Survival Analysis of Under-Five Child Mortality and Its Associated Risk Factors in Northern Nigeria

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***Abstract*:- National developmental indices in Nigeria make for a bleak reading; paramount among this is the high prevailing under-5 child mortality rates which as a continuum, is a major public health challenge. The polarization of childhood health outcomes across regions still persist, this reality is being exacerbated by social and economic inequalities. We attempt to investigate the impact of individual-level and community-level risk predictors associated with child survival in the Northern region of Nigeria. A population-based cross-sectional study design was employed to investigate under-five child risk factors, using data from the Nigerian Demographic and Health Survey (2013); Analysis was done using inferential statistics, and multi-level survival model. This study utilized an excellent predictive model which revealed that the likelihood of under-5 mortality in Northern Nigeria had an inverse relationship with the level of maternal education. After adjustment for individual-level and community-level predictors, most of the regional disparity in under-5 mortality was explained by differences in place of residence, population density and malaria prevalence. In the light of the findings, we posit that the realities of left behind children is endemic in Northern Nigeria and thus both individual-level and community-level based interventions should be effected in a bid to drastically elevate under-five child survival odds in this region. This paper extends on the literature of child mortality in Nigeria, by investigating the impact of individual-level and community-level risk predictors associated with child survival in Northern Nigeria.**

Keywords: **Community-level Predictors; Cox proportional-hazard; Child mortality;Hazard ratio; Northern Nigeria**

I. INTRODUCTION

Mortality among under-5 children de-accelerated in most developing countries from the mid-1980s and throughout the early part of the 21st century. However, this decline has recently slowed, stopped, or reversed itself among a growing list of countries within sub-Saharan Africa (Rustein, 2000; UNICEF, 2017). It is estimated that around 5.6 million children die before their fifth birth, mostly due to preventable causes and treatable disease such as pneumonia, diarrhea and malaria, even though the knowledge and technologies for life-saving interventions are available (UN IGME, 2017; UNICEF, 2017).

Under-5 mortality rate in Nigeria is still high despite the recent gains in the past decade.

The mortality rate has reduced from 157/1000 deaths in 2008 to 128/1000 deaths in 2013 (NPC&ICF, 2014). This implies that one in every eight Nigerian under-5 child die before their fifth (5th) birthday. Under-five mortality rates are higher in rural areas (167 deaths per 1,000 live births) in comparison with urban areas (100 deaths per 1,000 live births).Nigeria is riddled with high child mortality conundrum and thus is rightly classified as a fragile country in terms of early childhood survival outcomes; Nigeria is rated second only to India globally in this respect (UNICEF, 2017).

Past studies classified the predictors of child survival as, socio-demographic, economic and environmental risk (Caldwell, 1979; Bicego & Boerma, 1993; Akinyemi et al., 2013). The significant relationship that exist between the household environment and child survival was assessed by Rutstein(2000), Racioppi (2002) Murray *et al*(2007), Fayehun(2010) and Rutstein *et al* (2016). Rural residents experience greater child mortality in comparison with their urban counterparts (Alao and Adegbola, 1985; Sastry, 2004; Mishra & Retherford, 2007) and women with shorter birth intervals endanger their children's lives (Curtis et al, 1993; Zenger, 1993; Currie, 2000; Akinyemi et al, 2013). Rutstein (2000), Westoff (2003) and Mahy (2003) all outlined a comprehensive breakdown of key determinants as nutritional status, fertility behavior, nuptial trends, access to health service by child or mother, environmental factors and socio-economic realities. Sastry (1996), Antai & Moradi (2010a), Antai (2011b), Adekanmbi *et al*., (2011) and Adedini *et al*., (2015) examined the impact of place of residence and how it influences survival odds of under-5 children;it was also revealed that living in a socially and economically disadvantaged community negatively impacts on child survival odds (Antai & Moradi, 2010b; Aremu*et al*., 2011; Adedini *et al*., 2012).

Nigeria lags behind in terms of reduction of its national under-5 child mortality rate; this is exacerbated by inherent inequities such as, unbalanced distribution of health intervention and widespread poverty (Olaniyan & Lawanson, 2010; Adedini et al, 2012; Obansa & Orimisan, 2013; FMOH, 2013b; Chimezie, 2015). Regional inequalities and inequity still persist in Nigeria, especially in the Northern region where National health policy failures are more pronounced, evidence from the 2013 National Demographic and Health Survey (NDHS) report indicates that under-5 child mortality is highest in the North-western region of Nigeria (See Fig 1).

This scourge has always been an obstacle to the attainment of targeted [1]National millennium development goal (goal 1&4). Thus, the socio- economic realities for millions of households and their under-5 children in Nigeria can only be described as a crisis. Factors such as, low level of maternal education, unsafe drinking water and sanitation, low family income, birth interval, short breast feeding time, lack of place of birth delivery and wide spread poverty continues to put children at risk (Adedini et al.,2012; Riman&Akpan,2012).

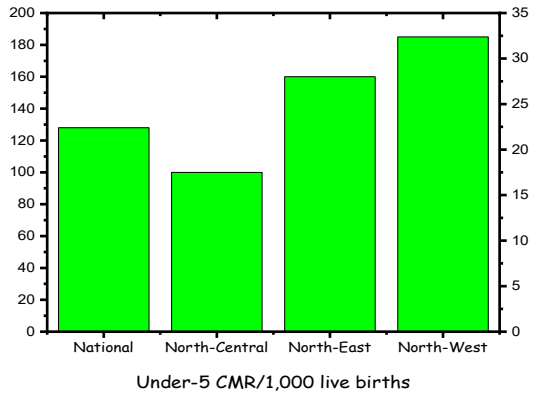

Figure 1: Under-5 Child Mortality Rate in Nigeria (2008-2013)

Source: Computed from NPC and ICF International (2014)

Moreover, the prevailing problem of "Children Left Behind" in Nigeria still persist, these flagged areas where exist macro-level child deprivation (see in Figure 1) persist. We investigate the Northern region of Nigeria where this children's plight is endemic. Northern Nigeria scores poorly in every child health indices and metrics in comparison with Southern Nigeria (NPC&ICF,2004;2009; 2014; FGN, 2016).

In spite of the numerous early childhoods mortality-based studies conducted in third world countries in contemporary times, there still exists paucity of information on comparison of under-5 child mortality inequalities across intra-zonal comparison to the best of our knowledge. In Nigeria limited studies have investigated intra-zonal early childhood health differential, for instance studies conducted by Shettima (2008), Doctor et al (2011) and Fagbamigbe & Alabi (2014) all focused on indirect estimation of infant and child mortality levels. Meanwhile, while many other studies have also been conducted on under-five mortality in Nigeria, these studies focused lesson the influences of contextual factors on child survival odds. As aforementioned, several studies e.g. (Adetunji, 1995; Akinbami, et al., 2010; Fayehun, 2010).Previous studies were based on individual-level characteristics. Whereas, literature shows that knowledge about the predictors of child mortality at the individual level is insufficient to address the problem (Sastry, 1996; Griffiths et al., 2004; Antai, 2011b; Adedini et al., 2012). This is because the contextual attributes of the community (macro-factor) is where a child is raised tend to influence household-level and individual-level factors (micro-factors) and therefore determine child survival.

Consequently, the pressing problem of excessive under-5 mortality in Northern Nigeria has to be examined. Thus, this study aims to study the geo-spatial realities of child mortality risks by examining the influences of individual-level and community contextual factors (risk factors) on child survival odds in the health-disadvantaged Northern Nigeria. The analysis is based on data gathered through the IPUMS/DHS programme.

II. MATERIALS AND METHOD

Study Settings

Nigeria is the most populous country in Sub-Saharan Africa. The Northern part of Nigeria has an estimated population size of 75,025,166 inhabitants, which constitutes about (53.7%) of the National population (NPC, 2009), Northern Nigeria(See in Figure 2) is located between Longitudes 3° and 15° East and Latitudes 9° and 14° North-wards. Administrative-wise this socio-geographic entity includes 19 (Nineteen) [2]Northern States of Nigeria including the Federal Capital Territory (FCT).This region is riddled with economics and social complexities (Grais et al., 2007; Chirdan et al., 2008; Adekanmbi et al., 2011).

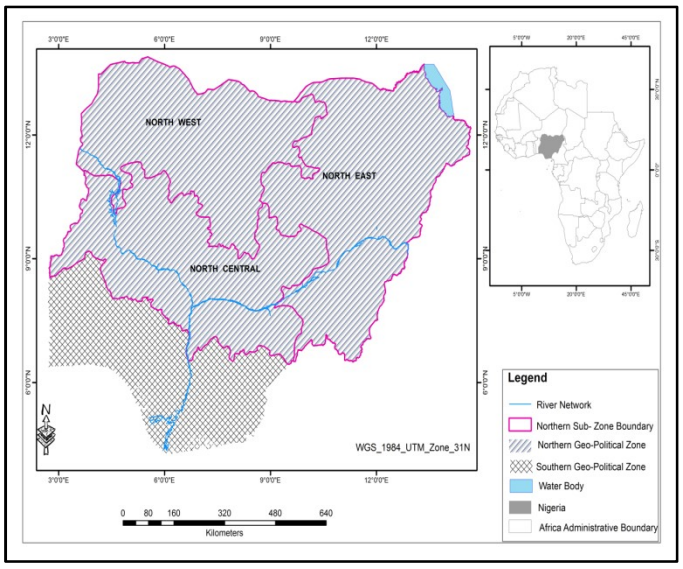

Figure 1: Nigeria showing its Northern Geo-political Zones

Source: Authors Compilation, 2019

[1] Most of the Nigerian millennium development goals were not achieved, pertinent to this study are goal 4-Reduce child mortality, Target 5- reduce under-five mortality by two-third between 1990-2015.likewise goal 1-Eradicate poverty and hunger, Target 1. Halve, between 1990 and 2015, the proportion of people whose income is less than one dollar a day

[2]List of Northern States
Plateau,Nassarawa,Niger,Kogi,Benue,Kwara,Borno,Yobe,Adamawa,Taraba, Bauchi,Gombe,Kaduna,Kano,Kastina, Jigawa, Zamfara, Sokoto, Kebbi and the Federal Capital Territory (FCT)-Abuja.

Spatial differentiation of this[3] region based on ecological, socio-economic position, cultural practices and health-seeking practices are closely associated with the formation of a varied epidemiological exposure patterns (Lawoyin, 2001; Shettima, 2008;Antai*et al*., 2009;Okoro*et al*., 2009;Akinbami et al., 2010;Adeboye, *et al.,* 2010; Antai, 2011a ; Aremu, *et al*., 2011; Doctor et al., 2011).

Source of data

The Demographic and Health Survey (DHS) programme is the world's largest survey, collecting information data collected during the Nigerian Demographic and Health Surveys (NDHS) of 2013. The survey was based on a stratified two-stage cluster design. Census Enumeration Areas (EAs) which are the primary sampling units were stratified into rural and urban residence. EAs were then selected in each state by systematic sampling. Subsequently, households were systematically sampled after a listing of all households in the selected EAs (NPC&ICF, 2014). All eligible women (aged 15-49 years) in selected households were interviewed (National {37,928} and Northern-Nigeria {20,433[54%]}). The child birth recode was utilized (NPC&ICF, 2014) women were asked questions about their summary (total children ever born{CEB} and surviving) and detailed reproductive history. The community-level variables were measured at the level of the [4]Primary Sampling Units (PSU's) which serves as proxies for communities or neighborhoods. A detailed documentation on the sample design and data collection for the surveys is contained in the report appendix A (NPC&ICF, 2014; Boyle et al., 2019).

Study Variable

Mosley & Chen's analytical framework was adopted for this study, because it explicitly outlines the salient factors influencing child survival in developing countries Although this model was conceptually identical to that formulated by Davis and Blake in 1956 (Mosley & Chen, 1984; Rutstein, 2000), the conceptual core of this model espouses proximate causes of early childhood mortality and morbidity, it establishes a relationship between survival and determinants at various stages {household, individual and community levels}(Mosley & Chen,1984; Caldwell,1986; Murray & Acharya, 1997; Fagbamigbe et al, 2014).Also salient is the contextual paradigm shift based on the impact of community on child survival outcomes as posited by Diez-Roux et al (2001) that the social and physical characteristics of place of residence may affect health and health-related behaviour.

The effect place of residence on child's survival has been widely investigated (Sastry, 1997; Rutstein & Rojas, 2006;Omariba et al., 2007; Antai & Antai, 2008; Adedini et al.,2015).Evidence suggests that residing in an economically and socially disadvantaged community is related with increased exposure to under-5 child mortality (Aremu, et al., 2011; Adedini et al., 2012). Furthermore, under-5 children from the same inhabited community tend to share identical environmental conditions (homogenous experience).

Outcome variable

Outcome variable measure is under-5 child mortality(This is defined as either the risk of a child dying before his/her fifth birthday) whose mothers (15-49yrs) are resident in North-east (NE), North-west (NW) and North-central (NC) regions of Nigeria. All children born within the five years preceding the survey were included in the study (Northern Nigeria). Specifically, all deaths that occurred between ages 0 to 59 months were regarded as cases. The children's survival status and the age at death in months (if the child had died) or the last month that they were known to be alive (if child is still living) were combined to generate the outcome variable for the survival analysis. Children known to have died (i.e. non- censored) were recorded as the cases, whereas children who were still alive after 59 months were right-censored. Each death case was coded as 1, and each non-death (Alive) case was re-coded as 0.

Explanatory Variables

Many health factors are associated with under-5 child mortality. The association of causal factors of child mortality is captured in the Mosley-Chen framework for child survival in developing countries (Mosley & Chen, 1983; Rutstein, 2000). The DHS/IPUMS data integration has improved by including factors that are of greatest interest for public policy and for which there are known interventions to reduce mortality. This study considers the four out of the groups of explanatory factors: fertility behaviour as reflected in the demographic characteristics of births, the use of health services, environmental health factors, socioeconomic factors and excludes the factor of nutritional status of children and patterns of breastfeeding and infant feeding, Consequently, the variables selected in this were modeled in line with those utilized in previous studies (Sufian,1990;Hartten & Misselhorn, 2006;Omariba et al., 2007; Fayehun, 2010; Kayode et al.,2012;Akinyemi et al,2013;Adedini et al.,2012).

Community-level Factors

The contextual characteristics of interest in this study included; place of residence (urban rural) and eco-region ((1) North-Central, (2) North-East and (3) North-West).

Individual-level Factors

The important individual-level characteristics assessed in this study were classified into two namely economic and social contexts. Mother's education, birth order, sex, maternal age, age at first birth, malaria

[3]This was done with a view to ensuring that the study provides an accurate picture of the current situations in the Northern Nigeria and its different geo-political zones.

[4]Enumeration Areas (EAs) were too small to be DHS clusters, the 2013 NDHS included several EAs per DHS cluster (with a preferred minimum cluster size of 80 households).

prevalence,[5]wealth index which measured the economic status of the households assessed. A principal components analysis was used in constructing the wealth index. Weights were assigned to the household facilities and assets of respondents. The facilities and assets captured were those that were consistent across the pooled $NDHS_{2013}$ data: television, radio, refrigerator, car, bicycle, and motorcycle, source of drinking water, type of toilet facility, electricity and type of building materials used in the place of dwelling. In the National DemographicHealth Survey data set, the household wealth index was categorised into five quintiles: poorest, poorer, middle, richer and richest. However, in the analysis, this index had to be recoded into three groups: the bottom 40% of households were referred to as poor households, the next 40% as middle households and the top 20% as rich households in order to enhance result readability.

Ethical Considerations

This study was based on a national representative dataset with all participant identifiers removed. The survey instruments received ethical approval from the Ethics Committee of the Opinion Research Corporation of the Macro International Inc. Calverton, MD, USA. Permission to use the 2013 Nigeria DHS data in this study was obtained via online request from ICF Macro Inc.

Statistical Analysis

The study utilized both inferential and descriptive statistics. Study data was sourced from the National Demographic and Health Survey. The characteristics of women (15-49 years) and under-5 children were presented using descriptive statistics. Cox proportional hazard model were fitted for under-5 child mortality (0-59 months). Further analysis was done using multilevel Cox proportional hazards regression analysis. All analysis was done using [6]STATA software (version 14.2). Weighting factors were applied to adjust for oversampling of some regions in the survey.

Survival analysis: Survival analysis referred to statistical methods for analyzing survival data. Survival time refers to a variable which measure the time from a particular starting time (e.g. Time initiated the treatment) to particular end point of interest (e.g. attaining certain functional abilities) (Cox & Oakes, 1984; Rutstein, 2000; Adedini et al., 2012; Getachew and Bekele, 2016) Survival analysis is concerned with studying the time between entry to a study and a subsequent event and becomes one of the most important fields in statistics. Standard statistical techniques cannot usually be applied because the underlying distribution is rarely normal and the data are often 'censored'. Usually, a first step in the analysis of survival data is the estimation of the distribution of the survival times. Survival times are often called failure times, and event times are uncensored survival times. The survival distribution function (SDF), also known as the survivor function, is used to describe the lifetimes of the population of interest. Let T be a random variable representing survival time of subjects in the population, and t be the realization of T. Then the cumulative distribution function of T is given as F(t)= P(T<t)where T is the survival time of randomly selected individual and a specific point of time.

The survival function: S(t)gives the proportion of children whose survival times are *t* or longer.

$$S(t) = \mathbf{Pr}(T \geq t) = \mathbf{exp}(-\int_0^t \lambda(u)du) \ldots\ldots\ldots \mathbf{1}$$

The hazard function can be used to represent the probability that an individual dies at time t., conditional on having survived to that time. That is, the function represents the instantaneous death rate for an individual surviving to time t.

$$\lambda(t) = \lim_{\delta \to 0+} \frac{p(t \leq T < \delta | Y \geq t}{\delta} = \frac{P(t \leq T < t+\delta)}{P(T \geq t) * \delta} \ldots\ldots\ldots \mathbf{2}$$

Where λ(t): is the hazard function, T is the survival time, S(t):is the survival function, δ: is the instantaneous change.

Non parametric method

Kaplan-Meier estimates: Kaplan Meier estimator is non-parametric and hence no parametric assumptions. We can compare data from two or more different groups by visual inspection of their respective estimated survival functions or some statistical tests (Muleta, 2003; Box-Steffensmeier & Jones, 2004;Cleves et al., 2010; Getachew&Bekele,2016). Thus, we can compare different levels of a certain factor. The Kaplan-Meier estimator at any point in time is obtained by multiplying a sequence of conditional survival probability estimators.

Each conditional probability estimator is obtained from the observed number at risk of dying (n) and the observed number of deaths and is $equal(n-d)/n$To apply the Kaplan-Meier method supposes that there are$n$ independent individuals in a random sample with observed survival times $t_{(1)}, t_{(2)} \ldots\ldots, t_{(n)}$.The distinct ordered failure times observed among the n individuals are $t_{(1)}, t_{(2)} \ldots, t_{(m)}$, $m < n$ as there are more than one individual with the same observed survival time and some of the observations may be right-censored, i.e., the survival status of the individual might not be known at the time of the analysis.

The probability of survival at time $_{(j)}, (t_{(j)})$ is then estimated by

$$P(t_{(j)}) = {(n_j - d_j)}/{n_j} \ldots\ldots\ldots 3$$

Where,

[5] Wealth index was applied in this analysis as a composite index and an indicator of the socioeconomic status of households. This was because the Demographic and Health Survey generally does not collect information on household income or wealth of household assets collected through the DHS surveys.

[6] Http://www.Stata.com/manuals 14/.mc
Stata survival analysis and epidemiological tables reference manual

n_j is the number of individuals who are alive just before time t_j and d_j is the number of those who die during this time. Consequently the estimated probability of surviving beyond t_j, S(t) is

$$\hat{S}(t)\prod_{j|t(j)\leq t} {}^{n_j - d_j}\Big/_{n_j} \quad \ldots\ldots\ldots\ldots 4$$

Cox's proportional hazards regression model: A popular model used in survival analysis that can be used to assess the importance of various covariates in the survival times of individuals or objects through the hazard function (Cox & Oakes,1984; Afzal and Alam, 2013 Hosmer et al., 2008; Cleves et al.,2010; Vittinghoff et al., 2012). Cox proportional hazards model is a commonly used model in providing hazard ratio to compare survival times of two or more population groups. The exponentiated linear regression part of the model describes the effects of explanatory variables on hazard ratio.

The Cox model is given in the form of

$$h(t, x, \beta) = h_0(t)exp(\beta'\text{-}x_i) \ldots\ldots\ldots\ldots\ldots\ldots 5$$

Where $h_0(t)$ is the baseline hazard function at time t, $x_i' = x_{1i}, x_{2i}, \ldots x_{pi}$for i =1,2= …is a vector of measured covariates for the i^{th} individual at time t, and β' is a p vector of unknown regression parameters that are assumed to be the same for all individuals in the study.

III. RESULT AND INTERPRETATION

Demographic and socio-economic characteristics of children and their Mothersin Northern region of Nigeria

The results elucidate that with the exception of child's sex; all the other examined socio-demographic characteristics were statistically significant but at varying degrees (See in Table 1). Findings also revealed that male and female children evenly populated (50.8%:49.2%). In the case of birth order, overall for the region, almost 2 in 5 children (40.0%) were of birth order 5 and Higher (5^{+}).The North-central region fared better in terms of birth order as28.1% of the children belonged to birth order 5 or higher while the North-east (41.4%) and North-west (44.3%) which both more than doubled that of North-central region. Furthermore, an estimation of maternal educational level revealed a large cohort of uneducated women (66.1%). The North-west were worse off with 79.4% of women haven't received no prior formal education before study, followed by the Northern-east (67.4%) and the North-central (35.6%) which was the most literate Northern region (See in Table 2).

Mother's occupation, in all the regions, maternal unemployment rates was high (34.4%) given that mothers were less likely to be employed by the civil service (0.2%) despite the fact that in this region, government (Federal, State and Local) is a major source of employment (influenced by religion and gender exploitation). Results revealed that they were more into sales and manual related professional occupations (65.5%) like agricultural sector. Results further show that, overall, the children predominantly were mothered by married women in all the regions, and most mothers where within the 25-34 age bracket.

Table 1: Percentage Distribution of Child-Mother & Level Characteristics in Northern Nigeria

Variables	Northern Nigeria [n (%)]	Regions			*P*-value (p<0.001)
		North-Central	North-East	North-West	
Region of Residence	21,037(100%)	4614(21.9%)	6517(30.9%)	9902(47.2%)	0.000*
Sex of child					
Male	10,677(50.8%)	2309(50%)	3394(52.1%)	4974(50.2%)	0.036
Female	10,360(49.2%)	2305(50%)	3123(47.9%)	4932(49.8%)	0.000*
Total	21,037	4,614	6,517	9,902	
Birth order					
First birth	3,670(17.4%)	1018(22.1%)	1085(16.6%)	1567(15.8%)	0.000*
2-4birth order	8,969(42.6%)	2298(49.8%)	2735(42%)	3936(39.7%)	0.000*
5^{+}birth order	8,398(40%)	1298(28.1%)	2697(41.4%)	4403(44.5%)	0.000*
Maternal-Educational Status					
No education	13,900(66.1%)	1643(35.6%)	4390(67.4%)	7867(79.4%)	0.000*
Pry school	3468(16.5%)	1237(26.8%)	1075(16.5%)	1156(11.7%)	0.091
Sec school	2973(14.1%)	1302(28.2%)	882(13.5%)	789(8%)	0.022
Tertiary	696(3.3%)	432(9.4%)	170(2.6%)	94(0.9%)	0.565
Maternal Occupation					
Not working	7,217(34.3%)	997(21.6%)	2847(43.7%)	3375(34.1%)	0.744
Civil service	36(0.2%)	22(0.5%)	9(0.13%)	5(0.05%)	0.000*
Professional	2,834(13.5%)	1011(21.9%)	802(12.3%)	1021(10.3%)	0.332
Sales	10,950(52%)	2584(56%)	2859(43.9%)	5507(55.6%)	0.122
Maternal Age					
15-24	5,718(27.2%)	1094(23.7%)	1884(28.9%)	2740(27.7%)	0.031

25-34	5,132(24.4%)	1051(22.8%)	1570(24.1%)	2511(25.3%)	0.726
35^{+}	10,187(48.4%)	2469(53.5%)	3063(47%)	4655(47%)	0.241
Wealth Index					
Poor	13,033(62.0%)	1426(30.9%)	4516(69.3%)	7091(71.6%)	0.992
Middle	6,419(30.5%)	2,405(52.1%)	1655(25.4%)	2359(23.8%)	0.129
Rich	1,585(7.5%)	783(17.0%)	346(5.3%)	456(4.6%)	0.074

Source: Authors computed based on the NDHS, 2013

Community-level characteristics by region of residence

The wealth index distribution (Table 1) indicates that socio-economic inequalities were endemic in Northern region of Nigeria; results revealed that majority of households in the region were classified as poor (62.0%). This phenomenon was most pronounced in the North-west (71.6%) and North-east (69.3%) where social mobility appear to be an institutional barrier in comparison with the North-central (30.9%) where based on results it was revealed that women have more socio-economic/class mobility.

Findings further revealed that all the selected community-level characteristics vary significantly between the regions of residence ($p<0.001$). Examination of the factor related to place of residence, Northern Nigeria generally has predominantly high proportion of women resident in rural areas (70.3%).Furthermore, sub-regional differences show variations between the proportion of urban and rural dwellers. Results indicate that 79.2%of women in the North-eastzone were resident in rural areas, while they are 75.5% and 70.3% in the North-west and North-central regions respectively living in rural areas.

Table 2: Percentage Distribution of Community level Characteristics in Northern Nigeria

Variables	**Northern Nigeria** [n (%)]	**Regions**			*P*-value (p<0.001)
		North-Central	North-East	North-West	
Place of Residence					
Urban	4,675(22.2%)	1,370(29.7%)	1,353(20.8%)	1,952(24.5%)	
Rural	16,362 (70.3%)	3,244(70.3%)	5,164(79.2%)	7,954(75.5%)	0.000
Community Hospital Service					
Low	12,686(60.3%)	1,279(27.7%)	4,106(63%)	7,301(73.7%)	
Medium	5,003(23.8%)	1,444(31.3%)	1,459(22.4%)	2,100(21.2%)	
High	3,348(15.9%)	1,891(41%)	952(14.6%)	505(5.15%)	0.000
Population Density					
Low	3,722(17.7%)	2230(48.3%)	1128(17.3%)	364(3.7%)	
Medium	16,977(80.7%)	2251(48.8%)	5314(81.5%)	9412(95%)	
High	338(1.6%)	133(2.9%)	75(1.2%)	130(1.3%)	0.000
Malaria Prevalence					
Low	18,721(89%)	3,451(74.8%)	5,913(91.1%)	9,357(94.4%)	
Medium	1620(7.7%)	731(15.8%)	434(6.7%)	455(4.6%)	
High	696(3.31%)	432(9.4%)	170(2.6%)	94(1%)	0.000
Covered by Health Insurance					
No	20,765(98.7%)	4,454(96.5%)	6,445(98.9%)	9,899(99.6%)	
Yes	272(1.3%)	160(3.5%)	72(1.1%)	7(0.4%)	0.000
Total	21,037(100%)	4,614(100%)	6,517(100%)	9,906(100%)	-

Source: Authors computed based on the Nigeria 2013 DHS

Early childhood mortality associated risk factors (Survival analysis)

Table 4 presents the results of Cox proportional hazard models specification for under-5 childmortality (Models 1&2).[7]Results of the analysis showed that a total number of 2,135(about 10.2% of child born five years preceding study) under-five child died before their fifth year birthday. Explicitly Table 4 presents the relationship between individual level risk factors and community risk factors and their impact on the level of under-five child mortality outcomes.

Model 1 (Table 4) shows that the risk of under five deaths were significantly higher among neonates whose mothers were Traditionalist (HR: 2.02; CI: 1.90-2.15) and Muslims (HR: 1.34; CI: 1.28-1.41) in comparison to children whose mothers were Christians, likewise among divorced or widowed women (HR: 1.04; CI: 0.80-1.36) relative to children in the reference category. The risk of childhood mortality were significantly higher for Children of birth order five or higher (HR: 0.43; CI: 0.99-1.12) relative to the children who were first born. A child's gender was a key factor in Northern Nigeria(influenced by faith-based gender discrimination), result revealed that female children (HR: 0.99; CI: 0.97-1.02) had a significant lower survival odds

[7]Survival analysis in our study was carried out without the analytical disaggregation of infant and under-5 child mortality rates in order to better understand the extent to which individual and contextual factors (of the community where children are born and are resident in) influence the survival chances during the first five years of life.

when in comparison to their male counterparts. Further findings also revealed that the risks of early childhood mortality were significantly lower among children whose mothers had attained secondary or higher education (HR: 1.15, CI: 1.09-1.20) compared with children of mothers with no education. It was also noted that children of mothers whose age at first birth was 16 years or higher experienced lower risks of death (HR: 0.27, CI: 0.89-1.02); and children of mothers in the rich quintile consequently had reduced exposure to mortality (HR: 0.93, CI: 0.87-0.99) relative to children in the reference. categories.

Furthermore, model-2 (Table 3). Results indicate that the risks of death of under-five children also had a spatial dimension. Significantly, under-five children whose mothers were resident in the North-West (HR: 1.05; CI: 1.17-1.82) and North-East (HR: 1.01, CI: 0.97-1.06) compared with children in the North-Central region. Risks were also higher for children raised in the rural areas (HR: 1.04, CI: 0.90-1.10). In contrast, the risks of death were significantly lower amongst children whose mothers were resident in communities with higher population density (HR: 1.07, CI: 0.55-0.79). Increased access to community healthcare service increased the odds of child survival (HR: 0.66, CI: 0.55-0.79), communities with high proportion of treated mosquito net utilisation (HR: 0.99, CI: 0.95-1.02) and insurance coverage.

Table 3: Hazard ratios and 95% confidence intervals for individual-level & Community-level characteristic associated with infant and under-five mortality in Northern Nigeria (Model 1& 2)

Individual-level Variables Covariates **(Reference)**	**(Model-1) 95% CI for HR**	**Community-level Variables** Covariates **(Reference)**	**(Model-2) 95% CI for HR**
Religion		**Region**	
Christianity(Ref)	1	North-Central(Ref)	1
Islam	1.34(1.28-1.41)	North-East	1.01(0.97-1.06)
Traditional\ Animist	2.02(1.90-2.15)	North-West	1.05 (1.01-1.09)
Marital Status		**Place of Residence**	
Single(Ref)	1	urban(Ref)	1
Married	0.97(0.87-1.08)	Rural	1.04(0.99-1.07)
Divorced	1.04(0.80-1.36)		
Marital Age		**Population Density**	
15-24(Ref)	1	Low(Ref)	1
25-34	0.27(0.86-1.07)	Medium	1.09(1.05-1.13)
35^{+}	0.25(0.89-1.04)	High	1.07(0.90-1.10)
Birth Order		**Community Health Service**	
First order(Ref)	1	low(Ref)	1
2-4 birth orders	0.17(0.98-1.18)	Medium	0.60(0.97-1.19)
5^{+} birth orders	0.43(0.99-1.12)	High	0.24(0.98-1.13)
Child Sex		**Malaria Prevalence**	
Male	1	low(Ref)	1
Female	0.99(0.97-1.02)	Medium	0.97(0.91-1.04)
		High	0.99(0.95-1.02)
Age of 1st birth-		**Health Insurance** Coverage-	
<16years(Ref)	1	Insured(Ref)	1
>16 year old	0.27(0.89-1.02)	Un-insured	1.01(0.72-1.42)
Maternal Occupation-		***Prob>chi2=0.013*** ***p<0.05, **p<0.01, ***p<0.001**	
Not working (Ref)	1		
Civil service	0.92(0.81-1.04)		
Professional	0.95(0.92-0.98)		
Sales	0.96(0.92-0.99)		
Wealth Index-			
Poor (Ref)	1		
Middle	0.97(0.94-1.00)		
Rich	0.93(0.87-0.99)		
Prob>chi2=0.000 ***p<0.05**			

Source: Authors computed from the NDHS,2013

The result of the survival analyses (Table 3) reveals that most of the study risk factors variables were found to be significant and therefore they can be retained in the model. Thus, after the final model of significant explanatory variables was created, it was necessary to [8]validate the proportional-hazards which assume homogeneity of variance across risk sets. We tested the proportional-hazards assumption using a Schoenfeld residuals fitting model test plot for Northern Nigeria (See Fig 5(individual-level predictors)-7(community-level predictors)).

[8] Cox proportional hazards models assume that the hazard ratio is constant over time. The proportional hazards (PH) assumption is just another way of saying that the Hazard Ratio (HR) does not change over time for some predictor.

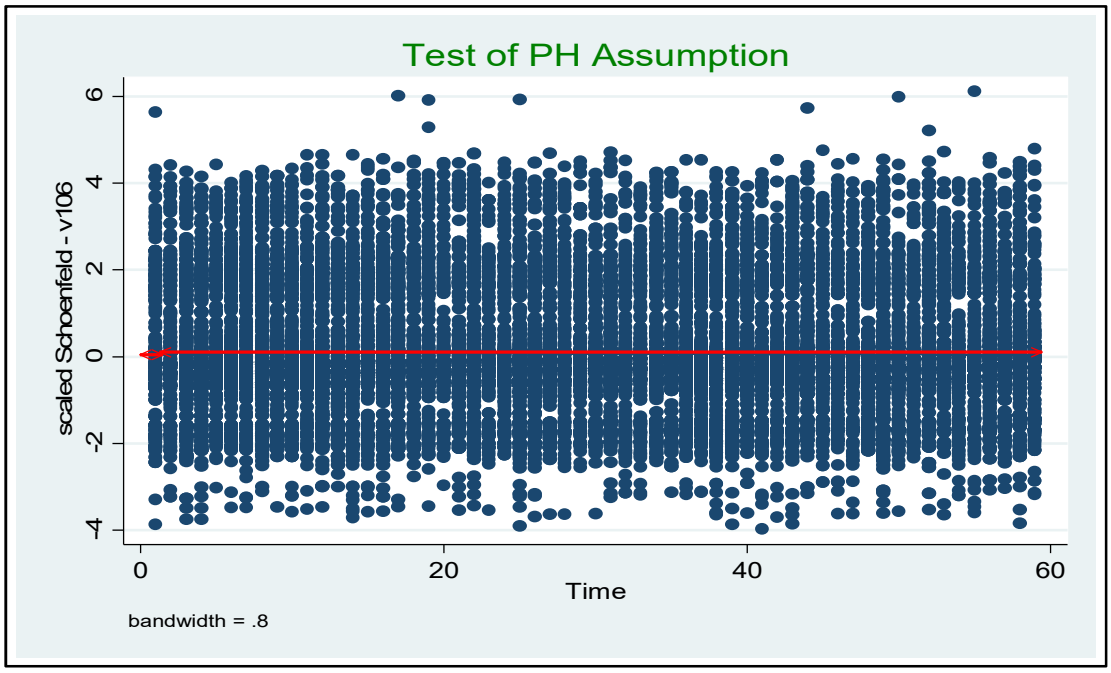

Figure 2: Schoenfeld Residual Maternal Educational Level(Individual-level Predictor)

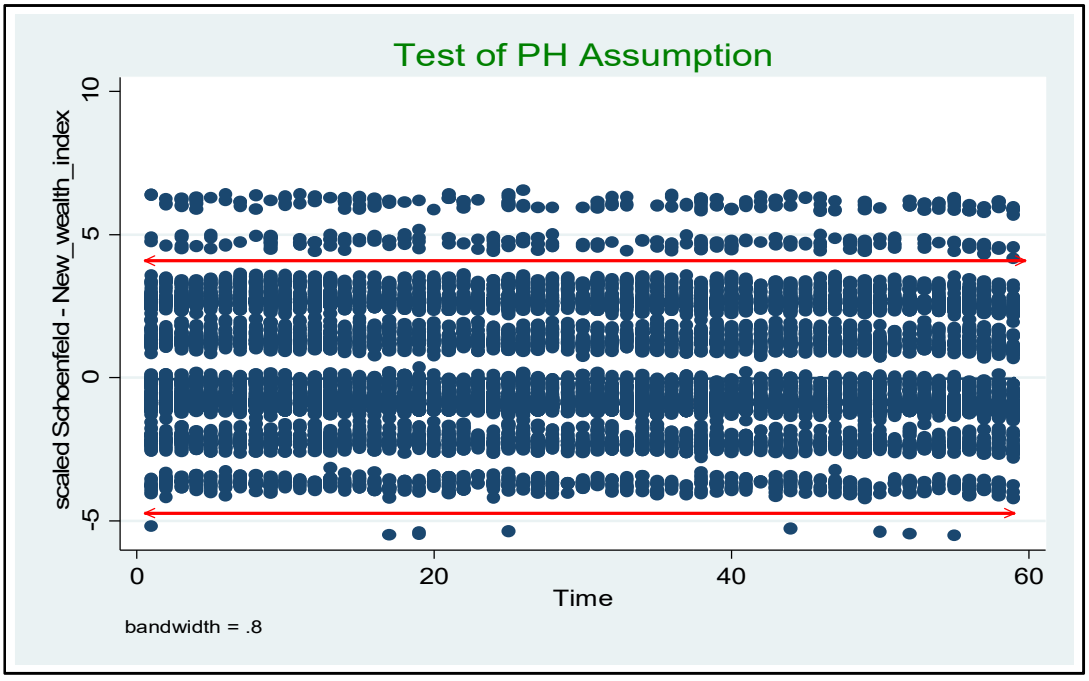

Figure 3: Schoenfeld Residual -Wealth index(Individual-level Predictor)

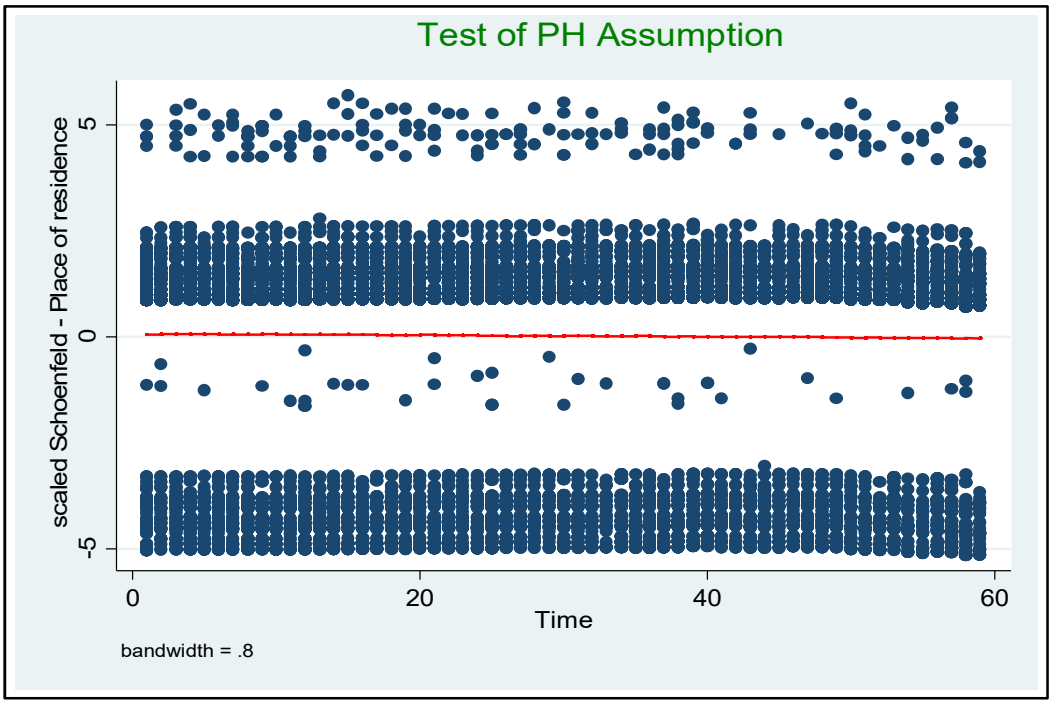

Figure 7: Schoenfeld Residual-Place of residence (Community-level predictor)

3.4 Risk factors of under-five child mortality (A multilevel analysis)

A null model (empty) was fitted in order to determine whether the utilization of a multilevel model was necessary in the study analysis. The null model (Table 4, column 2) indicated a significant variation in under-five child mortality for both the individual-level (variance of 0.91) and community-level (variance of 0.90); thus this gives credence for the usage of multilevel models in the analysis. The incorporation of the Northern regions of residence into the multilevel models as contained in model 1-3(Table 4, column 3-5), indicate that under-five aged children resident in both North-East (HR: 0.18; CI: 0.40-0.59, $p<0.05$) and North-West (HR: 0.43; CI: 0.58-1.11, $p<0.05$) regions had significantly higher risk of deaths relative to those resident in North-Central region.

In-line with focus of this paper to assess the concurrent influence of both individual-level and community-level risk factors on regional variations in under-five child survival odds in Northern Nigeria (North-East, North-West and North-Central). Selected risk factors of under-five children in Northern Nigeria were first adjusted for by using community-level risks factors and this was incorporated into model 2 (See Table 4, column 4), under-five child survival odds still remained significantly low, but in comparison with those levels in model 1 there seem to be slight reductions in death events, for instance in the North-West (HR: 0.25; CI0.43-1.08, Evidence from model 2 further showed that place of residence is a key predictor of under-five child mortality as risks of death were estimated to be 77% higher for the children resident in the rural areas relative to their counterparts in urban locales.

Furthermore, to adjust for the effect of individual-level and community-level risk factor and their relationship with under-five child survival, steps were taken to incorporate this varied levels risk factor into a unitary model (model-3, Table 4). Results from this model also revealed that significantly, high risk of under-five child mortality still persisted across all three Northern regions but became slightly rarefied compared with the results obtainable in other models(model 1&2). Adjusting for the individual-level attributes in model 3, the significant contextual characteristics include: Region of residence, Place of residence, Population density, Malaria prevalence and Health-insurance coverage. Considering the individual-level attributes included in the full model, children of mothers with secondary or higher education had significantly lower risk of death (HR:1.23; CI:0.74-0.86) relative to children of mothers with no education. We also found that children of divorced mothers experienced a much greater exposure to death than children of the married mothers (HR: 1.23; CI: 0.74-0.86).

Table 4: Hazards ratios and confidence intervals for Individual and Community-level risk factors of under-5 mortality				
Variables **Fixed part**	**Model 0 (Null model)**	**Model 1 (Region of residence) HR (CI)**	**Model 2 (Community-level variables) HR (CI)**	**Model 3 (Community & Individual levels Variables) HR (CI)**
Region of Residence				
North Central		1	1	1
North East		0.18(0.04-0.59)*	0.13(0.30-0.51)	0.05(0.22-0.33)
North West		0.43(0.581.11)**	0.25(0.43-1.08)*	0.17(0.34-0.54)
Place of Residence				
Urban			1	1
Rural			0.29(0.44-0.14)***	0.20(0.36-0.40)*
Insurance Coverage				
Un-insured			1	1
Insured			0.03(-0.03-0.14)	-0.31(0.12-0.61)
Malaria(Morbidity)				
Low			1	1
Middle			0.21(0.04-0.39)**	0.22(0.04-0.39)**
High			0.09(0.06-0.18)**	0.10(0.06-0.18)*
Population Density				
Low(Ref)			1	1
Middle			0.16(0.05-2.65)*	0.81(-0.35-1.97)
High			0.31(0.17-0.44)***	0.18(0.02-0.34)**
Child Gender				
Male(Ref)				1
Female				0.12(0.04-0.193)*
Religious Affiliation				
Christianity(Ref)				1
Islam				0.14(0.03-0.27)**
Traditional				0.10(0.06-0.25)
Age at first birth				
Early(Ref)				1
Middle				0.10(0.01-0.19)*
Mature				0.26(0.68-1.22)
Marital status				
Single(Ref)				1
Married				0.19(0.05-0.07)
Divorced				0.02(0.17-0.36)**
Wealth Index				
Poor(Ref)				1
Middle				0.06(0.01-0.19)*
Rich				0.26(0.68-1.22)
Maternal Education				
No Education(Ref)				1
Primary Education				0.25(0.72-0.84)
Secondary Education				1.23(0.74-0.86)**
Tertiary				1.11(0.84-0.96)
Maternal Occupation				
Not working (Ref)				1
Civil service				0.46(0.92-1.01)*
Professional				0.91(0.82-1.01)**
Sales				0.92(0.89-0.95)**
Random Part				
Individual-level effect				
Variance(SE)	0.91(0.61)**	0.902(0.88)***	0.770(0.01)***	0.997 (0.007)***
Community-level effect				
Variance	0.90(0.89)**	0.138(0.77)***	1.376(0.04)***	0.76(0.007)***
Log Likelihood	-4564.2	-4572.5	-2811.9	-2780.4
*p<0.05, **p<0.01, ***p<0.001, SE – Standard Error				

Source: Authors computations based on the NDHS,2013

IV. DISCUSSION

The menaces of widespread under-five child mortality in Nigeria still persist, although, substantial progress has been made in recent times, there is still no doubt that there exist under-five child health inequalities (children left behind or deprived) across regions in Nigeria.

The objective of this study was to examine the extent to which risk factors (individual-level and community-level) influence regional variation in under-five child mortality in Northern Nigeria. Findings from this study revealed that regional residency is a significant predictor of under-five child mortality within various regions in Nigeria, thus supporting the findings of preceding studies (Antai, 2011a; Antai, 2011b; Adedini, 2012; Kayode et al, 2012). In Nigeria, socio-economic differentials have been largely linked to differences in regional child health resources such as distributional location of healthcare facilities (i.e. Primary Healthcare Facilities (PHC)), social services and cultural orientations (Fayehun, 2010; Antai, 2012b; Adedini, 2012).

The findings from this present study showed that generally, risks of under-five child death were high in Northern Nigeria, despite the fact that this cohort death rate has attenuated in recent times. Region of residence was found to be a significant predictor of under-five child mortality across all three regions in Northern Nigeria. In particular, the rate of under-five child mortality in the North-east and North-west were estimated to be 160 deaths and 185 deaths per 1,000 live births respectively (NPC and ICF macro, 2014). According to inferential findings in our study analysis, North-west and North-east regions are regions are mortality hot spot.

Results from the multilevel model (table 4, model-2) indicated that place of residence is significant predictors of under-five child mortality in Northern Nigeria, as the survival odds were much lower than that of children resident in rural locales relative to their peer's resident in urban centres. This finding was deductive in nature and it correlates with result reported in previous studies (Adekanbi et al, 2011; Riman & Emmanuel, 2012; Akinyemi et al, 2014). Location of parental residence is also a lead determinant of under-five child survival because Northern Nigeria is predominantly rural (North-east and North-west) and with this rurality comes reduced accessibility to good health care services. Besides, women in the rural areas are less educated compared with their urban dwelling counterparts, couple with this is the fact that women resident in rural centres are most likely to be relatively younger and inexperienced at the birth of their first child and also are liable to inadequate birth-spacing, thus significantly diminishing the odds of child survival. Adjusting for the individual-level attributes in multilevel analysis slightly reduced the risks of dying for children in all the regions and also for children of mothers resident in rural areas. This shows that individual attributes such as higher maternal education and improved wealth status can lead to reduced under-five mortality even in socially and economically disadvantaged areas in Northern Nigeria.

Furthermore, this study revealed that communal malaria prevalence remained a significant predictor of under-five child mortality post adjusting for other factors. Also, numerous individual-level factors such as maternal education, occupation and religious affiliation remain important predictors of under-five child mortality in Northern Nigeria. Interestingly, children of women who were civil servants (Covered by the National Health Insurance Scheme ((NHIS) and full-time stay home (had extended time for care giving) mothers were found to have significantly lower exposure to mortality in comparison to children of women engaged in sales and professional occupations. Study results also revealed that children of mothers who were either divorced or widowed had a higher risk of death in comparison to those whose mothers were either married or single. This finding is also in line with results of earlier studies (NDHS and ICF macro 2004; 2009; 2014). This can be attributed to the near absence of social support services and the stigmatization of widowhood within certain ethnicity in Northern Nigeria.

Thus, this study has established that a combination of individual-level and community-level (contextual) risk factors are important predictors of under-five mortality in Northern Nigeria. These risk factors include maternal education, Child gender, maternal occupation, , region of residence, place of residence, population density and malaria prevalence. The North-west and North-east are regions where under-five child survival odds are lowest and largest population of left behind children; these regions are riddled with large scale educational, socio-economic inequities which are being exacerbated by the Boko-Haram scourge. Also in these regions, mothers are relatively young at first birth, thus exposing them to life threatening issues like anemia, postpartum haemorrhage, fistula and even maternal mortality (Wall, 1998; NDHS and ICF macro, 2014).

These findings would be of great benefit to policy makers, should they be robustly examined, considered and integrated during the planning, formulation and implementation phase of the national socio-economic construct, as a result it is now expedient to factor in both the individual-level and community-level (contextual) predictors concurrently while addressing the issue of under-five child mortality. Moreover, the contemporary problem associated with regional differentials in child survival odds in Northern Nigeria requires a top-bottom vertically integrated governmental multi-level approach.

This study has its limitations such as some determinants (i.e. religious-based, cultural practices and traditions factors) could not be accessed and then investigated in this study, Borne out of the fact, that this study dataset was secondarily sourced from DHS repository and unavailable in the dataset. Despite these limitations notwithstanding, the strength of this study include the fact that the DHS datasets

are not only nationally representative but is designed in a hierarchical format which allowed for both regional and cross-regional analyses.

V. CONCLUSION

An under-5 child survival odd has improved in Northern Nigeria between 2003 and 2013. The region has experienced significant but sub-optimal improvements in individual-level and community-level factors associated with under-5 child healthcare status. Maternal education, Child gender, maternal occupation, marital status, region of residence, place of residence, communal educational level and mosquito net prevalence are important factors driving mortality changes and regional disparities. Effort aimed at improving under-five child interventions and other risk factors need to be accelerated in a bid to attain the national set Sustainable Development Goals(SDG)3 and 10. The realities of left behind children is endemic in Northern Nigeria and thus both individual-level and community-level based interventions should be effected in a bid to drastically improve under-five child survival odds in this region.

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