UNOBSERVED HETEROGENEITY AND DETERMINANTS OF INFANT AND CHILD MORTALITY IN RURAL NIGERIA

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ABSTRACT

Background: Infant and child mortality remains significantly high among those living in rural Nigeria than their urban counterparts. Besides, previous studies have rarely explored the role of unmeasured variables in the rural-urban differential. This study was conducted to determine which of infant or child mortality is most affected by unobserved heterogeneity.

Methods: Data from 2013 Nigeria Demographic and Health Survey were analysed to examine the factors that predispose to infant and child mortality in rural Nigeria. Weibull proportional hazard and Weibull frailty models were used. The Hazard ratio (HR) and its 95% confidence interval (CI) were estimated.

Results: After controlling for other variables it was found that the risk of infant mortality was lowest among female children (HR=0.83, CI=0.75-0.93) as compared with male children. Hazard of infant mortality was highest among children whose mother's age at child birth was 35 yr or more (HR=1.40, CI=1.13- 1.74) as compared with children whose mother's age was less than 20 yr. Hazard of death was 46 percent (CI=0.54-0.76) and 54 percent (CI=0.40- 0.73) higher at infancy and childhood respectively among birth interval of 35 months or more compared with the first birth. The risk of infant dying was higher among children of other Christians (HR=1.26, CI=1.03. 1.51) compared with children of Catholic faith, and the risk of death at childhood was highest among other (non Christian) religion (HR=2.46, CI=1.34-4.51). The risk of death was significantly highest in North-east (NE) and North-west (NW) both in infancy and childhood compared with the North-central. At the infancy: NE, (HR=1.26, (CI=1.05-1.51); NW, (HR=1.40, CI=1.16-1.67) while at childhood: NE, (HR=1.68, CI=1.26-2.24); NW, (HR=1.88, CI=1.41-2.51). Access to improved toilet facilities reduces the risk of death at infancy compared with unimproved while secondary or higher education reduces the risk of death at childhood. Only maternal age at first birth was significant in the frailty model. Hazard of infant mortality was highest among children whose mother's age at first birth was 35 yr or more (HR=4.45, CI=1.23-16.11) as compared with children whose mother's age was less than 20 yr. The frailty value in infant and child mortality are 51.8 and 56.5 percents respectively, which means that the covariates in infant and child models explained 48.2 percent and 43.5 percent family variation in infant and child deaths in rural Nigeria.

Conclusions: Bio-demographic variables are important determinants to infant mortality while socioeconomic variables are important determinants to child mortality. Regional differential also exist in rural Nigeria. Unobserved heterogeneity was found to be significantly associated with high rate of infant and child mortality in rural Nigeria.

Key words: mortality determinants, Frailty, Nigeria, Under-five mortality, Rural Nigeria.

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DEDICATION

This work is dedicated to survival of under-five children in rural areas of Nigeria.

CERTIFICATION

I certify that this Dissertation was carried out by Wegbom, Anthony Ike under my supervision in the Department of Epidemiology and Medical Statistics, Faculty of Public Health, College of Medicine, University of Ibadan.

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LIST OF ABBREVIATIONS

AU	African Union
CEB	Children Ever Born
DHS	Demographic and Health Survey
EAs	Enumeration Areas
FCT	Federal Capital Territory, Nigeria
HR	Hazard ratios
LDCs	Less Developed Countries
MDG	Millennium Development Goal
NDHS	Nigeria Demographic and Health Survey
NPC	National Population Commission, Nigeria
PH	Port Harcourt
PSU	Primary sampling units
RSUST	Rivers State University of Science and Technology
UK	United Kingdom
UN	United Nations
UNDP	United Nations Development Programme
UNFPA	United Nations Population Fund
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Childhood mortality remains significantly high in sub-Saharan African countries. Internationally, it is estimated that 7 million children under the age of five died in 2011 (UNICEF, 2012). Sub-Saharan African region is a major contributor to this statistics.

Although, the health outcomes of children improved dramatically worldwide during the 21st century, enormous disparities still exist between developed and developing countries. The variation in under-five mortality is about 78 times more in developing countries than developed nations. Estimates showed 180 per 1000 live births in Angola to only 2.31 per 1000 live births in Singapore (World Facts Book, 2011).

More so, UNICEF (2010) in the state of the world's children report stated that 8.1 million children worldwide died in 2009 before their fifth birthday lived in developing countries and died from diseases that could easily have been treated or prevented. It also estimated that half of these deaths occurred in just five countries namely; Nigeria, India, Pakistan, the Democratic Republic of Congo, and China with Nigeria and India both accounting for one third of the total number of under five deaths across the world. The report describes the slow rate of decline as disturbing and grossly insufficient to achieve the MDG goal by 2015 since only 9 out of the 64 countries with high child mortality rate are on track to meet the MDG goal.

Children in rural areas face higher mortality than their urban counterparts (Cai 2006). According to Ellen (2009), higher rates in infant mortality in rural areas are derived from both observed and unobserved disadvantages in household characteristics and these explain for two-thirds of the differentials, less than one-quarter of the differentials is explaincd by Community characteristics, with about two-thirds coming from community unobserved heterogeneity while the most contributing factors are the environmental factors (such as electricity, a safe source of drinking water, and quality of housing materials). There are significant spatial differences in infant mortality rates and under-five mortality rates among the Nigerian six geo-political regions and by rural urban residence (Aigbe, G. O and Zannu,

A. E. 2012). Also, a study by Abimbola (2015) in rural Nigeria shows that access to good health facilities and antenatal care, birth interval, maternal education, mother source of income, where babes is delivered and mothers age at birth are factors responsible for high rate of child mortality in rural Nigeria.

Because of the challenge infant and child mortality pose to public health in Nigeria and other developing countries, researchers have made considerable efforts to understand factors motivating the phenomenon. Many studies have shown that infants and child mortality rates vary by socio-economic and bio-demographic characteristics (Antai 2010; Odimegwu, 2002; Omariba & Boyle, 2007; Damodar S. et al 2015).

1.2 Problem Statement

It is a known fact that infant and child mortality remains a major public health challenge in Nigeria and other parts of the developing world with rural areas sharing the largest burden which of course have devastating effects on concerned mothers and the population at large. Child mortality reduction has become a common agenda of public health and international agencies (Mutunga, 2007). Espo (2002) stated that approximately 10 million children under-five years die each year with huge variation across region and countries as well as urban and rural areas.

In Nigeria, according to 2013 NDHS report, infant and child mortality is 69 and 64 per 1000 live births respectively. This means that, one in every 15 Nigerian children die before reaching age 1, and one in every sixteen do not survive to their fifth birthday from their first. Also, Infant mortality is 43 percent higher in rural areas (i.e. 86 deaths per 1,000 live births) than in urban areas (60 deaths per 1,000 live births) and child mortality is 89 deaths per 1,000 live births in the rural areas as against 42 deaths per 1,000 live births in urban areas. These associations with infant and child mortality even after accounting for different observed factors of mortality in rural areas have been attributed to unobserved heterogeneity.

1.3 Justification

It is important to focus research efforts on infant and child mortality in rural Nigeria in order to generate new scientific evidence on how best to tackle its factors. Although several researchers have examined factors influencing infant and child mortality in Nigeria (e.g.

Adeboye et al.; 2010, Akinbami et al., 2010; Nwokocha and Awomoyi, 2009), studies that examine childhood mortality at the rural levels is sparse. Despite all efforts geared towards reduction of infant and child mortality in Nigeria by national and international agencies and organisations, there seen to be no significant reduction. Which suggest that unobserved heterogeneity (such as genetic, behavioral and environmental factors, occurring at individual, family and community levels (Sastry 1997), might be responsible for the menace And some of these factors (covariates) are not observed or captured in a social survey like NDHS which is the dataset that most researchers in Nigeria utilized. As a result, a study that considers the influence or effects of unobserved heterogeneity as well as observed factors on infant and child mortality in rural Nigeria will contribute significantly to the existing body of knowledge.

Therefore, this study will examine the factors predispose to infant and child mortality in rural Nigeria.

1.4 Research Objectives

1.4.1 General objective

The general objective of this study is to determine the factors predisposing to infant and child mortality and also to ascertain the role of unobserved heterogeneity in infant and child mortality in rural Nigeria.

1.4.2 Specific objectives

1. To determine the effect of some socioeconomic and biodemographic factors on infant and child mortality in rural Nigeria.
2. To determine which of infant or child mortality is most affected by unobserved heterogeneity in rural Nigeria.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter presents the review of relevant literature. Important literature related to the study was collected through various sources: PubMED, Google search engine, Google scholar, books and reports. Keywords for literature search include: infant mortality, child mortality, determinants of infant and child mortality, unobserved heterogeneity as well as Weibull and frailty models.

Demographic, public health and economics literatures was found to be stuffed with studies on various outcomes of child health and survival. Several studies on infant and child mortality have yielded diverse findings on the determinants of infant and child deaths. For proper review of literature in this chapter, reviewed literature would be presented under the following sub-headings: the global overview of infant and child mortality, infant and child mortality in Africa, infant and child mortality in Nigeria, the determinants of infant and child mortality, rural-urban differentials in infant and child mortality, and use of frailty model in determinant of infant and child mortality.

2.1 Global Overview of Infant and Child Mortality

Under five deaths globally, is estimated at about 10 million annually and about half of these deaths occur in just six countries while 42 countries account for 90% of these deaths (Black et al, 2003). The authors also observed that more than 2 in 5 of child deaths occur in sub-Saharan Africa and 34% occur in the South Asia. Again, Rutherford (2010) reported a global estimate of 9.7 million under-five deaths each year. Again, about 41% of these deaths occur in the sub-Saharan African countries. UNICEF (2012) put the 2011 global under-five deaths at around 7 million. More recently, UNICEF (2014) reported that globally estimate of 6.3 million children died each year as a result of preventable causes. The report also showed 49% drop of under five mortality rates between 1990 and 2013 implying that about 17,000 children under age five dic every day globally in 2013. Though childhood mortality seems to be declining, the figure still remains high with sub-Saharan Africa remaining the major contributor to this figure.

It is important to note that infant and child deaths vary substantially among the regions of the world. For instance, the variation in childhood deaths between the developing and developed nations is slightly more than 78-fold from a high of 180 per 1000 live births in Angola to only 2.31 per 1000 live births in Singapore (World Fact book, 2011). Considering factors influencing infant and child mortality, Whitworth and Stephenson's (2002) study in India found that higher level of maternal education has the advantage of weakening the effect of short birth interval because increased female autonomy and access to resources tend to remove the competition for resources that often characterize short birth interval.

Kravdal (2004) showed that apart from the effect of maternal education on child mortality in India, the average education of women in an enumeration area also has strong association with child mortality. A study by Antai (2011) has attributed ethnic differentials in the risk of under-five mortality to disparities in maternal level of education among various ethnic groups in Nigeria. Uthman (2008) also observed that maternal education significantly plays a protective role against infant mortality in Nigeria. Kravdal (2004) also noted that equitable care for sons and daughters work to the advantage of children born to the educated mothers.

In a study by Zanini, et al. (2009) which analyzed the trend in infant mortality among the Brazilians using multilevel analysis, infant mortality was found to be positively associated with the proportion of low birth weight newborns and number of hospital beds per 1000 inhabitants; but, infant mortality was found to be negatively correlated with the cesarean rate and number of hospitals per 100,000 inhabitants. The authors, in addition, observed that individual and community-level characteristics have significant effects on the reduction of infant mortality rates. Griffiths et al (2004) opined that childhood malnutrition is not as prevalent as child mortality in sub-Saharan Africa; whereas, about half of the children in India alone are affected by malnutrition. The authors suggest that homogenous nutritional outcomes are found among the children in the same community "because of shared behavioural practices like cultural norms in terms of food. Some of the identified covariates of child malnutrition are size of the child at birth, age of the child, maternal level of education, breastfeeding status, and diarrhea. Supporting this finding, Lykens et al (2009) observed that nutrition is a significant factor in child survival. Furthermore, Subramanian and colleagues' (2006) study provided evidence that socio-economic effect of mortality is substantial among the Indian and that the burden of poor health outcomes

disproportionately affect the economically disadvantaged. Antai et al (2010a) also stressed the need for community-level intervention to improve access to health care services in Nigeria.

Whitworth and Stephenson (2002) established that competition for resources between the newborn and the previous sibling is the pathway through which short birth intervals increase the mortality risk among the children. The authors conclude that children of young mothers, children of high parity and children whose previous sibling died or breastfed for short durations are at greatest risks of dying if their births follow a short birth interval. Also, Schell and colleagues (2007) conducted a study on socio-economic determinants of infant mortality, using 152 lows-, middle- and high-income countries' data and found that relative significance of key determinants of health varies significantly between income levels; as a result extrapolating health strategies from high- to low-income countries becomes more difficult.

In addition, other researchers like Omariba et al (2007), Harttgen and Misselhorn (2006), Adedini et al (2015) and Griffiths et al, (2004), had also employed multilevel modeling to examine the relationship between community characteristics, household attributes, and child survival in a number of countries in South Asia, Latin America and South America; and they established significant relationship between child mortality and a number of community-level variables. Studies conducted in those regions established that child health outcomes are influenced by such factors that operate at the individual level as well as those within the familial and community in which a child is raised.

In fact, the global discuss on infant and child mortality is endless because of its importance in the development of a nation.

2.2 Infant and Child Mortality in Africa

A number of Demographic and puhlic health as well as economics literature confirm that infant and child mortality remains a serious challenge in the African continent. In particular, there exists an enormous variation in infant and child mortality rates in the sub-Saharan African countries. Becher (2010) noted that about one-third of all countries in Africa show a decline of 30% or more in under-five mortality, while in contrast, a number of countries sadly show a significant increase. In agreement with this argument, Ewhank et al (2002) maintained that decades of sustained childhood mortality reductions still see the mortality levels in many parts of

Africa to be relatively high. Lykens et al (2009) observed that an infant born in a less developed nation is over 13 times more likely to die before reaching fifth birthday compared to his/her counterparts in the developed world. As a result, under-five mortality is seen as a major public health issue of concern in Africa as in other developing world.

Hammer et al (2006) argued that roughly 40% of under-five deaths occur during the neonatal period and this proportion was said to be considerably lower for regions with high absolute rates such as the sub-Saharan Africa. The rates of under-five mortality are as high as 163.2 and 197.6 deaths per 1000 live births in Guinea and Niger republic respectively; and as low as 28.3 deaths per 1000 live birth in Egypt (Macro International Inc, 2011). It may be reasonably assumed that there is a huge variation in infant and child mortality from one country to another in the African continent because various countries are at different stages of economic development.

Also, a number of factors have been adduced for persistent high infant and child mortality in the continent. For instance, Becher and colleagues' (2004) study in rural Burkina Faso found that death of the mother, maternal age, birth spacing, ethnic group, proximity of health facility and season of birth are risk factors to infant and child death. The study goes on to state that it would be harmful for a child if the mother remarries to a new husband, a practice which is common in many countries. Stressing the significance of the mother's roles in successful childrearing, Rebecca et al (2000) study in rural Gambia noted that living mother, maternal grandmother or an elder sister has a significant relationship with child's survival. The study goes on to state that motherless children aged two years or below were 11 to 13 times more likely to die relative to those whose mothers are alive. Whercas, beyond age two, motherless children were found not to be at greater risks of dying than those whose mothers are still living.

In a related study, Berger et al (2002) stressed the importance of maternal age and breastfeeding practice for the newborn. Using Zambia 1992 DHS datascts, the authors established that maternal age at birth and breastfeeding duration are positively associated with child mortality. Corroborating this point, Rebecca et al (2002) noted that due to the lack of alternatives to breast milk, an infant is unlikely to survive after the death of his/her mother. Houle (2015) observed that children who's their mother die early were at 15 times the risk of dying compared to children who's their mother survival. All these findings point to the significance of mother's care to child's health and survival.

Also, Buor (2002) examined the effect of mothers' education on childhood mortality in Ghana and found that mothers' education is inversely related to childhood mortality. In contrast, Barbara and others' (2002) study among the African and Coloured Population in South Africa indicates that, mother's education notwithstanding, environmental factors such as source of domestic water and type of sanitation significantly influence infant and child survival.

Writing on the significance of family structure, Omariba and Boyle (2007) observed that children in polygynous settings have greater risks of dying than children whose mothers are in monogamous unions. The authors noted that factors such as socio-economic status, place of residence and education greatly influence the variations associated with polygyny. This finding, thus contrasts a study by Rebecca et al (2002) which established that there is a negligible difference between children mortality rates in polygynous unions and those in monogamous settings. The authors also observed that there was slight variation in the mortality rates of children who were born to monoganious or polygynous fathers (Rebecca et al (2002). Argescanu (2004) threw support behind this argument by stressing that the children of married women have a greater advantage of surviving relative to the children of the unmarried women; and that children in polygynous marriages tend to have higher survival chances compared to the children in monogamous unions.

2.3 Infant and Child Mortality in Nigeria

Nigeria is one of the major contributors to global statistics on infant and child mortality. The country's rate of under-five mortality – 128 per 1000 live births (2013 NDHS) – is among the highest in the world. Moreover there is a significant geographic variation in the patterns of under-five mortality rates in the country from the lowest of 90 per 1000 live births in the South-western Nigeria to the highest of 185 per 1000 live births in the northwest. Also, great variation exits among place of residence with 100 per 1000 live births in urban and 167 per 1000 live births in rural areas. A number of reasons have been given for this enormous regional difference. For instance, Antai's (2010b) study on inequality in under-five mortality in Nigeria found that under-five death is highest among Hausa/Fulani/Kanuri in the Northern Nigeria. This is because these ethnic groups have the poorest maternal and child health indicators such as access to good quality health care and availability of skilled birth attendants. Again, a study by Antai (2011) established that under-five mortality rates were significantly higher in some regions compared to

the others. In supporting these Adedini et al. (2015) opined that there are sizeable regional differences in under-five mortality in Nigeria.

In another study, Antai et al (2010) stressing the relationship between migration and child health inequalities in Nigeria noted that children of rural-urban migrants tend to have significantly higher under-five mortality compared to the children of rural non-migrant mothers. Similarly, Antai and Moradi (2010) in another study noted that under-five mortality in urban areas is positively correlated with the rate of urbanization over the 1983-2003 periods in Nigeria. The authors stressed the need for further studies on community-level determinants of under-five mortality in Nigeria. In a study by Adedini et al. (2015), they stated that individual and community level characteristics have significant relationship with health outcome. Also, the study observed that individual-level factors explain regional variation in infant mortality while community-level factors explain child mortality in Nigeria.

A study by Griffiths et al (2004) which analyzed the multilevel comparison of the determinants of child nutritional status using DHS data of seven countries including Nigeria emphasized the significance of household and individual characteristics like age, the size of child at birth diarrhea, duration of breastfeeding, and as well as maternal education. Findings have established that formal education as well as health education significantly improves child survival (Abimbola et al 2012). Also, Anyamele's (2009) analysed DHS data of selected sub-Saharan African countries, including Benin and Nigeria corroborated the findings by Abimbola and colleagues by establishing that literacy is significantly related to child mortality.

A study by Akinyemi and others (2013) reported that dynamics of decline in under-five mortality has not yet be given adequate attention in Nigeria. In this study it was observed that improved source of drinking water contribute the highest (24.2%) while skilled delivery contribute the lowest (3.0%) to under-five mortality in Nigeria. In a related study by Akinyemi et al. (2015) identified that health care related characteristics and Bio-demographic factors are significant determinants of neonatal mortality in Nigeria.

Furthermore, there are other hospital-based Nigerian studies on infant and child mortality. A number of such studies emphasized drug use, treatment and hospital admission vis-à-vis child's health outcomes. For instance, in a study by Disu (2015) estimated that about 250,000 infants die

annually in Nigeria due to lack of unskilled health workers and antenatal care. Also, Adeboye et al (2010) conducted a hospital-based study of mortality pattern within 24-hour of emergency pediatric admission in Nigeria and found that majority of infant deaths occur within the first day of admission as a result of causes attributable to malnutrition and malaria. A study by Oniyangi et al. (2006) on the pattern of pediatric HIV/AIDS in Abuja Nigeria showed that pediatric HIVAIDS occurs mostly through mother-to-child transmission. The authors further established that pediatric HIV/AIDS constitutes a significant cause of morbidity and mortality among children admitted at Abuja National Hospital in Nigeria. Also, a study by Grais et al (2007) on child mortality in Niger, Nigeria and Chad established that preventable diseases such as measles still remain a serious killer disease in some parts of these countries.

2.4 Determinants of Infant and Child Mortality

Ascertaining the determinants of childhood mortality in the developing world is rather a difficult task (Rodgers, 2002). Although, many studies have identified various determinants of infants and child mortality ranging from bio-demographic to socio-economic as these have brought about huge differentials in the mortality risks among the infants and children. Black, et al (2003) opined that the factors influencing child deaths vary substantially from one country to another. Hale and colleagues' (2006) study provided evidence that substantial variations in infant and child mortality exists in Bangladesh from one region to the other.

A number of studies have examined the effect of educational level on the risk of infant and child mortality and found that the former significantly influence the latter. However, Jamison et al (2007) did a different analysis by examining the effect of quality of education and established that infant and child mortality rate is strongly influenced by quality of parents' education. Again, Whitworth and Stephenson (2002) noted that higher level of maternal education which is associated with greater access to household resources and improved health care could reduce the effect of sibling rivalry that characterizes short birth interval. As earlier pointed out, Uthman et al (2008) noted that maternal education plays a significant role in protecting infant against mortality.

A study by Palma-Soliso and others (2009) found that reduction in government expenditure can significantly compromise the attainment of MDG4 in many developing countries. The authors

further observed that the rates of infant and child mortality are not just associated with a single characteristic but linked with several manifestations of people's living conditions. Manda (2001) supports this argument by suggesting that mortality risks of children from the same household tend to be alike and that that of the children from the same community will also be influenced by the same environmental conditions. Zanini and colleagues' study (2009) in Brazil throws weight behind this argument by establishing that about half of the variability in infant mortality rates was due largely to community-level characteristics. They concluded that individual and community characteristics have significant effects on the reduction of infant mortality rates. Meanwhile, a comparative study by Griffiths et al (2004) contrasts the foregoing by establishing that community characteristic such as place of residence is not as important as the family correlation and that the community correlation of health outcomes appears less important than the family correlation.

Also, Antai et al (2009) argued that, the number of health facilities notwithstanding, the use of maternal and child health services is largely determined by mother's indigenous religious affiliation and this significantly influences the risk of infant and child mortality. Akinyemi and others (2015) while examining the trend in neonatal mortality in Nigeria identified that antenatal care, births interval less than 24 month, delivery at health facility and small birth size were factors significantly associated with neonatal deaths. Stressing on the importance of maternal factors, Houle et al (2015) observed that children (especially less than one month) who their mother is not alive is at higher risk of dying compare those their mother is alive. Contributing to this, Sear et al (2000) found in a study in rural Gambia that while paternal grandmothers and male kin, including fathers have very negligible contribution to improve child survival, maternal grandmothers are the only kin that significantly improve child's survival apart from the mothers.

In a study by Edeme et al (2014) on the relationship between household income and child mortality in Nigeria, observed significant effect of household income on neonatal mortality rate but insignificant effect on infant and under-five mortality rates in Nigeria. The study also revile that household size has significant effect on both infant mortality rate and neonatal mortality rate in Nigeria. In support of this finding, Rodgers (2002) had early established that income distribution is significantly correlated with mortality. Also in line with this argument, Collision

et al (2007) narrowed down on childhood mortality and established that a very strong relationship exists between income inequality and child mortality even in the wealthy nations.

Also, emphasizing the importance of maternal education, Oditnegwu (2002) observed that education is a key determinant in decision to breastfeed a baby. Meanwhile, Kravdal (2004) noted that maternal education operates through a number of community-level variables that are influenced by average educational status of mothers in a community. In a study by Manda (2001) short birth spacing, short breastfeeding duration and the death of a preceding child were found to be significantly associated with increased risk of child death. Palma-Soliso et al (2009) noted that the rates of infant and child mortality are not just associated with a single characteristic but linked with several manifestations of people's living conditions.

Furthermore, Sastry's (1997) study among the Brazilians suggests that family mortality clustering often arises from the family situations that predispose the siblings to the same mortality risks. Rebecca (2000) established that presence of maternal grandmothers tend to improve child survival rates, while presence of certain other kin was also found to be inimical to child survival. A study by Damodar et al (2015) observed that household wealth, birth interval and region as well as maternal education level were significantly associated with infant and child mortality in rural India.

Other studies that made significant contributions on the determinants of infant and child mortality includes, women with low or no education (Kanjala et al, 2010); women in lower wealth index (Harttgen & Misselhorn, 2006); women who reside in rural areas and who have no or poor access to electricity (Wang, 2003); women in polygynous unions (Omariba and Boyle, 2007); women who delay commencement of breastfeeding (Harttgen and Misselhorn 2006) tend to have higher infant and child mortality. Kanjala et al (2010) also found that children of mothers with primary education are 18% less likely to die while children whose mothers had secondary or higher education are 47% less likely to die compared with children whose mothers had no education.

2.5 Rural-urban Differentials in the Infant and Child Mortality

A number of article publications and reports have showed that Children in rural areas are face with higher mortality rates than children in urban areas (Cai and Chongsuvivatwong 2006,

Heaton and Forste 2003; Wang 2003). Although the rural disadvantage in child survival especially in developing countries is firmly due to, observed and unobserved household environmental factors and community characteristics (Van del Poel et al. 2009). According to the authors, the most contributing factors of observed environmental factors are electricity, a safe source of drinking water, and quality of housing materials and this account for about two-thirds of the gap while community factors account for one-quarter of the gap, out of which two-thirds is from community unobserved heterogencity and one-third from the presence of a healthcare facility within the community. Also, Sastry (1997) stated the contribution of community-level factors in explaining rural-urban differential in infant mortality in Brazil. Whereas, Heaton and Forste (2003) provided evidence that suggest that inadequate availability of health care facilities is partly responsible for the high mortality rate in rural Bolivia.

The 2013 NDHS showed that infant and child mortality is high in rural areas than urban areas. And this is even more pronounced in under-five mortality, with 100 deaths per 1000 live births in urban areas against 167 deaths per 1000 live births in rural areas. A study by Akinyemi et al. (2015) on the trend in neonatal mortality in Nigeria showed that there has been consistent rural-urban differential in neonatal mortality in the last twenty years in Nigeria. The authors also observed that urban residence have reduced risk of neonatal death compare to their rural counterparts.

2.6 The Use of frailty models in Analysis of Childhood Mortality Determinants

The use of frailty model in the study of mortality determinants especially, childhood mortality determinants have gained increased application. Researchers have used frailty model to examine the association between family and community effects and childhood mortality. These associations with infant and child survival outcomes even after accounting for different known determinants of mortality has been credited to unobserved heterogeneity or frailty. Frailty is the variance in mortality as a result of unmeasured factors.

Frailty models treat the situation where the same individual may experience the hazard more than once, raising the likelihood that due to some unmeasured and perhaps unknown cause (i.e. unobserved heterogeneity), and a number of subjects may be more likely than others to

experience repeated hazards. This likelihood is the frailty of these subjects and in standard Cox models are unmeasured effects.

A study by (Rasugu et al. 2013) examined infant and child mortality determinants in Kenya, controlling for frailty effects. They compared the standard Weibull survival models to those of Weibull shared gamma frailty survival models to examining the extent to which the risk of child survival continue to vary net of measured factors and the extent to which non frailty models are biased as a result of the violation assumption of independence. It was found that there was great difference between families in the risks of child mortality that was not accounted for. The effect of family socioeconomic status was stronger for child mortality than for infant mortality and frailty effects are highly significant in both infancy and childhood. Similarly, (Mani et al. 2012) compared the frailty model and the usual Cox proportional hazards models in studying the determinants of under-five mortality in rural India. Their study observed that frailty models provide more valid estimates of the effects of covariates. And covariates such as, sex of the baby, mother's age at birth, place of delivery, baby size at birth, birth order and birth interval, and breastfeeding were identified as significant determinants of under-five mortality in rural India, after controlling for the familial frailty effect. On the other hand, Rasugu et al. 2013 argues that the basis of frailty is that children belonging to one mother or one family or one community have certain shared characteristics that predispose them to common risk. It is these characteristics that make them different from the other children. They further states that frailty effects can broadly be classified as behavioural, environmental and genetic factors that occur at various levels that include the child, the family and the community.

Furthermore, (Nasejje et al. 2015) showed that there is presence of unobserved heterogeneity at the household level but there no enough evidence at the community level to conclude the existence of unobserved Heterogeneity which suggested that unobserved heterogeneity were significant at the household level but insignificant at the community level. Also, sex of the child, sex of the household head and number of births in the past one year were found to be significant. But on the contrary, (Van de Poel et al. 2009) observed that out of the one-quarter of observable and unobservable community characteristics that explain the gap in infant mortality in rural areas using six Francophone countries in West and Central sub-Saharan Africa, about two-thirds comes from community unobserved heterogeneity. Manda (2001) opined that mortality risks of

children from the same household tend to be alike and that the children from the same community will as well be influenced by the same environmental conditions. The frailty effects were more significant in childhood and child deaths were mostly determined by demographic and socioeconomic factors, of which household socioeconomic status was the most important factor (Niragire et al. 2011).

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

This chapter will deal with the following subheadings: Study Setting, Data Sources, study design, study population, Sample Design of NDHS, Variables and Variable Measurement, data management and analysis plan, and study limitations.

3.1 Study Setting

The population of Nigeria based on 2006 population and housing census was 140,431,790 with an estimated growth rate of 3.2% per annum (NPC 2009). But United Nation population Fund in 2011 put Nigeria population at 167 million which is the sixth largest in the world after Brazil, Indonesia, USA, India and China.

Administratively and politically, Nigeria is divided into six geo-political zones: South- South, South East, South West, North Central, North West, and North East and these is subdivided into 36 states and a Federal Capital Territory. Presently, Nigeria is governed by democratically elected leaders both at national and state levels.

The Nigeria fertility rate has remained high since 2003 with a Total Fertility Rate (TFR) of 5.5 births per woman. The North West Zone has the highest TFR of 6.7 while the lowest is the South -South Zone with TFR of 4.3 births per woman. Also, the rural areas have higher TFR than the urban areas (6.2 versus 4.7) (NDHS 2013).

3.2 Data Sources

This study utilized 2013 Nigeria Demographic and Health Survey (2013 NDHS) datasets. The 2013 Demographic and Health Survey elicited information on demographic and health indicators both at the national and state levels.

3.3 Study Design

This study involved secondary analysis of nationally representative data from the 2013 Nigerian Demographic and Health Survey.

3.4 Study population

The data for this study were children born within the last five years before the survey (i.e. under five children) in rural Nigeria. The information was derived from women age 15-49 years who had at least one live birth within these period extracted from the 2013 NDHS datasets.

3.5 Sample Design of 2013 NDHS

The 2013 NDHS program adopted the sampling frame designed for the 2006 population and housing census. The primary sampling unit (PSU) regarded as a cluster for 2013 NDHS and was defined on the basis of Enumeration Areas (EAs) from 2006 EA census frames. Sample for the surveys were selected using stratified two-stage cluster design consisting of 904 clusters, 372 in urban areas and 532 in rural areas. (NPC and ICF 2014).

A representative sample of 40,320 (urban 16,695 and rural 23,625) households were selected for the surveys and 38,522 households were interviewed (urban 15,859 and rural 22,663). The second stage of selection process involved a complete listing of the 886 selected clusters followed by a selection of an average of 45 households in each cluster, using equal probability systematic sampling. A minimum of 943 completed interviews was target per state. The number of households was proportionately distributed between rural and urban areas. All women within the reproductive age 15-49 years who were either permanent residents in the selected households or visitors that slept in the selected households on the night preceding the survey were eligible to be interviewed. Thus, the 2013 NDHS had an overall household response rate of 99%.

Overall, data were collected from 38, 522(15,545 urban and 23,403 rural) women age 15-49 and 17,359 (7.144 urban and 10,215 rural) men age 15-59 years in randomly selected households across all the 36 states and the FCT. The survey elicited information on demographic and health indicators both at the national and state levels. Also the sample design allowed for specific

population and health indicators to be computed for each of the 6 geopolitical zones and 36 states and the FCT.

3.6 Variables and Variable Measurement

The dependent and independent variables for this study were contained in the 2013 NDHS datasets.

3.6.1 Dependent Variables

The dependent variables in this study are (1) the risk (or hazard) of infant death (i.e. the risk or hazard of death during age 0 to 11 months) and (2) the risk (or hazard) of child death (i.e. the risk of death during age 12 to 59 months). The risk of death in infancy or childhood is measured as the duration of survival since birth (in months).

3.6.2 Independent Variables

The selection of independent variables is based on the Mosley and Chen (1984) conceptual framework and existing literature on child mortality. In the Mosley and Chen framework all socioeconomic and bio-demographic determinants of child mortality operate through a common set of five or six proximate factors (household environmental contamination, maternal factors, personal illness control, nutrient deficiency, and injury). The socioeconomic (covariates) factors considered in this work are maternal education, socioeconomic status, type of toilet facility, source of water, marital status, religion, region of residence while the bio-demographic (covariates) factors are child's sex, type of marriage, Maternal age at birth of child, preceding birth interval, child year of birth and age of respondent at first birth.

3.6.3 Definitions of selected variables

Table 3.1: Definitions of socioeconomic variables

S/N	Variables	Definitions
1	Maternal education	Highest educational level of the mother
2	Socioeconomic status	Wealth index of household where respondent lived
3	Type of toilet facility	Household type of toilet facility
4	Source of drinking water	Household source of drinking water
5	Marital status	Marital status of respondent
6	Religion	Respondent's religious affiliation
7	Region	Geopolitical zone where respondent lives

Table 3.2: Definition of bio-demographic variables

S/N	Variables	Definitions
1	Maternal age at birth of the child	Age of the mother at the time of child birth
2	Type of marriage	Type of marriage of respondent
3	Birth interval	Number of months between preceding birth and the birth of the child in question
4	Child's sex	Sex of the child
5	Child year of birth	The year of the child's birth
6	Maternal age at first birth	Age of mother at first birth

3.7 Addressing the study Objectives

Table 3.3: Methods used to address the study objectives

S/N	Objectives	Variables	Statistical Method
1	To determine the effect of selected socioeconomic and bio-demographic factors on infant and child mortality in rural Nigeria.	Maternal education, region, child sex, birth interval, source of water, etc	Weibull proportional hazard model
2	To determine which of infant or child mortality is most affected by unobserved heterogeneity in rural Nigeria.	Maternal education, region, child sex, birth interval, source of water, etc	Weibull proportional hazards model with frailty (or Frailty model).

3.8 Statistical Model

3.8.1 Weibull Proportional Hazards Model (Survival Analysis)

Survival analysis (Cox regression) technique initially developed by Cox (1972) is a useful technique for analysis of survival data and it takes care of censoring problem in mortality data and this is its major advantage. In this technique, the outcome variable is the risk of death in infancy or childhood measured as the duration of survival since birth in months. The difference between various survival models is based on the distribution that the timing function is assumed to follow (Cleves et al. 2004). Based on literature, we will utilize the Weibull proportional hazards model of the form:

$$h_i(t/x_i) = \lambda \exp(\beta' x_i) p t^{p-1} \quad (1)$$

Where:

$h_i(t/x_i)$ = the hazard of death for child *i* at time t;

p = shape parameter estimated from the data,

β =the vector of unknown coefficients of the explanatory variables x_i

The hazard ratio between two different values of x is given by

$$\frac{h(t/x1)}{h(t/x2)} = \exp\{\beta_1(x_1 - x_2)\} \quad (2)$$

Weibull model is chosen because is suitable for hazards that are either monotonically decreasing or increasing (Blossfeld and Rowher 2002 as sited by Omariba 2007). And it is an established knowledge that mortality in human population is usually high in the first year of life; then it declines in other ages of childhood and throughout most of the teenage years, then increasing slowly in adult ages to old age.

3.8.2 The hazard model with frailty

The frailty α being an unobserved multiplicative effect on the hazard function which is assumed to follow gamma distribution $g(\alpha)$ with $\alpha > 0$ and the mean of $g(\alpha)$ equal to 1. The variance of $g(\alpha)$ is a parameter θ (theta) that is usually estimated from the data. The model assumes that the individual risk of death is a function of measured (covariates) factors. The model is of the form:

$$h_{ij}(t/x_{ij}, \alpha_j) = \alpha_j h_{ij}(t/x_{ij}), \quad (3)$$

Indexes i and j correspond to observations in children and mothers, respectively. If the variance estimate θ is different from zero it indicate that unobserved and unmeasurable family factors affect the risk of death hence their survival risks are correlated. And if the variance estimate θ is zero, then, all families have the same risk of death. Also, individuals with frailty $\alpha > 1$ have a higher hazard and decreased chance of survival compared to those with frailty $\alpha = 1$. And individuals with frailty $\alpha < 1$ have a decreased hazard and higher chance of survival compared to those with frailty $\alpha = 1$. (Klienbaum et al 2005).

Further, at the multivariate level, analyses were run separately for infant mortality and separately for child mortality, to examine the effect of some selected covariates on infant and child mortality and how unobserved heterogeneity affect survival chance in infancy and childhood. As a result, there were eight models at the multivariate level (four models for each of the two outcome variables). Out of the four models, two models are frailty models. The frailty model is use to ascertain which of infant or child mortality is most affected by unobserved heterogeneity.

3.9 Data Management and Analysis Plan

All data extraction, cleaning and univariate analysis were done using SPSS (version 20) while survival analysis were done using Stata statistical package (version 12). In this study, first, univariate analysis was used to presents the percentage distribution of the respondents according to the selected variables. And the second level of analysis, Weibull proportional hazards model and Frailty model was employed to examine the relationship between the outcome variables (risk of infant/child mortality) and a set of selected independent (covariates) variables. Also, design weights were calculated to account for the complex nature of sample design of NDHS.

In all there are four models, two each for infant and child mortality. The models are classified as follows:

Model 1 – This model contains the selected socioeconomic variables and outcome variable

Model 2 – This model contain the combination of socioeconomic and bio-demographic variables and outcome variable

Model 3 – This is frailty model of the selected socioeconomic variables and outcome variable

Model 4 – This is frailty model of the combination of selected socioeconomic and bio-demographic variables and outcome variable.

Table 3.4: **Bio-demographic variables and its codes**

S/N	Variable	Coding
1	Maternal age at birth of the child	< 20(1) 20-35 (2) >35 (3)
2	Type of marriage	Monogamous (1) Polygamous(2)
3	Birth interval	First birth (1) < 24 months(2) 24-35(3) >35 (4)
4	Child's sex	Male(1), female(2)
5	Child year of birth	2008-2009 (3) 2010-2011 (2) 2012-2013 (1)
6	Maternal age at first birth	< 20 (1) 20-35 (2) >35 (3)

Table 3.5 Socioeconomic variables and its codes

S/N	Variable	Coding
1	Maternal education	None (1), Primary (2) Secondary or higher (3)
2	Socioeconomic status	Poor (1) Middle (2) Rich (3)
3	Type of toilet facility	Unimproved (1) Improved (2)
4	Source of drinking water	Unimproved (1) Improved (2)
5	Marital status	Never married (1) Married (2)
6	Religion	Catholic (1) Other Christian (2) Islam (3) Others (4)
7	Region	North-central (1) North-east (2) North-west (3) South-east (4) South-south (5) South-west (6)

CHAPTER FOUR

RESULTS

4.1 Distribution of Selected Variables

In this section, the percentage distribution of the characteristics of the study population is presented according to selected variables. Selection of variables (which could influence infant and child mortality in the rural areas) was guided by the literature. The selected independent variables (covariates) are divided into two – socioeconomic and bio-demographic factors. At the Socio-economic level, the variables analyzed include: Maternal education, socioeconomic status, marital status, Religion, Source of drinking water, type of toilet facilities and region. While at the bio-demographic level, the variables analyzed include: Sex of the child, Type of marriage, maternal age at child birth, Birth interval, maternal age at first birth and Child year of birth.

4.2 Distribution According to Selected Socio-Economic Factors

With respect to maternal education, results showed that highest proportion of the children (63.5%) belonged to mothers with no formal education while children their mothers had primary education and secondary/higher education have almost the same proportions (18.2% and 18.3%) It could be observed from Table 4.1 that the mothers were predominantly married (86.5%) while the remaining 13.5% were children of never married women. With respect to religious affiliation, 8.8% of the children Catholics mothers, slightly more than one-quartile (29.9%) were children of other Christian mothers, slightly less than half (48.4%) were children of Muslim family while 1.0% were children of other religions. A consideration of socioeconomic status showed that most of the children (43.3%) were delivered by poor mothers, less than one-quartile (17.2%) were children of middle socioeconomic mothers whereas slightly more than one-quartile (28.0%) were children of rich mothers.

Table 4.1 further showed that more than half (54.2%) of the children were from household with unimproved source of drinking water whereas the remaining (45.8%) were from household with improved source of drinking water. Similarly distribution of type of toilet facilities, showed that more than half (63.0%) were children from households with unimproved toilet facilities whereas the remaining (37.0%) were children from households with improved toilet facilities. With

respect to region, results showed that most of the children (44.1%) resident in the North-west, 20.4% were children of mothers residing in the North-east. Another 16.3% of the children were children of mothers residing in the North-central, 4.2% of the children were children of mothers residing in the South-east. Also, 9.2% were children of mothers residing in the South-south and 5.9% were children of mothers residing in South-west.

Table 4.1: Percentage distribution according to selected Socio-economic factors

Variables	Frequency	Percentage
Socio-economic factors		
Maternal education		
No education	13144	63.5
Primary education	3763	18.2
Secondary and higher education	3795	18.3
Socioeconomic status		
Poor	8972	43.3
Middle	3555	17.2
Rich	5790	28.0
Marital status		
Never married	2796	13.5
Ever married	17906	86.5
Religion		
Catholic	1814	8.8
Other Christian	6199	29.9
Islam	10026	48.4
Others	199	1.0
Source of drinking water		
Unimproved	11215	54.2
Improved	9487	45.8
Type of toilet facilities		
Unimproved	13050	63.0
Improved	7652	37.0
Region		
North West	9125	44.1
North East	4213	20.4
North Central	3368	16.3
South East	860	4.2
South South	1908	9.2
South West	1228	5.9

4.3 Distribution According to Selected Bio-Demographic Factors

The distribution of the study population by selected bio-demographic factors is presented in Table 4.2. Results from 2013 datasets showed that male and female children in rural Nigeria were almost of the same proportion (50.4% vs. 49.6%). With respect to type of marriage, the proportion of children is higher in monogamous marriage than polygamous marriage (56.2% vs. 43.8%). A consideration of preceding birth interval showed that less than 1 in every five children had preceding birth interval of less than 24 and in their first birth (19.1% and 18.0%), whereas, more than 1 in 5 (32.7% and 29.9%) children, were delivered between 24 and 35 months and after 35 months preceding birth interval. With respect to maternal age at child birth, less than 1 in every five children (18.0%) were delivered by women less than 20 years, slightly more of three in every five children (67.1%) were delivered by women between the age 20 and 35 years while far less than one in every five children (11.7%) were born by women above 20years.

Table 4.2 further showed that slightly more than half of the children (53.6%) were delivered by mothers whose their age at first birth was less than 20 years, slightly more than one-quartile of the children (34.6%) were delivered by mothers whose age at first birth are between 20 and 35 years while insignificant proportion of children (0.2%) were delivered by mothers that gave their first birth when they were above 35 years. Considering child year of birth, about one-quartile of the children (25.8%) were delivered in the years 2012-2013, less than half of the children (34.9%) were delivered in the years 2010-2011 whereas slightly more than half of the children (27.8%) were delivered in the years 2008-2009.

Table 4.2: Percentage distribution according to selected bio-demographic factors

Variables	Frequency	Percentage
Sex of the child		
Male	10431	50.4
Female	10271	49.6
Type of marriage		
Monogamous	11635	56.2
Polygamous	9067	43.8
Maternal age at child birth		
<20 years	3719	18.0
20-35 years	13887	67.1
>35 years	2427	11.7
Birth interval		
First birth	3776	18.2
<24 months	3963	19.1
24-35 months	6775	32.7
>35 months	6188	29.9
Maternal age at first birth		
< 20years	11097	53.6
20-35years	7172	34.6
>35years	48	0.2
Child year of birth		
2012-2013	5347	25.8
2010-2011	7225	34.9
2008-2009	5746	27.8

4.4 Weibull Standard Model for Infant Mortality

The results in table 4.3, is that of survival analysis showing the effects of bio-demographic and socio-economic variables on the risk of infant mortality. The table contains two models- model I contains only bio-demographic variables while model II contains both bio-demographic and socio-economic variables. The models showed the average effects of each variable while controlling for the effects of other covariates.

The results in model I reveal that all socio-economic variables, controlling for each other, are significantly related to risk of infant death. In Model II, the risk of infant mortality is higher in the Northern than the southern regions of rural Nigeria. Also, the results revealed that female children had lower risk of death (HR = 0.83, CI = 0.75, 0.93) than male children. Infants whose parents marriage type are polygamous were associated with higher risk of death (HR = 1.04, CI = 0.92, 1.16) than children of monogamous type of marriage. With reference to maternal age at child birth, increase in age was associated with increased risk of death- 20-35 years (HR = 1.06, CI = 0.89, 1.25), and greater than 35 years (HR = 1.40, CI = 1.13, 1.74). Similarly, increase in maternal age at first birth is also associated with increased risk of infant death: 20-35 years (HR = 1.02, CI = 0.91, 1.14) and greater than 35years (HR = 2.46, CI = 1.22, 4.96). While increased birth interval reduces the risk of infant death: less than 24 months (HR = 1.05, CI = 0.88, 1.25); 24-35 months (HR = 0.64, CI = 0.64, CI = 0.54, 0.76) and greater than 35 months (HR = 0.46, CI = 0.38, 0.56). Furthermore, infants whose mothers had secondary and higher education had lower risk of infant death (HR= 0.91, CI= 0.75-1.10) while those whose mothers had primary education higher risk of death (HR =1.04, CI= 0.89, 1.21) than children whose mother had no education. Also, infants of middle socioeconomic status (HR=0.97, CI=0.84, 1.13) and rich socioeconomic status (HR=0.94, CI= 0.81, 1.08) all had reduced risk of infant death. Other risk factors are access to improved sources of drinking water (HR=1.03, CI=0.92, 1.15); infant of married parents had higher risk (HR = 1.16, CI = 0.79, 1.69) and use of improved toilet facilities had lower risk of infant death (HR=0.83, CI=0.74, 0.94).

Table 4.3: Effects of selected variables on Infant mortality in rural Nigeria using weibull Model

Variables	Model I HR (95% CI)	Model II HR (95% CI)
Sex of the child		
Male	1.00	1.00
Female	0.84 (0.75, 0.93) *	0.83 (0.75, 0.93) *
Type of marriage		
Monogamous	1.00	1.00
Polygamous	1.20 (0.90, 1.12)	1.04 (0.92, 1.16)
Maternal age at child birth		
<20 years	1.00	1.00
20-35 years	1.01 (0.86, 1.19)	1.06, (0.89, 1.25)
>35 years	1.37 (1.11, 1.69) *	1.40 (1.13, 1.74) *
Birth interval		
First birth	1.00	1.00
<24 months	1.12 (0.95, 1.32)	1.05 (0.88, 1.25)
24-35 months	0.68 (0.57, 0.80) *	0.64 (0.54, 0.76) *
>35 months	0.49 (0.40, 0.59) *	0.46 (0.38, 0.56) *
Maternal age at first birth		
< 20years	1.00	1.00
20-35years	1.03 (0.92, 1.14)	1.02 (0.91,1.14)
>35years	2.43 (1.21, 4.89) *	2.46 (1.22, 4.96)
Child year of birth		
2012-2013	1.00	1.00
2010-2011	1.12 (0.98, 1.28)	1.12 (0.98, 1.28)
2008-2009	1.10 (0.96, 1.26)	1.09 (0.95, 1.25)
Maternal education		
None		1.00
Primary		1.04 (0.89, 1.21)
Secondary and higher		0.91 (0.75, 1.10)
Socioeconomic status		
Poor		1.00
Middle		0.97 (0.84, 1.13)
Rich		0.94 (0.81, 1.08)
Marital status		
Never married		1.00
Married		1.16 (0.79, 1.69)

Table 4.3 cont'd.

Variables	Model I HR (95% CI)	Model II HR (95% CI)
Religion		
Catholic		1.00
Other Christian		1.26 (1.03, 1.51) *
Islam		1.07 (0.86, 1.34)
Others		1.11 (0.65, 1.92)
Source of water		
Unimproved		1.00
Improved		1.03 (0.92, 1.15)
Type of toilet facilities		
Unimproved		1.00
Improved		0.83 (0.74, 0.94) *
Region		
North Central		1.00
North East		1.26 (1.05, 1.51) *
North West		1.40 (1.16, 1.67) *
South East		1.25 (0.93, 1.67)
South South		1.03 (0.78, 1.35)
South West		1.04 (0.63, 1.40)
Sample size	18697	18605
Number of failures	1382	1369
Negative log likelihood	7224	7143
Likelihood ratio chi-square	157	197
Degree of freedom	11	25

4.5 Weibull Frailty Model for Infant Mortality

Table 4.4 present the results from two hazard models for infant mortality. It is an extension of table 4.3, but here, frailty model is use instead of standard weibull model to model the effects bio-demographic and socio-economic variables on the risk of infant death. The table show that a total of 1,382 children died in infancy. For all the models, the chi-squared statistics and log likelihood ratios describing the model goodness of fit are all significant.

The estimated variance parameters associated with the frailty effect, θ, in the Weibull frailty model in table 4.4 are 0.507 and 0.518 in Model I and Model II, respectively. These parameters are very significant and the standard errors associated with the hazard ratios of the variables are constantly higher in the frailty models than in standard Weibull models, which in turn result to wider confidence intervals. This indicated that Nevertheless, the increase is generally small and does not alter the significance of any of the parameter estimates.

Like table 4.3, the results in show that all the biodemographic and socioeconomic variables, controlling for each other, are significantly related to survival of infant. In Model I I, the risk of infant mortality is higher in the Northern region than the southern region of rural Nigeria. Furthermore, the results revealed that female children had lower risk of death (HR = 0.75, CI = 0.63, 0.89) than male children. Infants whose parents marriage type are polygamous were associated with higher risk of death (HR = 1.06, CI = 0.88, 1.28) than monogamous type of marriage. With reference to maternal age at child birth, increase in age is associated with increased risk of death- 20-35 years (HR = 1.07, CI = 0.81, 1.40), and children whose mother's age at child birth is greater than 35 years is about 2times more likely to die compare to those less than 20years, (HR = 1.67, CI = 1.18, 2.38). Similarly, increase in maternal age at first birth is also associated with increased risk of infant death: 20-35 years (HR = 1.03, CI = 0.85, 1.24) and children whose mother's age at first birth is greater than 35 years is about 5times more likely to die compare to those less than 20years (HR = 4.45, CI = 1.23, 16.11). While increased birth interval reduces the risk of infant death: less than 24 months (HR = 1.10, CI = 0.83, 1.47); 24-35 months (HR = 0.50, CI = 0.37, 0.66) and greater than 35 months (HR = 0.31, CI = 0.23, 0.42). Also, Children born in the period 2010-2011 are about 1.2times (HR = 1.19, CI = 0.97, 1.47), while those born in the period 2008-2009 are 1.1times (HR = 1.14, CI = 0.91, 1.47) more likely to die compared to those born in the period 2012-2013. The increase in coefficients associated

with the period of birth means that its relationship is better revealed in the presence of bio-demographic factors.

Furthermore, infants whose mothers had secondary and higher education had lower risks of infant deaths (HR= 0.88, CI= 0.65-1.19) than children whose mother had no education, and those whose mothers had primary education had higher risk of infant death (HR =1.08, CI= 0.85, 1.38) than children whose mother had no education. Also, infants of middle socioeconomic status had reduced risk of death (HR=0.93, CI=0.73, 1.18), and rich socioeconomic status also had reduced risk of death at infancy (HR=0.88, CI= 0.70, 1.10) compare to children of poor socioeconomic status. Regarding religion, children of Islamic mothers are about 1.34times; other Christian denominations are 1.46times while those of other religions are 1.28times more likely to die in infancy compared to children of Catholic mothers. Other risk factors are access to improved sources of drinking water (HR=1.04, CI=0.88, 1.26), children of married parents had higher risk (HR = 1.25, CI = 0.68, 2.31) and use of improved toilet facilities had lower risk of death at infancy (HR=0.76, CI=0.63, 0.91).

Table 4.4: Effects of selected variables on infant mortality in rural Nigeria, using Frailty model

Variables	Model I HR (95% CI)	Model II HR (95% CI)
Sex of the child		
Male	1.00	1.00
Female	0.75 (0.64, 0.89) *	0.75 (0.63, 0.89) *
Type of marriage		
Monogamous	1.00	1.00
Polygamous	1.02 (0.85, 1.22)	1.06 (0.88, 1.28)
Maternal age at child birth		
<20 years	1.00	1.00
20-35 years	1.01 (0.78, 1.32)	1.07 (0.81, 1.40)
>35 years	1.63 (1.16, 2.30) *	1.67 (1.18, 2.38) *
Birth interval		
First birth	1.00	1.00
<24 months	1.20 (0.91, 1.59)	1.10 (0.83, 1.47)
24-35 months	0.54 (0.41, 0.71) *	0.50 (0.37, 0.66) *
>35 months	0.33 (0.25, 0.45) *	0.31 (0.23, 0.42) *
Maternal age at first birth		
< 20years	1.00	1.00
20-35years	1.04 (0.87, 1.24)	1.03 (0.85, 1.24)
>35years	4.19 (1.15, 15.21) *	4.45 (1.23, 16.11) *
Child year of birth		
2012-2013	1.00	1.00
2010-2011	1.20 (0.97, 1.47)	1.19 (0.97, 1.47)
2008-2009	1.15 (0.93, 1.44)	1.14 (0.91, 1.47)
Maternal education		
None		1.00
Primary		1.08 (0.85, 1.38)
Secondary and higher		0.88 (0.65, 1.19)
Socioeconomic status		
Poor		1.00
Middle		0.93 (0.73, 1.18)
Rich		0.88 (0.70, 1.10)
Marital status		
Never married		1.00
Married		1.25 (0.68, 2.31)

Table 4.4 Cont'd.

Variables	Model I HR (95% CI)	Model II HR (95% CI)
Religion		
Catholic		1.00
Other Christian		1.46 (1.04, 2.03) *
Islam		1.34 (0.80, 1.61)
Others		1.28 (0.54, 3.01)
Source of water		
Unimproved		1.00
Improved		1.04 (0.88, 1.26)
Type of toilet facilities		
Unimproved		1.00
Improved		0.76 (0.63, 0.91) *
Region		
North Central		1.00
North East		1.42 (1.07, 1.90) *
North West		1.64 (1.23, 2.18) *
South East		1.40 (0.88, 2.24)
South South		1.07 (0.71, 1.63)
South West		1.05 (0.70, 1.56)
Sample size	18697	18605
Number of failures	1382	1369
Negative log likelihood	7139	7061
Likelihood ratio chi-square	150	184
Degree of freedom	11	25
Theta	0.507 (0.36, 0.71)	0.518 (0.36, 0.73)
Likelihood ratio chi-square of theta =0	170.54	163.07

* significant at $p < 0.05$

4.6 Weibull Model for Child Mortality

Table 4.5, shows the result of survival analysis on the effects of bio-demographic and socio-economic variables on the risk of child mortality. The table contains two models- model I contains only bio-demographic variables while model II contains both bio-demographic and socio-economic variables. The models showed the average effects of each variable while controlling for the effects of other covariates.

The results in model I reveal that all socio-economic variables, controlling for each other, are significantly related to risk of child death. In Model II, like table 4.3, the risk of childhood mortality is higher in the Northern than the southern regions of rural Nigeria. Also, the results revealed that female children had lower risk of death (HR = 0.838, CI = 0.74, 1.03) than male children. Children whose parents marriage type are polygamous were associated with higher risk childhood death (HR = 1.07, CI = 0.91, 1.27) than children of parents in monogamous type of marriage. With reference to maternal age at child birth, increase in age is associated with increased risk of death 20-35 years (HR = 1.06, CI = 0.83, 1.35), and greater than 35 years (HR = 1.32, CI = 0.98, 1.79). But, increase in maternal age at first birth is associated with reduced risk of childhood death: 20-35 years (HR = 0.99, CI = 0.84, 1.18) and greater than 35years (HR = 0.66, CI = 0.09, 4.69). Similarly increased or wider birth interval reduces the risk of childhood death: less than 24 months (HR = 1.08, CI = 0.83, 1.41); 24-35 months (HR = 0.86, CI = 0.66, 1.12) and greater than 35 months (HR = 0.54, CI = 0.40, 0.73). Furthermore, children whose mothers had secondary and higher education had lower risks of childhood deaths (HR= 0.44, CI= 0.0.31, 0.62) than children whose mother had no education while those whose mothers had primary education had lower risk of childhood death (HR =0.85, CI= 0.68, 1.07) than children whose mother had no education. Also, children of middle socioeconomic status (HR=0.99, CI=0.80, 1.22) had reduced risk of death than rich socioeconomic status (HR=1.06, CI= 0.87, 1.29). Other risk factors are access to improved sources of drinking water (HR=0.94, CI=0.81, 1.11); children of married parents had lower risk of death (HR = 0.96, CI = 0.58, 1.59) and use of improved toilet facilities (HR=0.96, CI=0.81, 1.13).

Table 4.5: Effects of selected variables on child mortality in rural Nigeria using Weibull model

Variables	Model I HR (95% CI)	Model II HR (95% CI)
Sex of the child		
Male	1.00	1.00
Female	0.88 (0.76, 1.02)	0.88 (0.74, 1.03)
Type of marriage		
Monogamous	1.00	1.00
Polygamous	1.06 (0.91, 1.24)	1.07 (0.91, 1.27)
Maternal age at child birth		
<20 years	1.00	1.00
20-35 years	0.91 (0.72, 1.15)	1.06 (0.83, 1.35)
>35 years	1.21 (0.91, 1.63)	1.32 (0.98, 1.79)
Birth interval		
First birth	1.00	1.00
<24 months	1.31 (1.01, 1.69) *	1.08 (0.83, 1.41)
24-35 months	1.02 (0.79, 1.32)	0.86 (0.66, 1.12)
>35 months	0.63 (0.47, 0.85) *	0.54 (0.40, 0.73) *
Maternal age at first birth		
< 20years	1.00	1.00
20-35years	0.99 (0.85, 1.16)	0.99 (0.84, 1.18)
>35years	0.67 (0.09, 4.79)	0.66 (0.09, 4.69)
Child year of birth		
2012-2013	1.00	1.00
2010-2011	1.09 (0.91, 1.32)	1.11 (0.92, 1.33)
2008-2009	0.91 (0.74, 1.11)	0.90 (0.74, 1.10)
Maternal education		
None		1.00
Primary		0.85 (0.68, 1.07)
Secondary and higher		0.44 (0.31, 0.62) *
Socioeconomic status		
Poor		1.00
Middle		0.99 (0.80, 1.22)
Rich		1.06 (0.87, 1.29)
Marital status		1.00
Never married		0.96 (0.58, 1.59)
Married		

Table 4.5 cont'd.

Variables	Model I HR (95% CI)	Model II HR (95% CI)
Religion		
Catholic		1.00
Other Christian		1.14 (0.87, 1.51)
Islam		1.08 (0.80, 1.47)
Others		2.46 (1.34, 4.51) *
Source of water		
Unimproved		1.00
Improved		1.03 (0.92, 1.15)
Type of toilet facilities		
Unimproved		1.00
Improved		0.96 (0.81, 1.13)
Region		1.00
North Central		1.68 (1.26, 2.24)
North East		1.88 (1.41, 2.51) *
North West		1.57 (0.93, 2.64) *
South East		1.24 (0.78, 1.98)
South South		1.21 (0.71, 1.87)
South West		18427
Sample size	18519	674
Number of failures	677	3026
Negative log likelihood	3090	149
Likelihood ratio chi-square	54	25
Degree of freedom	11	

* significant at $p < 0.05$

4.7 Weibull Frailty Model for Child Mortality

Table 4.6 present the results from two hazard models for childhood mortality. It is an extension of table 4.5, but here, frailty model was used instead of standard weibull model to model the relationship between bio-demographic and socio-economic variables and the risk of childhood death. The table show that a total of 677 children died between 12 and 59 months. The shape parameters P, in table 4.5 and table 4.6 indicate that the hazard is reducing in all the models. For all the models, the chi-squared statistics and log likelihood ratios describing the model goodness of fit are all significant.

The estimated variance parameters associated with the frailty effect, θ, in the Weibull frailty in Model I and Model II shown in table 4.6 are 0.602 and 0.565, respectively. Like in infant mortality, these estimates are significant and show that the risks of child death between families keep on differing even after controlling for a number of observed determinants of childhood mortality. The estimate in model II imply that one child death in a family is related to about 57 percent increase in the risk of the index child dying comparative to what it would have being assuming the child were alive. These results imply that, in contrast to infant mortality, there is huge difference between families in the risk of child mortality that is not accounted for by the measured and observed factors. Like in infancy, the standard errors are higher in the frailty models compared to the standard models. Again, since the effect of the factors is unchanged in both the standard Weibull model and frailty model. Nevertheless, it is obvious that the effect of the covariates on infant mortality is smaller than that observed for in child mortality.

Now we will provide an overview of the patterns shown in the table 4.6, and comparing them with that of infant mortality where necessary. Like table 4.5, the results in show that all the biodemographic and socioeconomic variables, controlling for each other, are significantly related to child survival. Also, in Model II, the risk of infant mortality is higher in the Northern region than the southern region of rural Nigeria and the risk is stronger, compared to what was observed in infancy. Furthermore, whereas in infancy, female had lower risk of death by 75%, in childhood there is slight increase, as the risk of death is about 83% (CI = 0.66, 1.05). Like what we observed in infancy, children whose parents marriage type are polygamous were associated with higher risk of death (HR = 1.09, CI = 0.84, 1.42) than monogamous type of marriage. With reference to maternal age at child birth, increase in age is associated with increased risk of death-

20-35 years (HR = 1.06, CI = 0.73, 1.54), and children whose mother's age at child birth is greater than 35 years have higher risk of death than those less than 20years, (HR = 1.44, CI = 0.90, 2.31). Though, this is higher compare to infancy. Contrary, to what we observed in infancy, increase in maternal age at first birth is associated with reduced risk of infant death: 20-35 years (HR = 1.03, CI = 0.80, 1.33) and children whose mother's age at first birth is greater than 35 years have a lower risk (HR = 0.45, CI = 0.02, 9.02) of death compare to those less than 20years. Similar to what we observed in infancy, increased birth interval reduces the risk of childhood death: less than 24 months (HR = 1.22, CI = 0.81, 1.86); 24-35 months (HR = 0.83, CI = 0.55, 1.25) and greater than 35 months (HR = 0.44, CI = 0.28, 0.70). Also, Children born in the period 2010-2011 had higher risk of death (HR = 1.16, CI = 0.88, 1.54), while those born in the period 2008-2009 had lower risk of death in childhood (HR = 0.85, CI = 0.63, 1.15) compared to those born in the period 2012-2013, whereas in infancy, we observed a higher risk all through the period of birth. Again, the differences in the hazard across the period of birth maybe associated with the presence of bio-demographic factors.

Furthermore, whereas in infancy children whose mothers had secondary and higher education had 88% risk of death compared those whose mother had no education, in childhood the risk of death reduced 32% (CI= 0.19, 0.52). Again, in infancy children whose mother had primary education had 108% risk of death compared to those without education, in childhood the risk of death also reduced to 78% (CI = 0.56, 1.11). Exactly, like in infancy, children of middle socioeconomic status had reduced risk of death by 93% (CI=0.67, 1.30) compared to poor socioeconomic status. In infancy, children of rich socioeconomic status had reduced risk of death by 88%, in childhood the risks of death increases in children of rich socioeconomic status (HR= 1.10, CI= 0.81, 1.49) compare to children of poor socioeconomic status. Regarding religion, children of Islamic mothers are about 1.14times (CI = 0.72, 1.81); other Christian denominations are 1.21times (0.79, 1.86) while those of other religions are 4.12times more likely to die in childhood compared to children of Catholic mothers. Again, while in infancy, improved source of water supply increase risk of infant death by 1.04 times, in childhood improved source of water supply reduced the risk of childhood death by 92% (CI= 0.72, 1.18) compared to unimproved source of water supply. Other risk factors of childhood mortality are children of married parents had lower risk of childhood death (HR= 0.93, CI= 0.41, 2.07) than children of never married parents. This is contrary to what we observed in

infancy as there are higher risks of infant deaths among married parents than never married parents. . And use of improved toilet facilities reduced the risk of childhood death by 95% (CI=0.74, 1.21). Whereas in infancy improved toilet facilities reduced the risk of death by 76%.

Table 4.6: Effects of selected variables on child mortality rural Nigeria using frailty model

Variables	Model I HR (95% CI)	Model II HR (95% CI)
Sex of the child		
Male	1.00	1.00
Female	0.82 (0.65, 1.03)	0.83 (0.66, 1.05)
Type of marriage		
Monogamous	1.00	1.00
Polygamous	1.08 (0.84, 1.37)	1.09 (0.84, 1.42)
Maternal age at child birth		
<20 years	1.00	1.00
20-35 years	0.88 (0.61, 1.26)	1.06 (0.73, 1.54)
>35 years	1.32 (0.83, 2.10)	1.44 (0.90, 2.31)
Birth interval		
First birth	1.00	1.00
<24 months	1.57 (1.05, 2.36) *	1.22 (0.81, 1.86)
24-35 months	1.05 (0.71, 1.56)	0.83 (0.55, 1.25)
>35 months	0.54 (0.35, 0.84) *	0.44 (0.28, 0.70) *
Maternal age at first birth		
< 20years	1.00	1.00
20-35years	1.04 (0.82, 1.32)	1.03 (0.80,1.33)
>35years	0.49 (0.03, 8.95)	0.45 (0.02, 9.02)
Child year of birth		
2012-2013	1.00	1.00
2010-2011	1.14 (0.86, 1.52)	1.16 (0.88, 1.54)
2008-2009	0.86 (0.64, 1.17)	0.85 (0.63, 1.15)
Maternal education		
None		1.00
Primary		0.78 (0.56, 1.11)
Secondary and higher		0.32 (0.19, 0.52) *
Socioeconomic status		1.00
Poor		0.93 (0.67, 1.30)
Middle		1.10 (0.81, 1.49)
Rich		
Marital status		1.00
Never married		0.93 (0.41, 2.07)
Married		

Table 4.6 cont'd.

Variables	Model I HR (95% CI)	Model II HR (95% CI)
Religion		
Catholic		1.00
Other Christian		1.21 (0.79, 1.86)
Islam		1.14 (0.72, 1.81)
Others		4.12 (1.47, 11.48)*
Source of water		
Unimproved		1.00
Improved		0.92 (0.72, 1.18)
Type of toilet facilities		
Unimproved		1.00
Improved		0.95 (0.74, 1.21)
Region		
North Central		1.00
North East		2.06 (1.36, 3.13)*
North West		2.41 (1.59, 3.66)*
South East		1.89 (0.90, 3.96)
South South		1.47 (0.76, 2.82)
South West		1.37 (0.67, 1.24)
Sample size	18697	18605
Number of failures	1382	1369
Negative log likelihood	7224	7143
Likelihood ratio chi-square	157	197
Degree of freedom	11	25
Theta	0.602 (0.39, 0.92)	0.565 (0.35, 0.90)
Likelihood ratio test of theta=0	117	106

* significant at $p < 0.05$

CHAPTER FIVE

DISCUSSION AND CONCLUSION

5.1 Discussion

5.1.1 Effects of Selected Socioeconomic and Biodemographic Factors on Infant and Child Mortality in Rural Nigeria

The first objective of this study was to determine the effects of selected biodemographic and socioeconomic factors on infants and child mortality in rural Nigeria. Weibull proportional hazard regression analysis and weibull frailty model was employed to identify the biodemographic and socioeconomic factors associated with infant and child mortality in rural Nigeria. The study identified biodemographic factors, such as child's sex, maternal age at child birth, birth interval, maternal age at first birth and socioeconomic factors such as, religion, type of toilet facilities, place o f residence and maternal education as factors associated with infant and child mortality in rural Nigeria. Most of these covariates or factors remained significantly associated with infant and child mortality even after controlling for the effects of other important factors, while some is to a lesser degree.

Considering sex of child, results shows a statistical significant relationship between child's sex and infant mortality, but not significant related to child mortality in rural Nigeria. Female children had reduced risks of dying at infancy compared to male children. This may be attributed to Cultural beliefs, that female children are more important to the family development than male counterpart. Since the study is rural base with where great proportion of the respondents had little or no formal education female children are regarded as a source of wealth in terms of bride price at marriage. Consequently parents show considerable care to females children than male siblings. This is consistent with similar studies both national and international. For instance, (Abimbola O. et al. 2012) in the study in rural Nigeria observed that man children are more likely to die than men children. Also, (Alex and Kaberuka 2015) in the study of factors associated with under five Mortality in Uganda identified sex of the child among the factors associated with child motality. Damodar S. et al (2015) also supported this argument in a study in rural India.

The study found that maternal age at child birth was significantly associated with infant mortality, but not significant to child mortality. Children of older age, more than 35years was at higher risk of dying compare to children of younger age. This finding is in consistent with Damodar et al, (2015) that the risk of infant death was highest among births to mothers aged 30years and more compare with children of mothers aged 20-29. Biological factors (Osital, and others, 2015) may be likely explanation for this. Similar findings have been identified in the previous studies, (Uthman, 2008); Heiko and others 2004); among others.

Further, as previously found in Nigeria (Uthman, 2008), (Akinyemi et al, 2013), (Adedini, et al. 2015) and elsewhere (Whitworth & Stephenson, 2002) this study established that birth interval was an important factor of infant and child mortality in rural Nigeria. Children with a longer birth interval had lower risks of death than children with a shorter birth interval of 24 months or longer. According to Whitworth & Stephenson, (2002), this could be due to the depletion in maternal syndrome as a result of having births that is too close, and due to competition for household resources often characterize with short birth intervals.

The study also identified that access to improved toilet facilities as significant factor to the risk of infant mortality in rural Nigeria. Though, it is not significant to child mortality. It was found that the risks of infant mortality were significantly lower if children are raised in houscholds that had access to improve toilet facilities. This is in agreement with Akinyemi, (2013). Since access to unproved toilet facilities is directly related to socio-economic status, it implies that socioeconomic status is also a factor affecting infant mortality, Osita and others (2015).

The study also established a significant association between region and infant and child mortality. As has been previously established (Antai, 2011) and (Sunday and others, 2015), this study observed that region where children were born or raised has a great influence on the risks of death at infancy as children residence in the northern region was at higher risk of infant mortality compared with children residence in southern region. The North-east and North-west has the highest risk of infant mortality while has the lowest risk of death at infancy. This also was consistent with Abimbola, and others (2012) which observed that shows that North-west region had the highest under-five mortality rate of 200.9 deaths per 1000 births, followed by North-east region with 195.8 deaths per 1000 births. The reasons for these disparities in infant and child mortality across regions in rural Nigeria are diverse. For instance, North-east and

North-west regions are regions where children were mostly of higher order birth – i.e. fifth order or higher, mothers were mostly uneducated, mainly unemployed and in poor households, and were mostly teenagers at the time of their first birth (Adedini, et al., 2011).

Another important factor to child mortality as revealed in the study was maternal education. The result identified that children whose mother had secondary or higher education had lower risk of death at childhood than children of mother with no education in rural Nigeria. Though, this is not statistically significant in infant mortality, but many previous studies on mortality identified maternal education as a very important factor to infant and child mortality, (Osita, 2015; Akinyemi et al, 2013; Antai, 2011; Uthman, 2008; Whitworth & Stephenson, 2002) An explanation for this could be that mothers with higher education could alter her approach to such practices as poor health-seeking behaviour, and frequency of births. Since education is directly related to wealth index, it implies that high educated mothers would have the resources to take care of the health and social needs of their children, which in turn increase chance of child survival. Also, even if an educated woman experiences births that are too close, maternal education has the advantage of weakening the effect of a short birth interval and through increased female autonomy and economic empowerment that guarantees access to resources, which could eliminate competition for household resources among siblings (Whitworth and Stephenson, 2002).

5.1.2 Influence of Unobserved Heterogeneity on Infant and Child mortality in Rural Nigeria.

It had been shown from result that infant and child mortality vary due to the measured socioeconomic, and biodemographic factors even though the relationships between the covariates and mortality were often not statistically significant. In this section we discuss the findings on frailty models. Frailty, in the infant and child mortality models, represents a child's vulnerability to the risk of death. It captures the total effect of all factors that influence the child's risk of death that are not included in the baseline hazards presented in the model, (Govert, 2014).

While standard weibull model can account for observed covariates, the frailty effects presented in frailty model represent unmeasured effects on infant and child mortality. In this study, almost

all covariates that are most biodemographic variables are significantly related to infant while most socioeconomic variables are significantly related to child mortality in the standard weilbull model and frailty model, except for maternal age at first birth which was significant in frailty model but not significant in standard weibull model for infant mortality. We observed that the risk of infant mortality is about 5times more likely for children of mother greater 35years old at their first birth compared with children of whose their mother's age as at the time of their first birth was less than 20years. This is in consistent with the study in Kenya by Rasugu et al, (2013). This high effect of maternal age at first birth to infant mortality may be due to physiological and sociopsychological. The reproductive system of older mothers are depicted compared to younger mothers (Adeboye, et al, 2010) and depression associated with late child delivery is also related to infant mortality, (John, 2013).

It was established from the study that there is marginal difference between the effect of frailty for both infant and child mortality. The frailty effects at the family level for infant and child mortality were 51.8 and 56.5 percent, respectively. The frailty effects were statistically significant. This implies that the risks of infant and child deaths between families differ significantly even after controlling for a number of known determinants of infant and child mortality in rural Nigeria. It further implies that the variables in the infant and child mortality model explained 48.2 and 43.5 percent of the family variation in infant and child deaths. Though, the variation was more in infant mortality than child mortality. These results, was in consistent with the findings of (Rasugu, et al, (2013), and Justine, et al (2015).

5.2 Limitations of the Study

Generally, mortality studies are associated with limitations of data, particularly in the developing countries like Nigeria where death is regarded as a sad event that respondents do not love to recall. This study is drawn on a cross-sectional secondary datasets; as a result, there is tendency for child deaths to be underreported. "Mothers usually do not talk about their dead children in order not to bring back sad memories or because their cultural reasons, (NPC and ICF Macro, 2014). As omission of deaths can affect levels and patterns of child deaths; so also misreporting of age at death (heaping or avoidance) can distort the age pattern of mortality. Also, because information on child's births and deaths was collected retrospectively, number of births and child deaths might have been underreported due to

memory loss. Nonetheless, it is not envisaged that the data limitations will pose a serious challenge to this study. This is because the data quality assessment done for 2013 NDHS data indicated that the surveys yielded far more reliable mortality data compared to the surveys earlier conducted (NPC and ICF Macro, 2014).

5.3 Conclusions

It was observed from the results that the extent of effect of the covariates is largely unchanged in the presence of frailty, suggesting that conclusions from the weibull standard models are robust to the collapse of the statistical assumption of independence. Nevertheless, the results of frailty model may better be reported because it is more precise and efficient.

The findings on the effect of selected determinants of childhood mortality illustrate that the bio-demographic variables are more important during the infant age (0-11 months) while socioeconomic variables are more important during the childhood age (12-59 months). Male children had higher infant mortality risk than female children. Infant and child mortality is increased for children of short birth interval. While increase in maternal age at first birth and maternal age at child all increase the risk of infant mortality. Though, maternal age at first birth was only significant in frailty model. Other factors identified that significantly associated with infant and child mortality is mother religion and region of residence. Furthermore, whereas, unimproved toilet facilities increase the risk of infant mortality, children whose mother had secondary or higher education had reduced risk of child mortality in rural Nigeria.

We found that family frailty for both infant and child mortality is 51.8 and 56.5 percents respectively in rural Nigeria. The magnitude of the unexplained variation in infant and child mortality by the measured covariates represents infant and child vulnerability to the risk of death. However, the frailty magnitude in this study could also be magnified by the unobserved community effects. More so, child mortality is most affected by unobserved heterogeneity than infancy in rural Nigeria even due the marginal difference from each other.

5.3 Recommendations

Based on the conclusions the following recommendations are made:

1) To rectify the current situation of infrastructural deficiencies in many communities in Nigeria, it is recommended that there should be increased or special budgetary allocation towards the provision of essential amenities like drinkable water, electricity, health facilities, and good toilet facilities in rural Nigeria.

2) The current family planning programme in the country should be strengthened and expanded in rural areas to ensure that all men and women who wish to space have the means to do so. This will bring about adequate spacing between births.

3) There is a need for all tiers of government to provide adequate funding to regions with high infant and child mortality risks.

4) There should be strong political commitments from governments at various levels towards achieving increase in the girl child enrolment in schools in rural Nigeria. This is important as it will reduce the high number of illiteracy in the rural areas.

5) Future studies should therefore endeavor to look at the unobserved heterogeneity in the entire country in order to ascertain which of infant or child mortality most affected by the frailty.

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