

# **Differentials in Infant and Child Mortality in Nigeria: Evidence from Pooled 2003 and 2008 DHS Data**

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## **Abstract**

The objective of this study is to examine the zonal differences in the role wealth, education and religion play in child and infant mortality in Nigeria. This study utilized 2003 and 2008 DHS pooled data of Nigeria. Logistic regression analysis technique is used to examine the difference in odds of mortality between the different wealth quintiles within urban and rural areas. The study used logistic regression technique to enable us to obtain the odds ratio of which group has lower or higher odds of child mortality based on wealth quintile and on geographic location in the various zones of Nigeria. Our findings show that education and wealth are significant factors in explaining the urban-rural differences in infant and child mortality rates in Nigeria. We also find that the risk of both infant and child mortality is higher in the Northwest and Northeast zones of Nigeria than any other zones. Also, the southwest region has the lowest risk of both infant and child mortalities in Nigeria. We find no evidence of statistically significant difference in the risk of both infant and child mortalities between the urban and rural poorer and poorest wealth quintiles in Nigeria. This study established the differentials in infant and child mortality in the six geo-political zones of Nigeria. Our results also show that there is a disparity in both infant and child mortalities between the urban and rural areas.

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**JEL classification numbers:** I14, I130

**Key Words:** Infant and child mortality rate, wealth and maternal education, six geo-political zones.

## 1 Introduction

Socio-economic status (SES) as a composite variable that comprises income, education, occupation, employment and behavior correlates impacts on an infant's well-being and survivability. Income predicts to a great extent the life chances and the environment that an infant is exposed to. Poor and polluted environment increases the susceptibility of the infant to unhealthy conditions and premature death. Poor hygienic conditions increase the vulnerability of infants to childhood diseases, which increase the probability of dying in the first year of life. Wealthy societies and individuals generally provide the enabling environment for best health practices, such as good hygiene, good nutrition for both the pregnant mother and the infant, good drinking water, unpolluted environment, and access to adequate health facilities.

The above mentioned factors help to create enabling environments that enhance the survival of live births beyond the first year of life and even beyond the first five years of life. Total factor productivity and reduced poverty are closely associated with improvements in a population's child nutrition, adult health, and schooling, particularly in low-income countries [1]. The levels of real income when nutrition is very low, these effects of health and nutrition on productivity and survival are substantial and that there is no consensus on the precise magnitudes of the productivity effects or how costly they are to achieve by private expenditures or public regulations or outlays.

Poverty arguably is almost solely responsible for the high prevalence of infant and child mortality in Nigeria. Nigeria consists of six geo-political groupings or zones: North Central, Northeast, Northwest, Southeast, South-south and Southwest. There are inter-zonal differences in wealth, urbanization, and literacy. This study seeks to examine the effects of these disparities on infant and child mortality differentials in Nigeria. Also, the study will analyze the differences between the six geopolitical zones in Nigeria. Our aim is to see if the recent health policies that aim to achieve the Millennium Development Goal (MDG) target date of 2015 in infant and child mortality in Nigeria is on course.

Examining the link between infant survival, wealth, and location is very important in explaining the regional differences in infant mortality rates. This paper, therefore, helps to fill the void that currently exists in the literature by using the DHS data to examine the impact of SES and location on infant and child mortality rate in the six geopolitical zones of Nigeria.

## **2 Literature Review**

It is well documented in the social science literature that education increases the chances of an infant's survival in the first year of life [2,3,4,5,6,7]. For this study, education is defined as the number of years of education completed as well as the ability to read and write. Education especially for the mother is very vital in improving the survivability of the infant or child. When the parents of an infant are literate, they are able to access vital health preventive information that is essential in decreasing the probability of infant or child mortality. The relatively small proportion of marriages where the wife is better educated than the husband and where decision about child care are likely to be exclusively in the hands of the mother, that child mortality is particularly low [3]. The decline in infant mortality in sub-Saharan Africa may have resulted from medical intervention measures and broad-based reductions in exposure to infectious diseases that prevent infant deaths rather than improved nutrition and childhood morbidity [8]. Their study compared infant mortality in other regions of the world with sub-Saharan Africa using height and nutrition. They found that infant mortality rates declined significantly in every country outside sub-Saharan Africa. Although urban advantage remains over rural areas in infant mortality in sub-Saharan Africa, this difference declines or disappears in many countries after controlling for socioeconomic and reproductive behavior factors [9].

However [10], found that urban rural differences exist in infant and child mortality in sub-Saharan Africa at every level of the wealth category for most of the 23 sub-Saharan African countries in the study. Perhaps, the limitations of [9] are the survey data which do not reflect the current trends in rural-urban differences. The use of migrant population alone makes the study very selective of the sample and thus subject to bias. Household level factors have been found to be important in explaining rural-urban differences in child mortality in sub-Saharan Africa [11]. Their study concludes that the rural-urban differences in household level determinants, which explain two-thirds of the gap, are much more important than those in community-level determinants, which explain less than one-quarter of the differences.

Household wealth and maternal knowledge about and access to community health services play an important role in reducing child malnutrition, and that there is significant interrelation for the low weight-for-age classification [12]. Household wealth in Kenya was found to be a significant determinant of under-five mortality [13]. The study argued that in rural areas, households with greater wealth were less likely to have under-five deaths compared with the poorest households. This difference was absent in the urban area in Kenya. Under-five mortality was found to have increased as urban population steadily increased between 1983 and 2003 in Nigeria [14]. However, this result is not consistent with other studies that show urban dwellers with an under-five mortality advantage over rural dwellers [10,15,16,17].

However, there are noteworthy zonal differences in infant and child mortality rates in the six geopolitical zones of Nigeria. Of the six zones in Nigeria, the Southwest zone has the lowest infant and child mortality rate. The South African sub-region infant mortality rate of 48 is less than the developing world average of 50 and a little more than the world average of 46. Overall the infant mortality rate of sub-Saharan Africa is still very high and well above the world average of 46. The above-mentioned statistics of the regional differences in infant mortality of sub-Saharan Africa makes sense because the Middle sub region of Africa that has the highest infant mortality rate also has the highest level of poverty [18].

Child mortality in general and infant mortality rate, in particular, are indicators of standard of living and wellbeing of a society or a country. Sub-Saharan African countries are of the level of the developed countries of the West in the 19<sup>th</sup> century. Poverty is the number one determinant of an infant or child's survival and wellbeing. Poverty determines to a great extent the geographical location of the infant or the child. The geographical location on the other hand predicts the child's health and survival. Poor hygiene and a polluted environment have been well documented as the major causes of childhood diseases which lead to high infant and child mortality [14, 19, 20, 21].

The disparity in infant and child mortality between rural and urban areas is even more apparent in developing countries where the mortality statistics show a disparity between the urban dwellers and the rural dwellers. A child born to parents living in urban areas have a higher probability of survival than their counterparts in the rural areas.

Infant mortality is a reference indicator for measuring the standard of living, development or wellbeing of a society as well as future workforce of a country or a nation. The literature on infant mortality rate is robust, but very few studies focused on the zonal differences in Nigeria with specific emphasis on the role of social-economic status in the urban-rural disparities of infant mortality rate. This paper is an attempt to fill this gap that currently exists in the literature on this important subject area. Understanding the zonal differentials in infant and child mortality rate in Nigeria is important in these respects:

First, by knowing the zonal differences, policy makers will be in a better position to target the zones in Nigeria where there are critical health needs of infants and children. Importantly, by knowing the urban-rural differences caused by socio-economic inequities, health policies can now be channeled to address the needs of the affected areas. In Nigeria, most of the services are concentrated in the urban areas where most of the elite live. There are very few resources in the urban slums and in the rural areas. The rural areas also have the disadvantage of having few educated and well-informed people who are the opinion leaders in the area through whom information dissemination gets to the general rural population. The beliefs, knowledge, attitudes, and practices that enable the survival of newborns through the first year of life and sometimes through the first five years of life are deficient in most rural areas of Nigeria.

With Millennium Development Goal (MDG) target date of 2015 now upon us, it is obvious that Nigeria will not meet the health goals of reducing infant and child mortality rates. It has, however, made significant efforts to close the huge health gap that exists between the developed countries of the world and the developing countries of Africa.

The level of infant mortality in a society is a strong indicator of the standard of living of society. Infant mortality rate is one of the major causes of the low life expectancy at birth in Nigeria. Most of the deaths occur in the first month (28 days of life) or neonatal mortality or the first year of life (infant mortality) or the first five years of life or child mortality.

Sub-Saharan Africa accounts for 45% of child mortality but accounts for only 20% of the world's births [22]. Nigeria accounts for a significant percentage of the infant mortality in Africa.

Although the gap in the infant and child mortality between developed countries and developing countries has narrowed since 1970, the gap has not closed because the developed countries are moving at a faster pace than the developing countries of Africa, especially Nigeria. Over one million children die annually in Nigeria from preventable diseases, making the country one of the least successful of African countries in achieving improvements in child survival during the past four decades [23]. Living in communities with a low proportion of mothers who had hospital delivery was associated with lower rates of full immunization when compared with high proportion of hospital delivery [24]. The study concludes that demographic and socioeconomic characteristics are important in explaining the full immunization differentials found between migrant and non-migrant groups, indicating that migrant selectivity is a significant factor in the immunization of children of migrants. It also found that individual and community level characteristics are important determinants of the likelihood of full immunization uptake among migrant groups.

Infants and children are highly fragile and totally dependent on the adult members of society. The high infant and child mortality rates in Nigeria are due to the inability to manage the problems that cause infant mortality. Japan and Sweden, the two countries that have the lowest infant mortality rates in the world, have the highest life-expectancy rates at birth. Both countries have infant mortality rates of below 3 per 1,000 live births. The world average is 46 per 1,000 live births. The above can be contrasted with the developing country of Nigeria where the infant mortality rate is over 78 per 1,000 live births and the lowest life expectancies in the world of about 40 years are found in sub-Saharan Africa. This is almost what the developed countries of Europe and North America had in the 19<sup>th</sup> century.

One of the major causes of death among infants is diarrhea dehydration [25, 26, 27]. This form of dehydration can be caused by any disease or imbalance or from polluted water. This is common among the poor in equatorial Africa or the sub-Saharan Africa. Improving the levels of income and education at both the societal and individual level is a solution to reducing high infant mortality in sub-

Saharan Africa. Improvement in the standard of living is in line with what the developed countries of the world did to lower their infant mortality rates.

In light of this background, this paper seeks to examine the zonal differences in infant mortality rates in Nigeria. Specifically, this study seeks to critically examine the role of SES within the urban and rural areas as well as time differentials in infant mortality in Nigeria from 2003-2008. Mothers residing in countries with higher literacy rates were more likely to use maternal health care, after adjusting for national economic development and individual socio-demographic factors [28]. The study highlights the importance of literacy in maternal health care use in sub-Saharan Africa. Biological and demographic variables were found to be more important determinants of infant and neonatal mortality in Kenya. Their study found maternal awareness and level of education to be important in child survival in urban areas of Kenya [29]. They conclude that once a child has survived the first month, ethnicity becomes the most important determinant of mortality in both urban and rural settings.

Infant and child mortality has been found to be unevenly distributed in the six geopolitical zones of Nigeria [30]. Their study found maternal education and location of residence to have strong association in infant and child mortality in Nigeria. They found Northwest and Northeast geopolitical zones to have the highest under-five mortality rates of 188 per 1,000 live births and 175.2 deaths respectively. Their study found the north central region with the lowest under-five mortality of 84.4 per 1,000 children. However, their study did not address the urban rural differences and how this disparity has changed over time. This study addresses this gap in the literature.

Countries with high infant mortality rates have low life expectancy, and the countries with low infant mortality rates have high life expectancy rates. The urban areas in all the regions fared better than the rural areas. This is because the disparity in health between the rural and urban areas is very high in Nigeria. In addition to the disparity of health between the rural and urban areas is a wide gap in the sanitation and hygiene differentials of the two environmental locations. Poverty is concentrated in the rural areas of Nigeria. The rural areas of Nigeria lack the amenities that provide enabling environment for the survival of children and infants. The rural areas have little or no adequate drinking water, no health care facilities, and no adequate affordable and accessible transportation available when compared with the urban areas. Adequate and sufficient nutrition is also lacking in the rural areas. The urban areas are far better than the rural areas in the six geopolitical zones of Nigeria in offering an optimal environment that enhances the survival of children and infants.

Both infant and child mortality decreased in urban and rural Nigeria between the 2003 and the 2008 DHS surveys. The rate of decrease in infant mortality in urban Nigeria was 16.46 percent while the decrease in rural Nigeria was 21.46 percent. The decrease in rural areas was 1.3 times greater than the decrease in urban area over the same period. As well, between 2003 and 2005, child mortality decreased in urban areas by 20.21 percent. During the same time,

child mortality decreased in the rural areas by 78.5 percent. This represents a significant decrease of 3.88 times in the urban/rural disparity in child mortality in Nigeria.

Nigeria has a large population relative to its size in both sub-Saharan Africa and the world. A comparison of Nigeria and sub-Saharan Africa shows that Nigeria lags behind on both infant and child mortalities. In 2010, we see that infant mortality fell from 105 to 76 in sub-Saharan Africa and from 126 to 88 in Nigeria. Under-5 mortality had a similar trend. In Nigeria, it fell from 213 to 143 while in sub-Saharan Africa it fell from 174 to 121. On an annualized basis, this represents a decrease of approximately 2.98 percent for Nigeria and 2.77 percent for sub-Saharan Africa. The annualized rate of decrease for Nigeria in infant mortality over the same period was 2.74 percent while for sub-Saharan Africa it was 2.51 percent [22].

### **3 Methods**

#### **Data Description**

This study utilized 2003 and 2008 DHS pooled data of Nigeria. DHS selected participants for the study through probability sampling procedures. Pooling data from different surveys requires that we account for the differences in survey years and regions. This is achieved by creating a strata identification using year and region as the stratification factor. DHS selected participants for the study through probability sampling procedures. It separated urban and rural strata, to provide valid samples of urban and rural populations at the national level. The DHS surveys were conducted in single rounds with two main survey instruments: a household schedule instrument and an individual questionnaire for women of reproductive age 15 to 49 years. Whereas the household schedule collects a list of household members and basic household demographic information and was used to select respondents who were eligible for individual survey, the individual survey provided information on household assets, reproductive history, health, and nutritional status of the women's young children. Our data is made up of 886 primary survey units (PSU). There are 34,676 households in the survey. The rural population is made up of 24,945 households or 71.9 percent of the data while the urban household is 9,731 or 28.1 percent of the households. 2003 DHS data constitute 17.35 percent of the data while the majority, 82.65 percent is from the 2008 DHS survey.

#### **Statistical Methods**

The analyses were carried out with Stata [31]. The complex nature of DHS survey design required us to apply sampling weights to correct for bias in probability selection. Logistic regression analysis technique is used to examine the difference in odds of mortality between the different wealth quintiles within urban

and rural areas. Using logistic regression technique, we are able to obtain the odds ratio of which group has lower or higher odds of child mortality based on wealth quintile and on geographic location in the various zones of Nigeria. Independently pooled cross-section is obtained by sampling randomly from large population at different points in time usually, but not necessarily, over different years [32]. Wealth as a measure of economic status has several advantages. It represents a more permanent status than does either income or consumption [33]. The DHS surveys use the following assets and services in constructing the wealth index.: type of flooring, water supply, sanitation facilities, electricity, radio, television, telephone, refrigerator, type of vehicle, persons per sleeping room, ownership of agricultural land, domestic servant and some country-specific items.

The model is given by a linear probability model (LPM) measure of a household experiencing infant or child mortality. If the household has lost a child before or at the 59<sup>th</sup> month, child mortality,  $Y=1$ , otherwise,  $Y=0$ . If the household has lost a child before or at the 12<sup>th</sup> month, infant,  $Y=1$ , otherwise,  $Y=0$ .

$$Y = \alpha + \beta X + u \quad (1)$$

$Y$  is a binary variable that takes the values of 1 or 0.  $X$  is a vector of independent variables,  $\alpha$  is the intercept term, and  $\beta$  is the vector of coefficients to be estimated, while  $u$  is the error term. The problem with the LPM is that the error terms are heteroskedastic. Also,  $U$  is not normally distributed since  $Y$  takes only two values of 1 or 0. The predicted probabilities can be greater than 1 or less than 0. In light of the above problems of LPM, we see the logistic regression as adequate for this study where the outcome variable takes the values of 1 or 0. Thus, we can write the logistic equation to be estimated as follows:

$$\text{Log} (P_i/1-P_i) = \alpha + \beta X + u \quad 2$$

Logistic regression with multiple predictor variables is well suited for this study. Each of the  $\beta$  coefficients estimated is a measure of the expected change in the log odds of a household experiencing infant or child mortality for a unit increase in the corresponding predictor variable, holding the other predictor variables constant at certain value.  $P$  is the probability of dying before the age of 59 months for the  $i^{\text{th}}$  child.  $\text{Ln} (P/1-P)$  is the logit transformation,  $\alpha$  denotes the constant term,  $\beta$  is coefficient for the dummy variable rural or urban residence and  $X_i$  denotes all other covariates.

### Exposure Variables

The categorical and socio-economic and socio-demographic variables used for the multivariate analysis are: place of residence (urban / rural residence), wealth quintiles (poorest 20% is assigned the lowest quintile and the richest 20% is assigned the highest quintile), mother's educational attainment (no education, primary, secondary and higher), Geopolitical regions or zones of six (Northcentral, Northeast, Northwest, Southeast, South-south and Southwest), age at first birth (less than 18 years, greater than 18 years and less than 25 years,



greater than 25 years and less than 30 years, greater than 30 years and less than 35 years, and greater than 35 years), religion (Christians, Islam, Traditionalist, Other), use of health facility (use / not use health facility).

As mentioned earlier, beliefs and attitudes do impact health practices. To try and capture this, we include religion. To measure the effects of community level variables, we include health facility usage in our model. We expect a reduction in infant and child mortality for households that make use of health facilities.

### **Analysis**

Table 1 is pooled 2003 and 2008 DHS zonal distribution of risk of infant mortality by residence in Nigeria. The distribution of risk in infant mortality in the six zones with reference to the wealth quintiles, mother's educational attainment, age of the mother at first birth, religion, use of health facilities and the place of residence whether urban or rural. Table 2 is pooled 2003 and 2008 DHS zonal distribution of risk of child mortality. Table 3 is the multivariate logistic regression that shows the odds ratio of infant and child mortality based on zonal place of residence, wealth quintiles, mother's educational attainment, mother's age at first birth, use of health facility, religion, birth order less than four, number of births in the last three years, and place of residence either rural or urban. Table 4 is the multilevel logistic regression. The empty model is carried out with no predictor variable. This is the fixed effects part of the model which provides the basis for evaluating the level of variation in infant and child mortality due to zone and households. The intercept of the base model without predictors shows the mean of infant and child mortality. The error variance is the variance in infant and child mortality with no random effects by zones. The difference in variability in infant and child mortality that is unique to these zones is obtained by adding a random intercept to base model. If the random intercept variance is greater than zero, it means that there is variability in infant and child mortality that is unique to these zones.

## **4 Results of Descriptive Statistics**

### **Differentials in Infant Mortality**

Table 1 shows the zonal distribution of risk of infant mortality in Nigeria for the pooled 2003 and 2008 DHS. From Table 1, we see that the risk of infant mortality among the poorest wealth quintiles is highest in Northeast zone followed by the Northwest zone. However, among the poorer wealth quintiles, Northwest zone has the highest risk of infant mortality followed by the Northeast zone. Among the middle and richer wealth quintiles, the Southeast and South-south zones have the highest risks of infant mortality respectively. Among the richest wealth quintiles, the Southwest zone has the highest risk of infant mortality

followed by South-south and Southeast zones. Overall, the risk of infant mortality is inversely related to wealth quintiles.

Table 1 shows that the risk of infant mortality associated with mothers with no education is highest in the Northwest zone followed by the Northeast zone. Among those with primary education, Southeast and South-south have the highest risks of infant mortality. Among mothers with secondary level of education, South-south has the highest risk of infant mortality followed by the Southeast zone and Southwest. Also, Table 1 shows that mothers education is inversely related to the risk of infant mortality in Nigeria.

Among mothers who had their first birth at age less than 18 years, Northwest zone has the highest risk of infant mortality followed by the Northeast zone. For mothers who had their first birth at age greater than 18 years and less than or equal to 25 years, Southeast zone has the highest risk of infant mortality followed by South-south zone.

Table 1 also shows that the risk of infant mortality is 2.85 times higher for those who do not use health facility. This difference is higher in Northwest zone where it is 4.4 times followed by Northeast where the difference is 3.3 times. Northwest has the highest risk of infant mortality difference between urban and rural residents. The difference between urban and rural Northwest zone is 6.2 times compared with the second highest Northeast with 3.7 times difference between the urban and rural areas.

### **Differentials in Child Mortality**

Table 2 shows the pooled 2003 and 2008 DHS zonal distribution of risk for child mortality in Nigeria. The results shown in Table 2 are similar to those in table 1. Wealth, mother's education and mother's age at first birth are inversely related to the risk of child mortality. Table 2 shows that the risk of child mortality is less for those who use health facility in all the zones. Similarly, the risk of child mortality is less for the urban areas than rural areas in all the zones. Again Northwest zone and Northeast zone have the highest gaps in the risk of child mortality than the other zones of Nigeria. The Southwest zone has the lowest risk of child mortality than all the other zones of Nigeria. This is particularly not surprising given the concentration of many health facilities in this zone and the level of educational attainment of mothers in the zone compared to mothers in the Northwest and Northeast zones.

### **Multivariate Analysis**

#### **Infant Mortality**

Table 3 is the multivariate logistic regressions on Infant and child mortality in the six zones of Nigeria. Model 1 is pooled infant mortality. Model 1 shows that wealth is only significant in the richer and richest quintiles. Also, the level of mother's education attainments is only significant for those who have

higher education. Among the six zones, only the southwest zone showed a significant decrease in the risk of infant mortality compared with the north central zone. Infant mortality decreased for mothers who had their first birth at age more than 18 years and age less than or equal to 25 years. Infant mortality increased for those who practiced other religion. From table 1, infant mortality decreased for birth order less than or equal to 4 and it is very significant. Infant mortality also decreased for those who used health facilities over the past 12 months.

Model 2 depicts the results for infant mortality with urban/rural residence as an exposure variable in the model. While the result on wealth is similar, there are some differences. For the richer wealth quintile, infant mortality is higher by about 7.9% in Model 2 compared to Model 1 and 12.50% higher of the richest wealth quintile. This pattern is similar in all the variables. Table 3 Model 2 shows that the odds of infant mortality are 18% higher in the rural areas of Nigeria compared to the urban areas.

### **Child Mortality**

Model 2 is pooled child mortality in Nigeria. The results from Model 3 show that wealth in the richer and richest quintiles is highly significant in reducing the odds of child mortality in Nigeria. Mother's level of educational attainment is significant both for secondary and higher education levels in reducing the odds of child mortality in Nigeria. The odds of child mortality are 17%, 22%, and 17% higher in Northeast, Northwest, and Southeast zones of Nigeria respectively compared to the Northcentral zone of Nigeria. While the result is not significant for the south-south zone, it shows that the odds of child mortality are higher by 12% compared with Northcentral zone of Nigeria. Only the southwest zone had 19% lower odds of child mortality compared to the Northcentral zone and it is also significant.

The odds of child mortality are 10% lower for mothers who had the first birth between the ages of 19 and 25 compared to those who had the first birth at ages 18 or less. For religion, only those who practiced other religion and traditional religion have higher odds of child mortality. Those who used health facilities in the last 12 months has 10.20% lower odds of child mortality while those whose birth order is equal or lower than 4 had 16.54% lower odds of child mortality. Model 4 is child mortality in Nigeria with rural/urban residence as an exposure variable. The results are similar to the ones obtained from model 2 for infant mortality. The odds of child mortality are 19% higher in rural Nigeria compared to urban Nigeria.

### **Multilevel Analysis**

We use a two level multilevel logistic regression analysis with 898 households nested within 6 zones or regions. Table 4 presents the results of multilevel regression. The intercept of the base model without predictors shows the mean mortality in infant and child mortality. The error variance is the variance in infant and child mortality with no random effects by zones. This is also known

as the proportional change in variance (PCV) [34]. The interclass correlation (ICC) or variance partition coefficient (VPC) for both infant and child mortality of zones nested over households is .03 respectively. This result is very low and may lead one to question the benefit of multilevel logistic regression. This result shows that 1.27% and 1.55% of the total individual differences in both infant and child mortalities respectively is attributable to contextual clustering factors.

Table 4 presents the multilevel logistic regression results for infant and child mortality in Nigeria. In the Table, Model 5 is a reference point used to compare the results of Models 6 and 7. Models 6 and 7 shows that 7.9% and 1.3% variability in the risk of infant mortality respectively occurred at the zonal level and household level due to demographic and socio-economic status.

Model 8 is the empty model for the risk of child mortality in Nigeria. Model 9 and 10 show that the risk of variability in child mortality due to socio-economic status to be 10.3% and 1.6% respectively from the zones and households.

### **Principal Findings**

We find that wealth and mother's educational attainment is a major factor in reducing infant and child mortality in Nigeria between 2003 and 2008. We also find that the risk of both infant and child mortality is higher in the Northwest and Northeast zones of Nigeria than any other zones. Also, the southwest region has the lowest risk of both infant and child mortalities in Nigeria.

Our study finds no evidence of statistically significant difference in the risk of both infant and child mortalities between the urban and rural poorer and poorest wealth quintiles in Nigeria. This finding is very important since previous studies did not make any effort to distinguish this important difference between the rural poorer, poorest and the urban poorer, poorest [9,35,10,30].

## **5 Discussion**

Our study pooled 2003 and 2008 DHS data of Nigeria to study the zonal differences in infant and child mortality. This study used both multivariate and multilevel regression analysis to understand the level of association of socio-economic status as well as the source of variability in infant and child mortality in Nigeria. Knowing or understanding the source of variability outweighs the small coefficients that sometimes result in inter-class correlation (ICC) [36]. Multilevel analysis, sometimes results in informative insights that are sometimes difficult to obtain from measures of association. The results from Table 3 and 4 indicate that the multivariate regression overestimates the coefficients when compared with the multilevel regression results. This finding is similar to the findings of [37].

It is evident from these results that effort to reduce both infant and child mortality in Nigeria should target the Northeast, Northwest, Southeast, Northcentral, South-south and Southwest in this order to achieve maximum

results. One of the limitations of this study is that it does not account for what has transpired beyond 2008 data.

Our findings also show differences in child and infant mortality rates between the urban poor and the wealthy. The urban poor fares better than their rural counterparts despite their poverty; they do have some access to modern facilities such as good drinking water, light or electricity, health care facilities, vital health information and other amenities that enhance the survival of children and infants. This finding cut across all the six geopolitical zones in Nigeria and is consistent with previous findings on the topic [35,38,15,16,17,39,40].

## **6 Conclusion and Policy Implications**

This study established the differentials in infant and child mortality in urban and rural Nigeria. It also examined the geo-political differences in infant and child mortality in the six geo-political zones of Nigeria. Our results show that there is a disparity in both infant and child mortalities between the urban and rural areas. Our findings show that infant mortality is higher for the Northeast and Northwest zones compared to all the other zones of Nigeria.

Among mothers with no education, the risk of infant and child mortality is higher in northwest, northeast, northcentral, southeast, southwest and south-south in that order. This result is consistent with the conclusion that very high infant mortality rate is due to poor maternal health education [41]. The study also found no evidence of any statistically significant difference in the risk of infant and child mortality between the rural poorer and poorest wealth quintiles and their urban counterparts. Furthermore, only 7.9% and 1.3% variability in the risk of infant mortality respectively occurred at the zonal level and household level were due to differences in demographic and socio-economic status. Similarly, the study found that 10.3% and 1.6% variability in child mortality were due to differences in demographic and socio-economic status respectively from the zones and households.

To increase the survival rates of children and infants in Nigeria, policies and programs to urgently address poverty alleviation and increase the level of maternal education and literacy should be implemented in all the zones with the highest infant and child mortality rates in Nigeria. Public health policies geared toward reducing infant and child mortality should devote a significant amount of resources toward Nigeria if we are to succeed in achieving the millennium goal of infant and child mortality reduction in both Nigeria and sub-Saharan Africa.

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Table 1 Zonal Distribution of Risk of Infant Mortality by Residence in Nigeria Pooled 2003 and 2008 DHS

Infant Mortality	North Central	North East	North West	South East	South South	South West	Total Nigeria
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Pooled 2003 & 2008 DHS	6061 (17.48)	8046 (23.20)	9768 (28.17)	2974 (8.58)	3887 (11.21)	3940 (11.36)	34676 (100)
<b>Wealth Quintiles</b>							
Poorest	135 (2.23) ***	382 (4.75) ***	289 (2.96) **	33 (1.11) **	37 (0.95)	19 (0.48) **	895 (2.58) ***
Poorer	139 (2.29) ***	191 (2.37) ***	332 (3.40) **	59 (1.98) **	61 (1.57)	40 (1.02) **	822 (2.37) ***
Middle	112 (1.85) ***	123 (1.53) ***	160 (1.64) **	70 (2.35) **	80 (2.06)	39 (0.99) **	584 (1.68) ***
Richer	73 (1.20) ***	52 (0.65) ***	87 (0.89) **	76 (2.56) **	85 (2.14)	52 (1.32) **	425 (1.23) ***
Richest	43 (0.71) ***	7 (0.08) ***	35 (0.36) **	41 (1.39) **	54 (1.39)	71 (1.80) **	251 (.72) ***
<b>Mother's Education</b>							
No Education	247 (4.08) ***	574 (7.13) ***	737 (7.55) ***	51 (1.71) ***	26 (0.67)	42 (1.07) **	1677 (4.84) ***
Primary	159 (2.62) ***	134 (1.67) ***	113 (1.16) ***	98 (3.29) ***	119 (3.06)	79 (2.00) **	702 (2.02) ***
Secondary	84 (1.39) ***	45 (0.56) ***	42 (0.43) ***	116 (3.90) ***	155 (3.99)	90 (2.28) **	532 (1.53) ***
Higher	12 (0.20) ***	2 (0.02) ***	11 (0.11) ***	14 (0.47) ***	17 (0.44)	10 (0.25) **	66 (0.19) ***
<b>Age of Mother at first Birth</b>							
Age < 18	190 (3.13)	427 (5.31) ***	545 (5.58) ***	54 (1.81) +	114 (2.93)	53 (1.35)	1383 (3.99) **
Age > 18 & Age <= 25	276 (4.55)	297 (3.69) ***	339 (3.47) ***	169 (5.68) +	182 (4.68)	131 (3.32)	1394 (4.02) **
Age > 25 & Age <= 30	33 (0.54)	18 (0.22) ***	14 (0.14) ***	40 (1.34) +	18 (0.46)	31 (0.79)	154 (0.44) **

Age > 30 & Age <= 35	2 (0.03)	12 (0.15) ***	5 (0.05) ***	9 (0.30) +	3 (0.08)	6 (0.15)	37 (0.11) **
Age > 35	1 (0.02)	1 (0.01) ***	-	7 (0.24) +	-	-	9 (0.03) **
Religion							
Christians	268 (4.42) ***	118 (1.47) **	42 (0.43) *	236 (7.94) **	272 (7.00)	116 (2.94)	1052 (3.03) **
Islam	181 (2.99) ***	477 (5.93) **	658 (6.74) *	10 (0.34) **	36 (0.93)	94 (2.39)	1456 (4.20) **
Traditionalist	35 (0.58) ***	155 (1.93) **	192 (1.97) *	23 (0.77) **	5 (0.13)	11 (0.28)	421 (1.21) **
Other	18 (0.30) ***	5 (0.06) **	11 (0.11) *	10 (0.34) **	4 (0.10)	0 (0.00)	48 (0.14) **
Did not Use Health Facility	354 (5.84)	579 (7.20)	737 (7.55)	194 (6.52)	215 (5.53) *	123 (3.12) *	2202 (6.35) *
Use of Health Facility	148 (2.44)	176 (2.19)	166 (1.70)	85 (2.86)	102 (2.62) *	98 (2.49) *	775 (2.23) *
Urban	101 (1.67) ***	160 (1.99) ***	125 (1.28) ***	91 (3.06) ***	71 (1.83) ***	96 (2.44) ***	641 (1.85) ***
Rural	401 (6.62) ***	595 (7.39) ***	778 (7.96) ***	188 (6.32) ***	246 (6.33) ***	125 (3.17) ***	2333 (6.73) ***

+  $p < 0.10$ , \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table 2 Zonal Distribution of Risk of Child Mortality by Residence in Nigeria Pooled 2003 and 2008 DHS

Child Mortality	North Central	North East	North West	South East	South	South West	Total Nigeria
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Pooled 2003 & 2008 DHS	6061 (17.48)	8046 (23.20)	9768 (28.17)	2974 (8.58)	3887 (11.21)	3940 (11.36)	34676 (100)
<b>Wealth Quintiles</b>							
Poorest	168 (2.77) ***	523 (6.50) ***	449 (4.60) ***	38 (1.28) *	46 (1.18) **	21 (0.53) **	1245 (3.59) ***
Poorer	162 (2.67) ***	280 (3.48) ***	485 (4.97) ***	69 (2.32) *	77 (1.98) **	51 (1.29) **	1124 (3.24) ***
Middle	153 (2.52) ***	182 (2.26) ***	234 (2.40) ***	86 (2.89) *	102 (2.62) **	46 (1.17) **	803 (2.32) ***
Richer	90 (1.48) ***	69 (0.86) ***	128 (1.31) ***	89 (2.99) *	115 (2.96) **	66 (1.68) **	557 (1.61) ***
Richest	51 (0.84) ***	15 (0.19) ***	44 (0.45) ***	53 (1.78) *	65 (1.67) **	85 (2.16) **	313 (0.90) ***
<b>Mother's Education</b>							
No Education	317 (5.23) ***	823 (10.23) ***	1098 (11.24) ***	58 (1.95) ***	39 (1.00)	47 (1.19) ***	2382 (6.87) ***
Primary	192 (3.17) ***	183 (2.27) ***	173 (1.77) ***	121 (4.07) ***	156 (4.01)	101 (2.56) ***	926 (2.67) ***
Secondary	103 (1.70) ***	57 (0.71) ***	55 (0.56) ***	141 (4.74) ***	190 (4.89)	111 (2.82) ***	657 (1.89) ***
Higher	12 (0.20) ***	6 (0.07) ***	14 (0.14) ***	15 (0.50) ***	20 (0.51)	10 (0.25) ***	77 (0.22) ***
<b>Age of Mother at first Birth</b>							
Age < 18	242 (3.99)	597 (7.42) +	814 (8.33) ***	62 (2.08)	143 (3.68) +	60 (1.52)	1918 (5.53) *
Age > 18 & Age <= 25	343 (5.66)	434 (5.39) +	491 (5.03) ***	212 (7.13)	235 (6.05) +	170 (4.31)	1885 (5.44) *
Age > 25 & Age <= 30	35 (0.58)	25 (0.31) +	28 (0.29) ***	44 (1.48)	23 (0.59) +	33 (0.84)	188 (0.54) *

Age > 30 & Age <= 35	3 (0.05)	12 (0.15) <sup>+</sup>	7 (0.07) <sup>***</sup>	10 (0.34)	4 (0.10) <sup>+</sup>	6 (0.15)	42 (0.12) <sup>*</sup>
Age > 35	1 (0.02)	1 (0.01) <sup>+</sup>	-	7 (0.24)	-	-	9 (0.03) <sup>*</sup>
Religion							
Christians	323 (5.33) <sup>**</sup>	166 (2.06) <sup>***</sup>	52 (0.53) <sup>*</sup>	284 (9.55) <sup>*</sup>	344 (8.85)	143 (3.63)	1312 (3.78) <sup>**</sup>
Islam	232 (3.83) <sup>**</sup>	658 (8.18) <sup>***</sup>	992 (10.16) <sup>*</sup>	16 (0.54) <sup>*</sup>	50 (1.29)	108 (2.74)	2056 (5.93) <sup>**</sup>
Traditionalist	48 (0.79) <sup>**</sup>	234 (2.91) <sup>***</sup>	282 (2.89) <sup>*</sup>	24 (0.81) <sup>*</sup>	6 (0.15)	17 (0.43)	611 (1.76) <sup>**</sup>
Other	21 (0.35) <sup>**</sup>	11 (0.14) <sup>***</sup>	14 (0.14) <sup>*</sup>	11 (0.37) <sup>*</sup>	5 (0.13)	1 (0.03)	63 (0.18) <sup>**</sup>
Use Health Facility	179 (2.95)	251 (3.12)	237 (2.43)	103 (3.46)	130 (3.34) <sup>*</sup>	119 (3.02) <sup>*</sup>	1019 (2.94)
Did not Use of Health Facility	445 (7.34)	818 (10.17)	1103 (11.29)	232 (7.80)	275 (7.07) <sup>*</sup>	150 (3.81) <sup>*</sup>	3023 (8.72)
Urban	125 (2.06) <sup>***</sup>	228 (2.83) <sup>***</sup>	179 (1.83) <sup>***</sup>	115 (3.87) <sup>***</sup>	84 (2.16) <sup>***</sup>	118 (2.99) <sup>***</sup>	849 (2.45) <sup>***</sup>
Rural	499 (8.23) <sup>***</sup>	841 (10.45) <sup>***</sup>	1161 (11.89) <sup>***</sup>	220 (7.40) <sup>***</sup>	321 (8.26) <sup>***</sup>	151 (3.83) <sup>***</sup>	3193 (9.21) <sup>***</sup>

<sup>+</sup>  $p < 0.10$ , <sup>\*</sup>  $p < 0.05$ , <sup>\*\*</sup>  $p < 0.01$ , <sup>\*\*\*</sup>  $p < 0.001$

Table 3 Odds ratios and 95% confidence intervals for zonal and household level risk factors for Infant and Child Mortality

Independent Variables	Model 1 OR (95% CI) Pooled infant Mortality	Model 2 OR (95% CI) Pooled infant Mortality & Urban/Rural	Model 3 OR (95% CI) Pooled Child Mortality	Model 4 OR (95% CI) Pooled Child Mortality & Urban/Rural
<b>Wealth Quintiles</b>				
Poorest wealth quintiles	Reference (1.00)	Reference (1.00)	Reference (1.00)	Reference (1.00)
Poorer wealth quintile	0.99 (0.88-1.12)	1.00 (0.89-1.14)	1.02 (0.92-1.14)	1.03 (0.92-1.15)
Middle wealth quintile	0.92 (0.81-1.06)	0.96 (0.83-1.10)	0.92 (0.82-1.04)	0.96 (0.85-1.08)
Richer wealth quintile	0.80** (0.68-0.93)	0.86 <sup>+</sup> (0.73-1.02)	0.80** (0.70-0.92)	0.87 <sup>+</sup> (0.75-1.01)
Richest wealth quintile	0.64*** (0.53-0.79)	0.72** (0.56-0.91)	0.62*** (0.51-0.75)	0.71** (0.57-0.87)
<b>Mother's Education</b>				
No education	Reference (1.00)	Reference (1.00)	Reference (1.00)	Reference (1.00)
Primary education	0.97 (0.85-1.11)	0.96 (0.86-1.11)	0.97 (0.87-1.09)	0.98 (0.87-1.09)
Secondary education	0.94 (0.79-1.11)	0.94 (0.79-1.10)	0.88 <sup>+</sup> (0.76-1.02)	0.88 <sup>+</sup> (0.76-1.02)
Higher education	0.69 <sup>+</sup> (0.47-1.01)	0.69 <sup>+</sup> (0.47-1.02)	0.62** (0.44-0.88)	0.62** (0.44-0.88)
<b>Geo-Political zone</b>				
North Central region	Reference (1.00)	Reference (1.00)	Reference (1.00)	Reference (1.00)
North East region	1.04 (0.89-1.22)	1.06 (0.91-1.24)	1.17* (1.01-1.35)	1.19* (1.03-1.37)
North West region	1.03 (0.88-1.21)	1.03 (0.89-1.21)	1.22** (1.05-1.41)	1.22** (1.05-1.41)
South East region	1.17 (0.96-1.42)	1.18 (0.97-1.43)	1.17 <sup>+</sup> (0.98-1.40)	1.18 <sup>+</sup> (0.99-1.41)
South-South region	1.06 (0.88-1.27)	1.04 (0.87-1.26)	1.12 (0.94-1.33)	1.10 (0.93-1.31)
South West region	0.83 <sup>+</sup> (0.68-1.01)	0.84 <sup>+</sup> (0.69-1.02)	0.81* (0.68-0.98)	0.82* (0.68-0.98)
<b>Mother's Age at first birth</b>				
Age <= 18	Reference (1.00)	Reference (1.00)	Reference (1.00)	Reference (1.00)
Age > 18 & <= 25	0.89* (0.70-1.08)	0.89* (0.81-0.98)	0.90* (0.83-0.98)	0.90* (0.83-0.98)
Age > 25 & <= 30	0.87 (0.70-1.08)	0.87 (0.70-1.08)	0.84 (0.69-1.03)	0.84 (0.69-1.03)

Age > 30	1.18 (0.80-1.74)	1.18 (0.80-1.74)	1.03 (0.73-1.47)	1.03 (0.72-1.47)
Religion				
Catholic	Reference (1.00)	Reference (1.00)	Reference (1.00)	Reference (1.00)
Protestant	1.00 (0.84-1.19)	0.99 (0.83-1.19)	0.98 (0.83-1.14)	0.97 (0.83-1.14)
Islam	0.91 (0.75-1.12)	0.92 (0.75-1.12)	0.93 (0.77-1.11)	0.93 (0.78-1.11)
Traditional	1.08 (0.87-1.35)	1.08 (0.87-1.35)	1.17 (0.96-1.43)	1.18 (0.97-1.43)
Other	3.16 <sup>***</sup> (1.65-6.03)	3.21 <sup>***</sup> (1.68-6.12)	2.73 <sup>**</sup> (1.41-5.28)	2.77 <sup>**</sup> (1.43-5.36)
Health facility Use				
No health facility use	Reference (1.00)	Reference (1.00)	Reference (1.00)	Reference (1.00)
Used health facility	0.90 <sup>+</sup> (0.81-1.00)	0.91 <sup>+</sup> (0.82-1.01)	0.89 <sup>*</sup> (0.82-0.99)	0.90 <sup>*</sup> (0.82-0.99)
Birth Order <=4	0.84 <sup>***</sup> (0.76-0.93)	0.84 <sup>***</sup> (0.76-0.93)	0.83 <sup>***</sup> (0.77-0.91)	0.83 <sup>***</sup> (0.77-0.91)
Place of Residence				
Urban		Reference (1.00)		Reference (1.00)
Rural		1.18 <sup>*</sup> (1.03-1.34)		1.19 <sup>**</sup> (1.06-1.33)
Constant	0.13 <sup>***</sup> (0.10-0.16)	0.11 <sup>***</sup> (0.09-0.14)	0.17 <sup>***</sup> (0.14-0.21)	0.14 <sup>***</sup> (0.11-0.18)
	(-17.98)	(-16.66)	(-17.26)	(-16.37)
<i>N</i>	34466	34466	34466	34466
<i>F-Value</i>	8.09 <sup>***</sup>	7.90 <sup>***</sup>	14.79 <sup>***</sup>	14.43 <sup>***</sup>

*t* statistics in parentheses

<sup>+</sup>  $p < 0.10$ , \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

CI: Confidence Interval, OR: Odds Ratios

Table 4 Multilevel Odds ratios and 95% confidence intervals for zonal and household level risk factors of Infant and Child Mortality

Independent Variables	Empty Model 5 Infant OR (95%) Confidence Interval	Model 6 Zonal Infant OR (95%) Confidence Interval	Model 7 Household Infant OR (95%) Confidence Interval	Empty Model 8 Child OR (95%) Confidence Interval	Model 9 Zonal Child OR (95%) Confidence Interval	Model 10 Household Child OR (95%) Confidence Interval
Geo-Political Zones						
North Central Zone		Reference (1.00)	Reference (1.00)		Reference (1.00)	Reference (1.00)
North East Zone		1.01* (1.00-1.02)	1.00 (0.99-1.01)		1.03*** (1.02-1.04)	1.02** (1.00-1.03)
North West Zone		1.01* (1.00-1.02)	1.00 (0.99-1.01)		1.03*** (1.02-1.04)	1.02** (1.01-1.03)
South East Zone		1.01+ (0.99-1.02)	1.02* (1.00-1.03)		1.01 (0.99-1.02)	1.02** (1.00-1.04)
South-South Zone		0.99 (0.98-1.01)	1.00 (0.99-1.02)		1.00 (0.99-1.01)	1.01* (1.00-1.03)
South West Zone		(-0.22) 0.97*** (0.96-0.98)	(1.14) 0.99 (0.98-1.00)		(0.19) 0.96*** (0.95-0.98)	(2.05) 0.99 (0.97-1.00)
Wealth Quintiles						
Poorest Wealth Quintile			Reference (1.00)			Reference (1.00)
Poorer wealth quintile			1.00 (0.99-1.01)			1.00 (0.99-1.01)
Middle wealth quintile			0.99 (0.98-1.00)			0.99 (0.98-1.00)
Richer wealth quintile			0.98** (0.97-0.99)			0.98** (0.97-0.99)
Richest wealth quintile			0.97** (0.96-0.99)			0.97*** (0.96-0.99)
Mother's Education						
No education			Reference (1.00)			Reference (1.00)
Primary education			0.99 (0.99-1.01)			0.99 (0.98-1.00)
Secondary education			0.99 (0.98-1.00)			0.98** (0.97-0.99)
Higher education			0.97** (0.96-0.99)			0.96*** (0.94-0.98)
Age at first birth						
Age first birth <=18			Reference (1.00)			Reference (1.00)

Age >18 & <=25			0.99* (0.98-0.99)			0.99* (0.98-0.99)
Age >25 & <=30			0.99 (0.98-1.01)			0.99 (0.97-1.00)
Age >30			1.02 (0.99-1.04)			1.01 (0.98-1.04)
Religion						
Catholic			Reference (1.00)			Reference (1.00)
Protestant			0.99 (0.98-1.01)			0.99 (0.98-1.01)
Islam			0.99 (0.98-1.00)			0.99 (0.98-1.01)
Traditional			1.01 (0.99-1.03)			1.02** (1.00-1.04)
Other			1.12*** (1.07-1.18)			1.12*** (1.05-1.18)
Health Facility Use						
No health facility use			Reference (1.00)			Reference (1.00)
Used health facility			0.99 (0.99-1.0)			0.99 (0.98-1.00)
Place of Residence						
Urban residence			Reference (1.00)			Reference (1.00)
Rural residence			1.01* (1.00)			1.01** (1.00-1.02)
Birth Order <= 4			0.98*** (0.98-0.99)			0.98*** (0.97-0.99)
Fixed effects intercept	0.0859***	0.0828***	0.101***	0.117***	0.103***	0.127***
CI	(0.27-0.28)	(1.08-1.09)	(1.09-1.13)	(1.12-1.13)	(1.09-1.11)	(1.11-1.16)
Random effects variance						
Variance between zones	0.0786***	0.0784***	0.0776***	0.1029***	0.1025***	0.1013***
Variance between households		Reference	0.0002674		Reference	0.0002575
ICC between households		Reference	0.03		Reference	0.03
PVC	Reference	7.86	1.27	Reference	10.29	1.55
AIC	10163.47	10114.98	9876.25	19583.16	19427.34	19041.57
N	34676	34676	34466	34676	34676	34466
Log likelihood	-5079.73	-5049.49	-4912.12	-9789.58	-9705.67	-9494.78

t statistics in parentheses +  $p < 0.10$ , \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$  CI: Confidence Interval OR: Odds Ratio