was discovered that the estimated probabilities of death obtained in the study follow the general age pattern of mortality. Thus, probabilities of dying initially fall swiftly as age increases; but increases again with further increase in age. At older ages, the probabilities of dying increases again but now more progressively, indicating higher mortality levels at older ages. However, both child and adult mortality estimates are needed to estimate a good survival function and life tables and a plausible survivorship probability can be derived by linking estimates of childhood and adult mortality. Under-five mortality rate was also found to be higher in the Northern regions compare to the Southern regions. The Nigeria demographic and health survey yielded lower under-five mortality estimates than the Heligman Pollard model. Thus, it can be concluded that methodology adopted by the health surveys, as good as it may be, still under-estimates mortality rates in the population. Due to the high level of child mortality obtained in this study, programmes that target the alleviation of child mortality in Nigeria should be improved. Although the Heligman Pollard model provided higher estimates of childhood mortality than previous models used in Nigeria, the use is however recommended because of its high credibility reported by previous users.

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