Health Inequalities of children in sub-Saharan Africa from 1990 to 2010: Comparative analysis using data from Health and Demographic Surveys

by

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Abstract

This study is based on the assumption that the under-five mortality rate, in recent decades, has declined, particularly in developing countries. However, all the social strata across many countries do not seem to benefit from this reduction of mortality - and mortality remains abnormally high among children especially those from underprivileged social strata. This research is, therefore, a holistic approach to analyse and quantify the inequalities of health among children under five in sub-Saharan Africa over the last two decades (1990-2010). The research sought to investigate the trend and determinants of health inequalities of under-five years (mortality and morbidity) in sub-Saharan Africa (SSA) from 1990 to 2010. An essential point has been devoted to the decomposition of effects and analysis of the contribution of the factors explaining these inequalities.

The data used in the study come from Demographic and Heath Surveys (DHS) done between 1990 and 2015 in sub-Saharan Africa countries. In order to analyse the inequalities in trends of mortality and morbidity of children, different selected countries that have conducted at least three DHS during the 1990-2010 period.

Several statistical methods were used for data analysis. There were four chapters which is prepared with an article style. For the first paper titled "Decomposing Inequalities in Under-Five Mortality in Selected African Countries", concentration index (CI) and Generalised Linear Model (GLM) with a logit link were used to analyse and measure under 5 mortality inequalities and the associated factors. This paper has been published in the Iranian Journal of Public Health. For the second paper titled "*Determinants of Under-Five Mortality in Burkina Faso: A Concentration Dimension*". The study used logistics regression and Oaxaca-Blinder decomposition method for the binary outcome to analyse data was involved. For data analysis of the third paper titled "*Women Education, Health Inequalities in Under-Five Mortality in sub-Saharan Africa, 1990 – 2013*", logistic regression and Bius's decomposition method were used to examine the effect of mother's education level on childhood mortality. In the fourth paper titled "*Trends and Risk Factors for Childhood Diarrheal in sub-Saharan Countries (1990-2010): Assessing the Neighbourhood Inequalities*", a multilevel logistic regression modelling was used to determine the fixed and random effects of the risk factors associated with the diarrheal morbidity.

The work carried out during this on-going thesis helps to understand the magnitude of inequalities in under-five mortality in sub-Saharan countries. The findings showed that the

contributing factors of inequalities of child mortality were birth order, maternal age, parity and household size. With regards to the relationship between mother's education level and inequalities in mortality of children under-five in sub-Saharan Africa, findings showed that children of mothers who did not attend school have a higher rate of death compared to those who had been to school. However, we have observed that the inequalities have narrowed over time. The results showed the risk factors of diarrheal morbidity varied from one country to another, but the main factors included: child's age, the size of the child at birth, the quality of the main floor material, mother's education and her occupation, type of toilet, and place of residence.

In conclusion, the results of this study show that inequalities in under-five mortality are still important among different social strata in sub-Saharan Africa countries. It is then urgent to take actions to save the lives of children in disadvantaged social strata.

Key words: Sub-Saharan Africa, child, Mortality, Morbidity, Demographic and Health Surveys

DECLARATION

I declare that *Health inequalities of children in sub-Saharan Africa from 1990 to 2010: Comparative analysis of Demographic and Health Survey* is my own work, that it has not been submitted before for any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and acknowledged by complete references.

Aristide Romaric Bado March 2016

Signed: .....

Dedication

To Chris Yoann Alarick and Nina.

To my mother Pauline E Kandiel.

To my siblings.

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List of Acronyms and Abbreviations

BCG	Bacillus Calmette Gurine
BH	Birth History
CI	concentration index
ICC	intra-class correlation coefficient
ETAT	Tri-Assessment Emergency Treatment
DHS	demographic and health surveys
DPT	diphtheria-pertussis-tetanus
WHO	World Health Organization
SSA	sub-Saharan Africa
MDG	MDGs
HIV	Human Immunodeciency Virus
AIDS	Acquired Immunodeciency Syndrome
DK	not know
GLM	Generalized Linear Model
UNICEF	United Nations Children's Emergency Fund
U5MR	under-five mortality rate
SYLFF	Young Leaders the Fellowship Fund

Chapter 1: Introduction

1.1 Background

The Millennium Development Goals (MDGs) are the biggest commitment in history to fight against global poverty and ill-health (Schröders, Wall, Kusnanto, & Ng, 2015). The fourth MDG, in particular, calls for reducing mortality of children under-five years by two-thirds by 2015. Therefore, the health of children under-five years in general, and mortality, in particular, are a major priority for developing countries.

Recent studies indicate that while under-five mortality has decreased over the last few last decades in both developed and developing countries (Houweling & Kunst, 2010; T. A. Houweling, Ronsmans, Campbell, & Kunst, 2007; McKinnon, Harper, Kaufman, & Bergevin, 2014; UNICEF, 2012), it is very unlikely that the fourth MDG will be met by 2015 in many sub-Saharan countries in the light of progress made thus far (UNDP, 2013). Despite the drop in regional and global mortality rate of children, deaths remain alarmingly concentrated in the poorest regions of the world and sub-Saharan Africa is recorded to have the highest regional rate of mortality of children under-five years: one child over nine dies before their fifth birthday (The Inter-agency Group for Child Mortality Estimation (UN IGME), 2013). Similarly, inequalities exist, and remain both between countries, and within countries, between different sub-groups between socio-economic groups (Bhattacharya & Chikwama, 2012; Cleland, Bicego, & Fegan, 1992; Lauridsen & Pradhan, 2011; Minujin & Delamonica, 2004; Mustafa & Odimegwu, 2008; Razzaque, Streatfield, & Gwatkin, 2007), between the place of residence (Akoto & Tambashe, 2002; Fotso, 2006), between ethnicity (Adedini et al., 2012; Antai, 2011;

Razzaque et al., 2007) and between parental characteristics (Cleland et al., 1992) and children (Mustafa & Odimegwu, 2008).

Socioeconomic inequalities in childhood mortality are a major challenge to public health in developing countries. Substantial evidence suggests that low socioeconomic status is highly correlated with poorer health. Previous results found that childhood mortality is considerably higher among lower socio-economic groups within countries (Houweling & Kunst, 2010). Reducing these inequalities by improving child survival, in poorer regions, to the level of developing countries would substantially improve population health (Houweling & Kunst, 2010).

Specific attention is devoted to research on child health inequalities in the developing countries (Adedini et al., 2012; Akinyemi, Bamgboye, & Ayeni, 2013; Akoto & Tambashe, 2002; Amin, Shah, & Becker, 2010; Arifeen, 1989; Arokiasamy, Jain, Goli, & Pradhan, 2013; Arokiasamy & Pradhan, 2011; Asamoah, Agardh, & Ostergren, 2013; Barros & Victora, 2010; T. A. J. Houweling & Kunst, 2010; Kumar & Singh, 2013; O'Donnell, van Doorslaer, Wagstaff, & Lindelow, 2007; Pradhan & Arokiasamy, 2010; Wagsta, Wagstaff, Doorslaer, & Watanabe, 2003). Some of the researches have a focus on sub-Saharan African with emphasis on the gap between the richest and the poorest socio-economic status. However, little is done on the contribution of other factors to deepening inequalities in child heath.

1.2 Significance of the study

The primary focus of this study on the trends and determinants of inequalities in health among children under five years between the period 1990 and 2010 is linked to the evaluation of goal 4 of the MDGs in sub-Saharan countries. In effect, the results of this research may be useful on a national scale since the study uses sub-regional records in

assessing the progress in the fight against morbidity and mortality of children, as well as highlighting the inequalities that exist between different societies and countries.

Achieving health equity is an important health policy goal in health systems internationally (Asada, Hurley, Norheim, & Johri, 2014). Thus, the contributions of this study may be of interest to scholars, policy-makers, and researchers. Over the past decades, there has been a growing interest in studies focusing on health inequalities, particularly in developing countries. The health equity researchers and policy-makers and the World Health Organization (WHO)'s Commission on Social Determinants of Health, put health equity forward in policy agendas (Asada et al., 2014). The results of this research could be a significant contribution towards advancing research on this topic.

1.3 Aim of the study

This research is based on the assumption that the under-five mortality rate has declined in recent decades, particularly in developing countries. However, all the social strata across different countries do not seem to benefit from this reduction of mortality, and mortality remains abnormally high among children from underprivileged social strata. Therefore, this study is a holistic approach to analysing and quantifying the inequalities of health among children under five in sub-Saharan Africa, over the last two decades (1990-2010).

Although the under-five mortality level is declining in all countries, inequalities between social strata remain and there is a call for actions to reduce these inequalities. In general, this research is to investigate the trends and determinants of under-five year's health inequalities (mortality and morbidity) in sub-Saharan Africa (SSA) from

1990 to 2010. More specifically, aim is to: i) Quantify the socio-economic inequalities in mortality and morbidity in children under five years in SSA; ii) Quantify the contribution attributable to socio-economic characteristics: wealth index, education, neighbourhood inequalities; and iii) To access the profile of inequalities in mortality and morbidity in children under five years between countries.

As noted in the literature, inequalities in health are the consequence of an unfair distribution of power, money, resources and finally health services, as well as the overall conditions of everyday life of people (Friel & Marmot, 2011; Schröders et al., 2015; WHO Commission on Social Determinants of Health, 2008). Inequalities in mortality and morbidity of children under five years according to socio-economic status, maternal education and neighbourhood inequalities will receive more attention in this research.

1.4 Reader's orientation

In line with the regulations of the University of the Western Cape, this thesis is structured into nine chapters. Overall, the chapters attempt to address the overall aim of the study, however, each chapter address a specific objective of the thesis.

The thesis is organized as follows:

Chapter 2 presents the literature review while Chapter 3 provides an overview of the data and methods. The results are presented in 4 Chapters:

Chapter 4: Decomposing wealth-based inequalities in Under-five mortality in West Africa.

Chapter 5: Determinants of Under-Five Mortality in Burkina Faso: A Concentration Dimension.

Chapter 6: Women Education, Health Inequalities in Under-Five Mortality in sub-Saharan Africa, 1990 – 2015.

Chapter 7: Trends and Risk Factors for Childhood Diarrhoea in sub-Saharan Countries (1990-2010): Assessing the Neighbourhood Inequalities.

In Chapter 8, I discuss the results of the study and chapter 9 draw the study's conclusions.

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Chapter 2: Literature Review

The purpose of this chapter is to present the main approaches, through a review of the relevant literature on the determinants and health inequalities among children under five years old. The chapter is divided into two main areas: i) the explanatory approaches on health determinants of children and ii) the explanatory approaches of health inequalities among children under five.

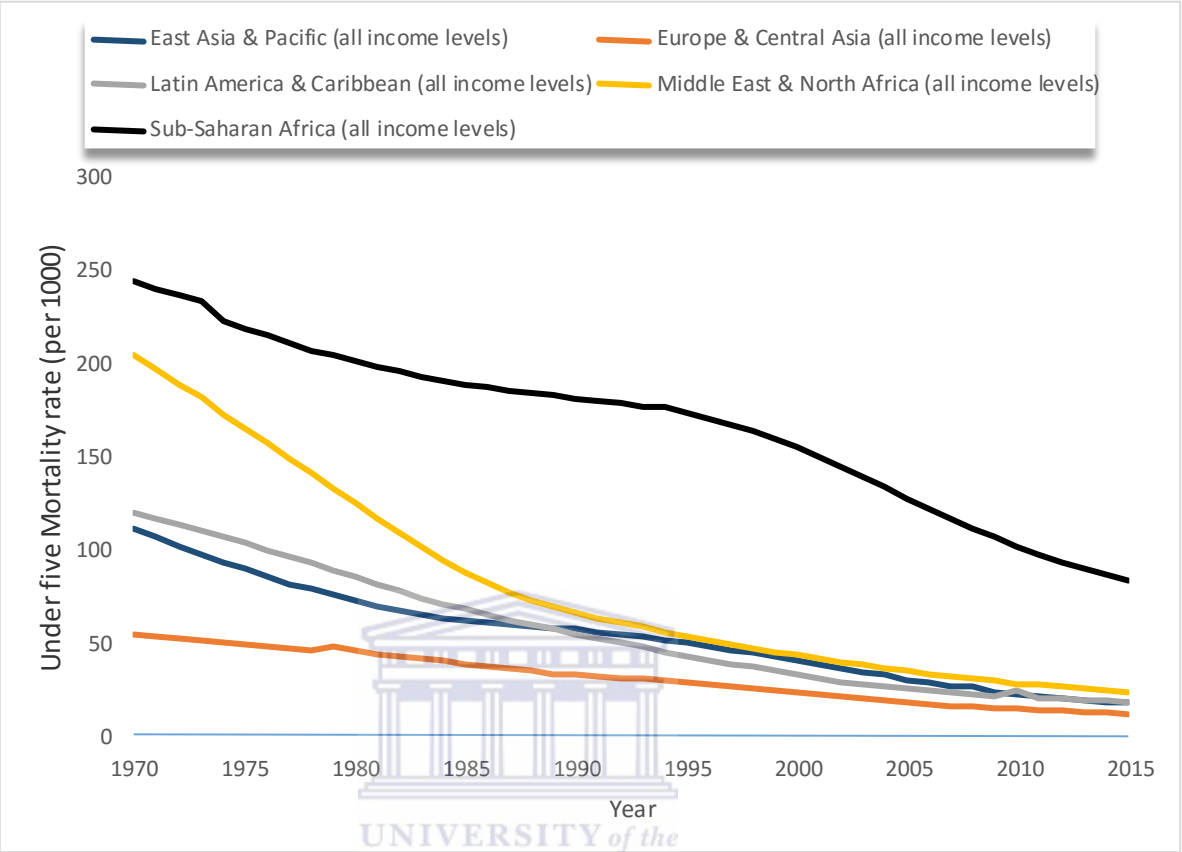
2.1 Levels and trends of under-five mortality in sub-Saharan Africa

The global progress towards reducing child mortality since 1990 has been very significant with the under-five mortality rate declining by nearly half from 90 deaths per 1,000 live births in 1990 to 48 per 1,000 in 2012 (The Inter-agency Group for Child Mortality Estimation (UN IGME), 2013), while the number of deaths of children under five dropped from 12.7 million in 1990 to 5.9 million in 2015 (The Inter-agency Group for Child Mortality Estimation (UN IGME), 2015).

Sub-Saharan Africa has witnessed a decline of under-five mortality rate over the last two decades (1990-2015). The decline in child mortality observed since 1990 is attributed to improved access to quality health care and affordable, as well as an extension of health programmes for newborns and vulnerable. However, Sub-Saharan Africa is by far the region with the highest level of mortality on the globe. It remains the region with the world's highest child mortality, although the annual rate of decline has doubled from 1.2% between 1990 and 2000 to 2.4% in the following 10 years, to 2010. However, one in eight (1 in 8) children die before their fifth birthday, more than 17 times the average for developed regions (The Inter-agency Group for Child Mortality Estimation (UN IGME), 2010).

As shown in Figure 2.1, Sub-Saharan Africa differs significantly from other regions of the world by its highest under-five mortality rate and the gap is very wide to fill anytime soon.

Figure 2.1: Trend in under-five mortality rate (per 1000) by continent

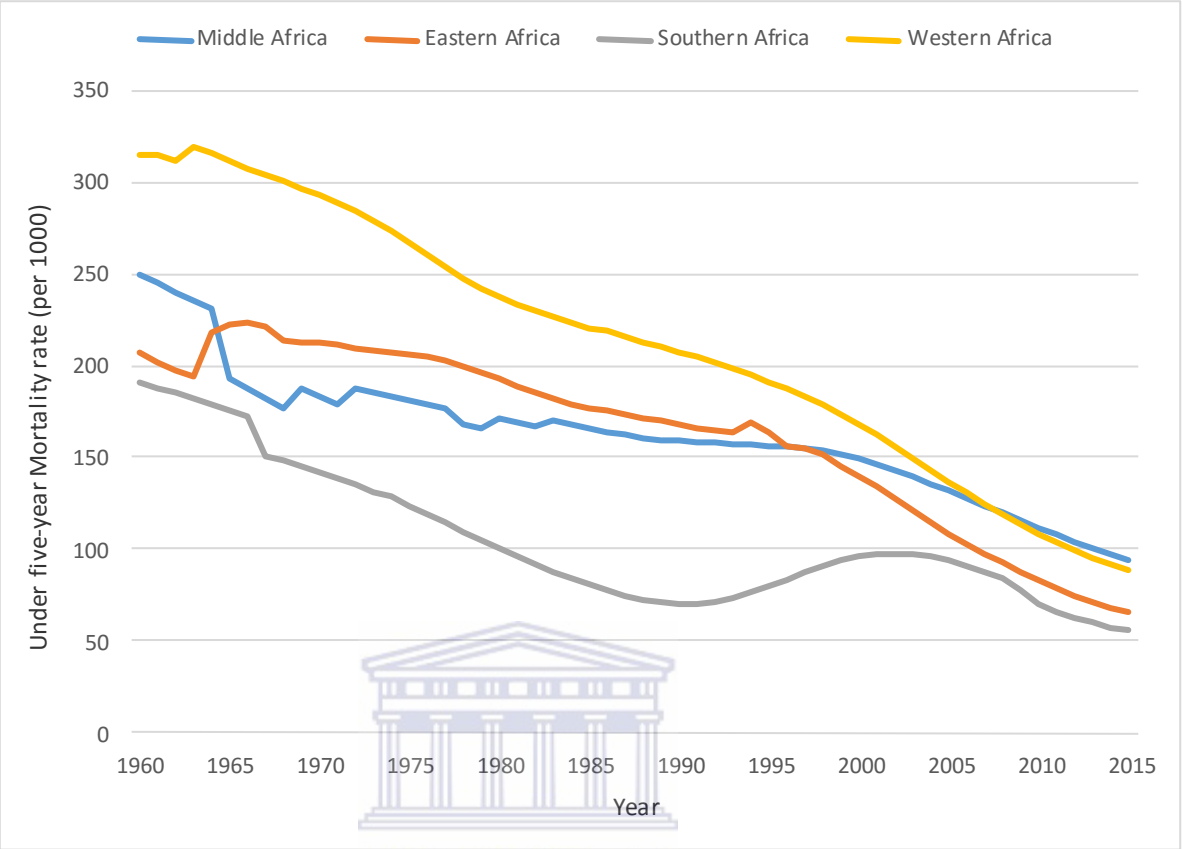


Source: Data from Word Bank

Figure 2.2 shows the sub-regional differences in under-five mortality in sub-Saharan Africa. In regard to sub-regional disparities, under-five mortality rates are the highest in West Africa compared to the other regions. But the decline in child mortality rates between 1960 and 2015 is higher in West Africa compared to the other sub-regions of sub-Saharan Africa. Of all sub-regions of Sub-Saharan Africa, countries in Southern Africa have had the lowest infant mortality rates. However, Southern Africa has experienced an increase in child mortality in the 1990s because of the HIV/AIDS.

At the countries level, large disparities exist: while in 2014, countries such as Angola, Chad, Somalia, Central African Republic, Sierra Leone, Mali and Nigeria recorded the highest death rates around 110 deaths per 1000 births. In the group countries, including Sao Tome and Principe, Senegal, Eritrea, Namibia, Congo Rep., Botswana, Rwanda and South Africa, the under-five mortality rates are less than five years below 50 deaths per 1000 births.

Figure 2.2: Trend in under-five mortality rate (per 1000) in sub-region in Sub-Saharan Africa (1960-2015)



Source: Data from Word Bank

2.2 Determinants of under-five mortality – A theoretical framework

Several conceptual frameworks have been developed in the literature to explain the determinants of child mortality in both developing and middle-income countries. Without being exhaustive, mention can be made of the theoretical frameworks of Mosley and Chen (Mosley & Chen, 1984), Garenne and Vimard (Garenne & Vimard, 1984), Barbieri (Barbieri, 1991), Commission on Social Health Determinants (2003) (WHO Commission on Social Determinants of Health, 2008), Wagstaff (Wagstaff, 2002b), Huynen Martens and Hilderink (Huynen, Martens, & Hilderink, 2005) and Houweling and Kunt (Houweling & Kunst, 2010). These different theoretical frameworks provide common understanding because they suggest that the likelihood of a child dying depends on a set of very complex distal and proximate factors including biological, economic, political, social, cultural, ecological, psychological, often

interactive factors, and exert their influences at the individual, family, community and national levels.

Among the existent conceptual frameworks, The Mosley & Chen framework is considered to be the most comprehensive, systematic and widely used model for analysing infant and child mortality (Agha, 2000). This analytical framework has for many years facilitated interdisciplinary research on child survival in Low and Middle-income countries (Macassa, Ghilagaber, Bernhardt, Diderichsen, & Burström, 2003). They claimed that all socioeconomic variables at the community level, as well as household and individual level, have to work through a limited set of proximate variables that directly affect mortality. Proximate determinants are variables with both behavioural and biological aspects that link other underlying variables such as income and education to the biological process causing illness. The conceptual core of their framework was the idea that all background (socio- economic and cultural) variables have to operate through a limited set of proximate determinants that directly influence the risk of disease and the outcome of disease processes (Hill, 2003).

Despite being widespread and widely used, the analytical framework of Mosley and Chen has a number of limitations pointed out in the literature. Researchers blame the model of Mosley and Chen have failed to take into account contextual factors such as political, economic and social environment at the international, regional, national and community in analysing the mechanisms of action of determinants of under-five mortality in low and middle-income countries. In this sense, recent studies on mortality inequalities among children under five years clearly show that health inequities in sub-Saharan Africa today are not the result of chance, but a direct result of national and international physical, economic, social and political conditions (Macassa, Hallqvist, & Lynch, 2011). Adapting the framework of Mosley and Chen resulted in more detailed models (Houweling & Kunst, 2010; Macassa et al., 2011) and more or less complete to understand the factors and mechanisms of inequalities in mortality in developing countries children.

Table 2.1: Proximate determinants of under-five mortality in low and middle-income countries

Mosley and Chen (1984)	**Garenne and Vimard (1984)**	**Houweling and Kunst 2010**
A) **Maternal factors** 1. age 2. parity 3. birth interval **B) Environmental contamination** 4. air 5. food/water/ fingers, 6. skin/soil/inanimate objects, 7. insect vectors **C) Nutrient deficiency** 8.calories, 9. protein, 10. micronutrients **D) Injury** 11. accidental, 12. intentional **E) Personal illness control** 13. personal preventive measures 14. medical treatment	**A) status at birth** 1. Genetic Heritage, 2. Birth weight, 3. Twins, 4. Age of mother, 5. Interval between birth 6. Rank at birth 7. Survival of the mother. **B) Disease:** 8. Exposure to disease 9. Presence of endemic diseases, epidemics **C) Health-related behaviour:** 10. Knowledge 11. Attitude 12. Practice **D) Nutrition** 13. Breastfeeding, weaning 14. Supplementation **E) Immunity** 15. Immunization, 16. Immunization acquired or transmitted.	1. Maternal education 2. Malnutrition 3. Exposure to disease pathogens 4. Quality of water and sanitation facilities 5. Housing conditions, 6. Breastfeeding and complementary feeding practices, 7. Hygiene behaviour (hand washing with soap) 8. Other practices related to child care 9. Characteristics of the mother (age at childbirth, her nutritional status, parity, child spacing)

2.3 Proximate determinants of under-five mortality

Under-five mortality is affected by two classes of determinants: the proximate and the socioeconomics or distal. Proximate determinants include child's biological characteristics, mother related factors, environmental, nutritional status and disease prevalence. Mosley and Chen's analytical framework distinguished five categories of a total of 14 proximate determinants: maternal factors (age, parity, birth interval); environmental contamination (air, food/water/ fingers, skin/soil/inanimate objects, insect vectors); nutrient deficiency (calories, protein, micronutrients); injury (accidental, intentional); and personal illness control (personal preventive measures; medical treatment). Determinants in the first four groups affect the rate at which children move from healthy to sick, whereas factors in the last group influence both this rate (through prevention) and the rate of recovery (through treatment) (Hill, 2003). In

the table 2.1, Garenne Vimard proposes a list of 16 proximate determinants, while Houweling and Kunst suggest a list of 13 proximate determinants.

The analyses of the different lists of proximate determinants of mortality in children under five highlight the following:

- ✓ Biological factors: (genetic inheritance, birth weight, age of child, sex of child, twins, preceding birth interval and birth order);
- ✓ Mother related factors: age, parity, mother's survival status, child spacing, mother's nutritional status;
- ✓ Environmental factors: air, food/water/fingers, skin/soil/inanimate objects;
- ✓ Nutrition: nutrient deficiency, calories, micronutrients, breastfeeding and complementary feeding practices, weaning;
- ✓ Exposure to disease pathogens: accidental or intentional injury;
- ✓ The presence of endemic diseases, epidemics;
- ✓ Hygiene behaviours and prevention: personal preventive measures, medical treatment, health behaviour (knowledge, attitude, practice), hand washing with soap; and
- ✓ Immunity: Vaccination or transmitted immunization.

These proximate determinants like biological, environment, nutrition and maternal factors, do not only impact chances of dying or surviving when the child has fallen ill, but could prevent sickness in the first place.

2.1.1 Bio-demographic factors

The bio-demographic factors related to the child include multiplicity of births, age and gender, weight at birth, preceding birth interval and birth order. Studies of the determinants of child mortality have evaluated the relationship between the child-related variables and the risk of dying before the age of five.

The effect of multiplicity of births was significant in several studies in sub-Saharan Africa (Akinyemi, Bamgboye, & Ayeni, 2013; Bado & Appunni, 2015; Huynen et al., 2005; Justesen & Kunst, 2000; Kembo & Van Ginneken, 2009; Uthman, Uthman, & Yahaya, 2008). Its effect is mainly associated with lower birth weight of twins or

triplets, which in turn is one of the most important factors affecting neonatal survival. The arrival of more than one child creates also an extra demand for food. Taking into account the fact that during early stages of infancy breastfeeding is one of the main sources of nutrition, multiple births might lead to lower calories intake and thus lower survival chances (Tymicki, 2009).

Previous research identified the sex of child us one of the factors linked to child survival during the early childhood period. The boys have a greater risk than girls in terms of dying before the age of five (Agha, 2000; Becher et al., 2004; D'Souza & Chen, 1980; Defo & Kuate-Defo, 1996; Kembo & Van Ginneken, 2009; Mekonnen, 2011). Higher male mortality is mostly due to greater immaturity (slightly shorter gestation period), and the differential effect of oestrogens and androgens on the immune system (Tymicki, 2009). The difference could also be due to a preference of parents towards children of one sex at the expense of the other sex. In Africa, the results of previous studies have shown that mothers gave much care to boys than to girls (Garg & Morduch, 1998). In India and Pakistan, studies have shown that the vaccine coverage rate is higher among boys than girls (Cockcroft et al., 2009; Singh, 2012).

Weight at birth and birth interval has been identified in the literature as a key biological determinant of child mortality. Low birth weight is associated with a high risk of child mortality (Tymicki, 2009) and it is mostly due to preterm birth (born before 37 weeks of gestation) meaning that the child's growth in the womb of his mother was not completed. Thus, the immune system may be faulty, hence exposing him to a greater risk of dying in his early life. Early mother's age at childbearing, multiple birth babies and mother's health statuses are the main factors of low birth weight (Syddall, 2005).

Regarding birth interval, many studies reported that children born at short birth intervals are at higher risk of infant and child mortality (Chowdhury, 2013; J. C. Fotso, Cleland, Mberu, Mutua, & Elungata, 2013; Kembo & Van Ginneken, 2009; Kozuki & Walker, 2013; Naldini & Jurado, 2013; S. O. O. Rutstein, 2005; S. O. Rutstein, 2000). There is a relationship between the birth interval and the child's breastfeeding duration and short birth interval may mean a short period of breastfeeding which affects the survival of the child (Tymicki, 2009).

A number of studies have shown mortality differential by birth order. It has been found that the first born, and children of high orders, have a higher risk of dying before their

fifth birthday (Chowdhury, 2013; Kembo & Van Ginneken, 2009; Naldini & Jurado, 2013; S. O. Rutstein, 2005).

2.1.2 Maternal related factors

Previous studies found that mother's characteristics have been associated with infant and child mortality. These characteristics include the age of the mother, her educational level, her parity and her nutritional status and these factors may create disparities in the probability of a child passing away before turning five years old. Maternal risk factors are more closely related to neonatal or early infant deaths because they are associated with premature and low birth weight infants and delivery complications.

The relation between mother's age at birth and the risk of child's death follows a "J" curvilinear relationship (Tymicki, 2009). High mortality has been associated with having a mother who is younger than 17 years of age or is older than 35 years at the time of the birth (S. O. Rutstein, 2000). This observation may be associated with the physiological immaturity of young mothers to the child's conception (Kozuki et al., 2013) while older women experience an increase in the incidence of congenital abnormalities as well as maternal morbidities such as hypertension and gestational diabetes (Kozuki et al., 2013). Previous studies have reported the strong association of the child mortality with parity (Adedini, Odimegwu, Imasiku, & Ononokpono, 2014) and the effect of parity on the risk of child mortality, similar to that of maternal age as these two factors are correlated (Kozuki et al., 2013).

2.1.3 Environmental factors

Environmental factors are among the proximate determinants in Mosley and Chen's framework that may be important determinants of infant mortality. The environmental factors include the source of drinking water, air/pollution, access and type of sanitation, source of energy cooking, type of dwelling and the vector of infectious agents and diseases and these factors have a direct effect on children's exposure to diarrheal disease, to breathing infection and parasitic diseases. Poor sanitation, lack of accessible clean water and inadequate personal and domestic hygiene are responsible for an estimated 88 percent of diarrhoea cases everywhere (World Health Organization, 2007).

The World Health Organization data shows that around 7% of the population in the developing countries become ill due to lack of adequate water and sanitation systems (World Health Organization, 2007).

The quality of drinking water, type of sanitation and domestic environmental conditions are strong predictors of child morbidity and mortality in the developing countries (Folasade, 2000) and are the major causes of pneumonia and diarrhoea, major killers of young children (World Health Organization, 2013). Each year, 1.4 million child deaths caused by diarrhoea are due to the use of unimproved water and sanitation and the majority of these deaths occur in sub-Saharan Africa where nearly half the population lacks access to improved water and sanitation (Ezeh, Agho, Dibley, Hall, & Page, 2014). Inadequate water and sanitation increased the risk of diarrhoea. A study in Peru found in Peru that children with the worst conditions for water and sanitation had more diarrhoea than did those with best conditions (Checkley et al., 2004). The main risk factors associated with the two leading causes of under-five mortality (*pneumonia and diarrhoea*) include low birth weight, lack of breastfeeding, under-nutrition, overcrowded conditions, indoor air pollution, unsafe drinking water and food, and poor hygiene practices. Most of the causes listed above as determinants of pneumonia and diarrhoea in children are related to the quality of the environment and the living environment for children.

Environmental factors influencing children's health are strongly correlated:

i) with the level of poverty of households (lack of the minimal needs, no access to the primary services (health, water, sanitation, and electricity));
ii) socio-economic conditions of the area for which the household belongs;
iii) and with the environmental standards of the country (level of development, education of individuals, availability of public services (water, electricity, water and air pollution).

2.1.4 Nutrition

Under-nutrition is a leading cause of child mortality in developing countries, especially in sub-Saharan Africa. This proximate determinant relates to the intake of the three

major classes of nutrients calories, protein and micronutrients. Mosley and Chen (Mosley & Chen, 1984) pointed out that the survival of children is influenced by nutrients available not only to the child but also to the mother. Nutrient availability to the infant or to the mother during pregnancy and lactation can be measured directly by the weighing of all foods before consumption, accompanied by the biochemical analysis of food samples. The three indicators of nutritional status are stunting, which indicates chronic undernutrition in children, wasting which indicates acute under-nutrition, and finally the proportion of children who are underweight. Malnutrition is one of the important risk factors for mortality due to acute respiratory infections.

Poor nutritional status in children[1] is strongly correlated with vulnerability to diseases, delayed physical and mental development, and increased risk of dying (Black et al., 2013). Furthermore, stunting is often linked to poverty-related factors, such as poor sanitation, socioeconomic status, hygiene, food preparation methods and maternal education (Zembe-Mkabile, Ramokolo, Sanders, Jackson, & Doherty, 2015).

2.1.5 Child Immunization status

Immunization is an important element of the child's prevention against diseases and the risk of dying young. It is a prevention against various child killer diseases such as tuberculosis (*Bacillus Calmette Gurine (BCG)*), tetanus, whooping cough, diphtheria, poliomyelitis, hepatitis B, yellow fever, and measles (Oyefara, 2014). In Africa, the implementation of the "*Expanded Programme on Immunization (EPI)*" to immunize all children under-five and pregnant women seem to have been a contributory factor in the continued decline in mortality (Desgrees Du Lou & Pison, 1995). Previous studies have shown a significant decrease in mortality in children under five due to immunization: Senegal had a 40% decrease in the mortality of children under five (Desgrees Du Lou & Pison, 1995). In Ghana, Nyarko et al. (2001) (Nyarko, Pence, & Debpuur, 2001) found that complete coverage by all EPI antigens reduces mortality between ages 9 and 59

[1] The nutritional status of under-five children is usually assessed through three standard indicators: stunting, wasting and underweight. A stunted child is a child who is too short for his/her age. Stunting is usually a result of nutritional deprivation over a lengthy period of time. A child is considered wasted when the weight is too low for the child's height. Wasting usually reflects an acute nutritional deficiency, due either to reduced food consumption or to acute weight loss during an illness. Finally, a child is said to be underweight if his/her weight is too low for his/her age, as a consequence of wasting, stunting, or both.

months by 70 percent. However, the effect of EPI remains mitigated in Nigeria (Paediatric Association of Nigeria, 2012).

2.2 Socio-economic determinants

Numerous factors at the macro-level influence the child's health status. These include social-cultural, economic, environmental and institutional factors (Huynen et al., 2005). These factors operate at different hierarchical levels of causality because they have different positions in the causal chain. The chain of events leading to a certain health outcome includes both proximal and distal causes; proximal factors act directly to cause disease or health gains, and distal determinants are further back in the causal chain and act via (a number of) intermediary causes (Huynen et al., 2005).

- **Income/wealth**

The probability of dying in childhood is strongly related to the socio-economic position of the parents or household in which the child is born. The empirical evidence shows a significant negative relationship between child mortality and wealth. The evidence is strong and the association is found at both the macro and micro level. There seems to be a graded relationship between socio-economic status and health, such that the more economically advantaged someone is, the better his or her health is likely to be (Adler & Ostrove, 1999; Bauman, 2006; Gwatkin, 2002; Kuate Defo, 1994). In a review of international evidence on child mortality in low and middle-income countries, Houweling and Kunst (Houweling & Kunst, 2010) use a household asset index to measure wealth. They find that the child mortality is significantly higher in the poorest compared to the richest bracket of society in 55 developing countries. There were not only differences between the poorest group and the rest, but also across other income groups. Quentin et al.(Quentin et al., 2014), using demographic and health surveys (DHS) data of 10 major African cities (Cairo, Lagos, Kinshasa, Luanda, Abidjan, Dar es Salaam, Nairobi, Dakar, Addis Ababa, Accra) found huge significant inequalities of child mortality rates between the poorest quintile and the richest quintile. Anyamele (Anyamele, 2009) also finds a significant negative association between wealth quintile and infant mortality in 20 countries in Sub-Saharan Africa. Findings from many sub-Saharan countries: in Tanzanian(Kanté, Helleringer, & Honorati Masanja, 2013), in DR

Congo, Egypt, Madagascar, Nigeria and Sao Tome & Principe(Van Malderen, Van Oyen, & Speybroeck, 2013), in Uganda(Ssewanyana & Kasirye, 2012) find a negative effect of wealth measured by household assets. There are several possible pathways through which income/wealth or poverty may affect child health such as poor nutrition, access to health care and neighbourhood conditions that may cause diseases (pneumonia and diarrhoea, the leading causes of death in children younger than 5 years). In addition to its direct impact on purchasing power and the ability to buy health-promoting goods and services, wealth is closely related to proximate determinants of child mortality; most of these factors show worse levels for the poorest (Houweling & Kunst, 2010). Wealthier households are likely to dwell in conditions with better sanitation, and display a higher level of education. Hence, they will probably have more knowledge about disease prevention and treatment, and to have access to higher quality health service than the less wealthy.

- **Urban/rural residence**

Numerous studies have found inequalities in child mortality and morbidity related to the place of residence and urban areas have lower infant and child mortality rates than rural areas (Anyamele, 2009; J. Fotso, 2006; Sahn & Stifel, 2003; Wang, 2003). The urban areas usually have better infrastructure for health services compared to non-urban areas, so the risk of higher mortality reflects differences in socioeconomic factors (income, education level, household demography) and infrastructures allocation that are often large between urban and rural areas (Sjursen, 2011).

Despite the difference in child mortality between urban and rural areas, the results show great heterogeneity between the same place of residence (urban or rural) [63,71]. The literature suggests that population and community characteristics are important in explaining the rural–urban disparity in child health outcomes (J. C. Fotso et al., 2013; Van de Poel, O'Donnell, & VanDoorslaer, 2009). The aggregate levels of under-five mortality in urban settings mask the uneven distribution of health gains within the urban population (Kjellstrom & Mercado, 2008). The poor urban setting is characterized by overcrowding, poor housing, slum area production, poor basic infrastructure poor water, sanitation, health and educational services (Kjellstrom & Mercado, 2008; Sartawi, 2013).

Deprivation in urban settings led to the rise of the "urban penalty" phenomenon, where health status in urban settings is worse than health in rural settings, and the rise of urban health inequalities (Sartawi, 2013). However, poor health in poor urban areas is not only a direct consequence of deprivation in the socioeconomic environment but is also a consequence of urban social inequalities (Kjellstrom & Mercado, 2008). The urban penalty phenomenon is closely related to social inequalities that lead to socioeconomic deprivation of the poor and the unequal distribution of social determinants in health (Kjellstrom & Mercado, 2008; Sartawi, 2013).

- **Access to health services**

Existing literature has documented the strong effects of access to health services and inequalities in child mortality and morbidity in sub-Saharan Africa. Access and use of modern health services, including maternity care, childhood vaccination and medical treatment of respiratory infections, diarrhoea and fever, is much lower among poorer and less educated groups within least income countries (Houweling & Kunst, 2010). Unequal access to healthcare for children under five years may be caused by a difference in access related to the distance from health services, the cost of health care access, or the availability of health services or staff qualified health (Rutherford, Mulholland, & Hill, 2010).

Empirical evidence from low incomes countries suggests that a long physical distance coupled with poor infrastructure and time constraints were strong predictors for children missing out vaccinations (measles, diphtheria-pertussis-tetanus (DPT), vitamin A supplementation) or not receiving postnatal care services (Rutherford et al., 2010; Schröders, Wall, Kusnanto, & Ng, 2015). The relationship between child health inequalities and distance to health facilities is been proven very strong in several studies in sub-Saharan Africa: Tanzania, Nigeria, Uganda and Burkina Faso (Rutherford et al., 2010). For instance, infants in southern Tanzania who live less than five km from the health facility were less likely to die than children living further away (Rutherford et al., 2010). The results are similar in Burkina Faso (Becher et al., 2004).

The importance of cost as a barrier to access is well documented, and results from studies conducted in many sub-Saharan countries (Ghana, Gambia, Zambia) highlighted the negative effect of users' fees and access to health care (Rutherford et al., 2010).

User fees exemption in Burkina Faso (Johri, Ridde, Heinmüller, Sossa, & Haddad, 2013) and cash transfer implementation in Malawi (Miller, Tsoka, & Reichert, 2011) for health care access to children of under five years have shown an important reduction in child mortality and a net increase in the use of health services.

Lack in quantity and availability, of trained health staff as well as structural and internal quality of facilities, time availability and low female autonomy are major obstacles for child health in rural and slum settings in low-income countries (Rutherford et al., 2010; Schröders et al., 2015).

- **Maternal Educational level**

Mother's education is one of the most frequently described social determinants of child mortality in developing countries, and empirical evidence strongly suggests that educated women have fewer and healthier children than the less educated (Bicego & Boerma, 1993; Caldwell, 1994; Hobcraft, 1993). It is widely recognized that education can lead to improved health by increasing health knowledge and healthy behaviours. This may be explained in part by literacy, allowing more-educated individuals to make better-informed, health-related decisions including about receipt and management of medical care for themselves and their families. Greater educational attainment has been associated with health-promoting behaviours and earlier adoption of health-related recommendations. The mother's educational level is also closely associated with immunisation rates (P. A. Braveman, Egerter, Cubbin, & Marchi, 2004). Maternal education is thought to exert its influence on increased status and decision-making power of mothers within the household, increased willingness and ability to travel outside the community, more timely use of health care, greater negotiating power with health care providers, increased knowledge, skills and identification with modern health systems and responsiveness to new ideas (Houweling & Kunst, 2010).

Education may also affect health by influencing social and psychological factors. High educational level has been associated with greater perceived personal control, which has frequently been linked with better health and health-related behaviours (P. Braveman, Egerter, & Williams, 2011).

2.2.1 Community and household factors

Community-level factors including ecological setting (climate, temperature, altitude, season, rainfall), political economy (organisation of food production, physical infrastructure like the railroad, roads, electricity, water, sewage, political institutions), health system variables are being listed as potential factors of under-five mortality (Masuy-stroobant, 2014). The community-level factors have a direct influence on the immediate environment of households and individuals and may also affect parents' ability to provide healthcare for their children (Agha, 2000). In the frameworks of analysis of the determinants of mortality in children under five (Garenne & Vimard, 1984; Mosley & Chen, 1984), socioeconomic factors are considered macro determinants that influence the health of the child through the proximate that are: maternal factors (age, parity, birth interval); environmental contamination (air, food/water/fingers, skin/soil/inanimate objects, insect vectors); nutrient deficiency (calories, protein, micronutrients); injury (accidental, intentional); and personal illness control (personal preventive measures; medical treatment) (Hill, 2003; Mosley & Chen, 1984).

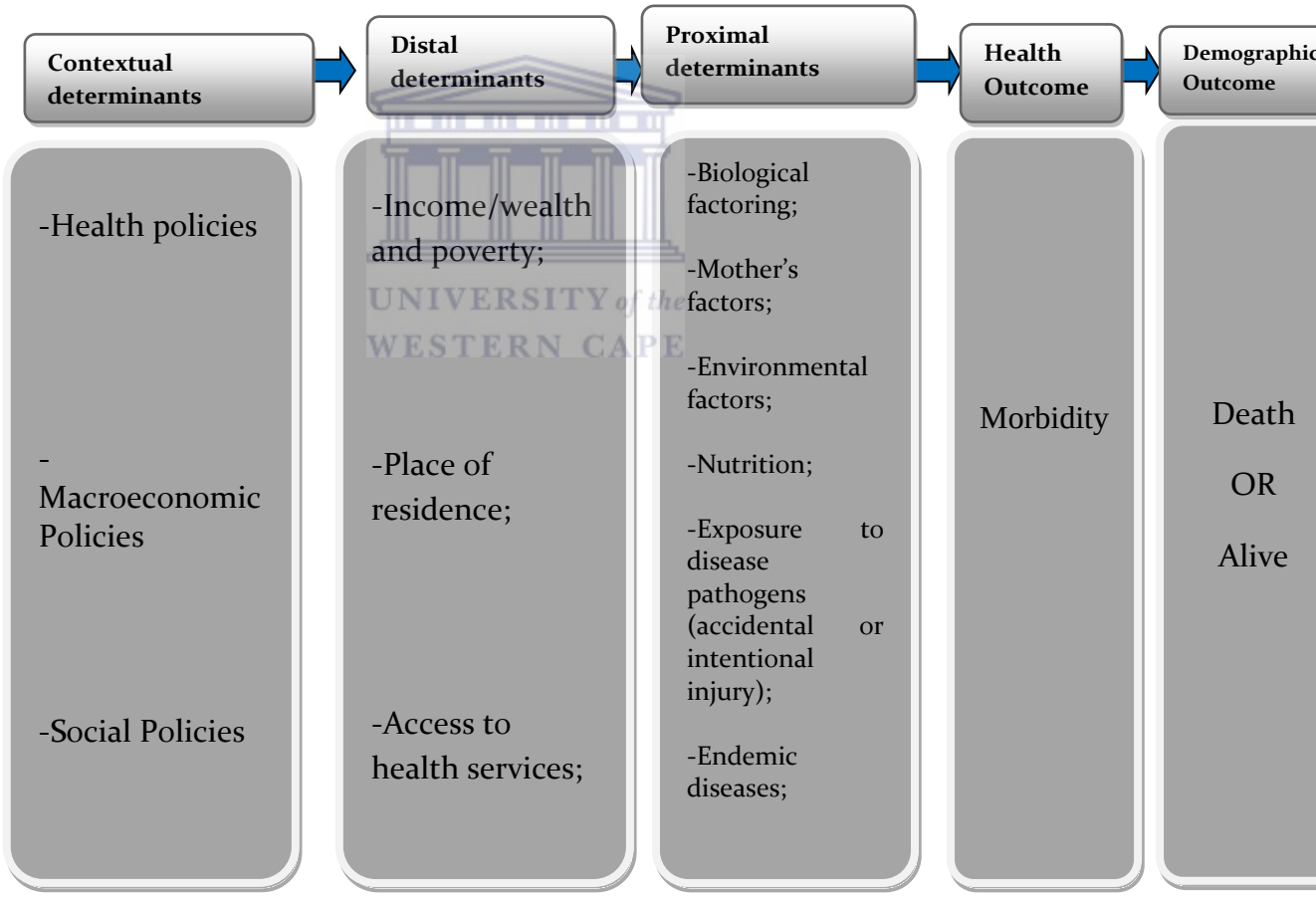
At the national level, public health policies directly determine the availability and access to health care and sanitation while the socio-economic policies have an indirect influence on literacy, health behaviours and living standards for example. At the community level, the availability of basic social services and infrastructure (markets, potable water, electricity, health services and family planning, etc.) have a direct or indirect influence on child mortality.

Factors at the household level are also a key importance to childhood mortality (Houweling & Kunst, 2010). Household characteristics including quality of the living environment, structure and household composition, income and living standards are household characteristics may induce a disparity in mortality among children under five. Results from previous studies have shown that a high number of people in the household and, in particular, a large number of children under two years in a household is a factor that can increase the child deaths risk under-five years (Schultz, 1984; Sparks, Wood, & Johnson, 2013). With the more members, there is a great competing demand on family resources and some children may be neglected in health-caring and nutrition than others. Unfavourable household economic conditions may result from

changes in household demographic composition increase the risk of death for children under the age of 5 years because of limited resources and intra-household competition (Sparks et al., 2013).

The household environment has a direct effect on the risk of child mortality. The quality of housing, the level of crowding and access to water and sanitation determine exposure to environmental contaminants: poor quality housing increases the chances of food contamination because of inadequate storage facilities; crowding increases the likelihood of infection; lack of access to piped water influences hygienic practices; lack of sanitation increases the chance of bacterial infections (Agha, 2000).

Figure 2.3: Framework of determinants of under-five mortality in least income countries



Source: Author, adapted from Mosley and Chen (1984)

2.3 Conceptual framework of inequality in childhood mortality

2.3.1 Definition and approaches of health inequality

An increasing attention has been devoted to inequalities in health, particularly among infants and children in the low-income countries. Authors define health inequality as a broad concept that examines the dispersion or disparities in health outcomes across individuals or groups (Kawachi, Subramanian, & Almeida-Filho, 2002). Health inequalities are perceived as unfair and these inequalities are avoidable and preventive if more attention is given to the health needs of vulnerable groups. The term health disparity has been used interchangeably with health inequality in many studies, especially in the United States (Alonge & Peters, 2015; Carter-Pokras & Baquet, 2002).

Two approaches are discussed in the literature: the pure health inequalities and socioeconomic inequalities of health. The first refers to the distribution of the health variable itself within the population while socioeconomic inequalities in health approach focus on the distribution of health between social and economic groups (Bommier & Stecklov, 2002).

Health inequalities are measured in different ways. The widely used approach is health inequalities with regard to different groups of incomes or socio-economic status (SES)(Costa-Font & Hernández-Quevedo, 2012; Marmot, 2005). Evidence demonstrates a huge variation of health outcomes with regard to social factors such as job status, education, urban/rural, ethnic groups, gender, state of residence, immigration status and wealth index (Costa-Font & Hernández-Quevedo, 2012; Wagstaff & Doorslaer, 2000).

Studies show a variation in mortality rate among children under five between sub-regions and countries. According to the 2014 report prepared by UNICEF, in Sub-Saharan Africa, the under-five mortality rate is more than 15 times the average for developed regions and the under-five mortality rate for low- income countries is more than 12 times the average for high-income countries (United Nations Children's Fund, 2014). Evidence shows alarming disparities in under- five mortality rates within countries. A child's risk of dying before age five increases if she/ he is born in a remote rural area, into a poor household or to a mother with no education.

2.3.2 Theories of child health inequalities

Various theories have been developed to explain inequalities in health. Mainly, four approaches are often used and these include the behavioural, materialist psycho-social, and the life course approach (Alonge & Peters, 2015; Scambler, 2012; Shaw, 2005).

The behavioural approach suggests that health inequalities are due to the differences in health promoting behaviours such as dietary choices, consumption of drugs, alcohol and tobacco, active leisure time pursuits, and use of immunisation, contraception and antenatal services (Scambler, 2012). In the case of the health of children under five years, inequalities in morbidity and mortality may be due to mothers, households and communities 'health behaviours.

The materialist approach is most commonly used for explanation of population health inequalities. According to this approach, health inequalities are strongly associated with wealth inequality (income, poverty). Disadvantaged people are more likely to live in areas where they are exposed to harm such as air-pollution and damp housing (Scambler, 2012). The study by Wagstaff (Wagstaff, 2002a) showed that poverty and poor health go hand in hand and this association shows causality in both directions: poverty breeds ill health and ill health perpetuates poverty.

The psycho-social model posits that health inequalities are due to differences in psychological stress from factors such as less control at work, less job security, lower levels of social support, and living in communities with higher crime. Such psychological stress leads directly to ill-health or indirectly through its effect on behaviours/lifestyle (Scambler, 2012).

The life-course model, on the other hand, was developed relatively recently and studies investigating life-course explanations require detailed longitudinal data. Health reflects the patterns of social, psycho-social and biological advantages and disadvantages experienced by an individual over time. The chances of good or poor health are influenced by what happened to a child in-utero and in early childhood. Disadvantages are likely to accumulate through childhood and adulthood. For example, individuals who experienced poor home conditions in childhood are more likely to experience occupational disadvantage.

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Chapter 3: Data and Methods

3.1 Study Setting

This study is focused on sub-Saharan African (SSA) countries – a part of Africa which is made up of 53 countries with a population of about 1.1 billion people and represents about 16% of the worlds' population. Although the socio-economic context is characterized by rapid economic growth, SSA is also the poorest part of the world where 46.4 per cent of the population live below the poverty line. This unfavourable economic situation reduces the access of majority of the poor to preventive and curative interventions, such as antenatal care, immunizations, treated bed-nets, and therapy for diarrhoea and medicines for reducing fever.

It is projected that the population of sub-Saharan Africa would grow to about 1.6 billion by 2030 and it will represent 20% of the world's population. Compared to other continents, Africa is the one whose population is relatively young with about 44 per cent of the population being younger than 15, and the median age of the population is 17.5 years. Socio-demographic indicators in the sub-Saharan Africa region are worrying - characterize by high childhood mortality, high fertility, and high prevalence of diseases (HIV, malaria, Ebola) causing huge loss of life each year.

Moreover, fertility in Sub-Saharan Africa continues to be the highest in the world despite some decline in recent years. The fertility rates are higher in sub-Saharan Africa than any other major region of the world. The youthfulness of the population reflects fertility and mortality rates, which in turn have an impact on the epidemiological characteristics of the population. High fertility and high adult mortality lead to a high proportion of young people, who are much less likely to be vulnerable to chronic diseases that typically affect the adult and elderly populations. Epidemiology and demography thus interact to generate the overall disease and mortality patterns in which infectious diseases are dominant over non-communicable diseases and conditions.

The under-five mortality rate is a key indicator of child well-being, and the important indicator to measure the health of the population of a country. Worldwide, about 6 million children die each year (5.9 million children under age five died in 2015, 16,000 every day) (WHO, 2015). Under-five mortality is higher in sub-Saharan Africa than in other regions in

the world (United Nations and African Union Commission, 2012). The risk of a child dying before five years of age in sub-Saharan Africa (81 per 1000 live births) is about seven times higher than that in European Region (11 per 1000 live births).

Fertility behaviour in sub-Saharan Africa, like other parts of the world, is determined by biological and social factors. Several factors have contributed to sustaining relatively high levels of fertility in most.

Sub-Saharan Africa. These factors include high levels of infant and child mortality, early and universal marriage, early childbearing as well as childbearing within much of the reproductive life span, low use of contraception and high social value placed on childbearing.

3.2 Data sources

The study of the level and trend of mortality of children under five require the availability and quality of data on child survival. One of the current constraints to analysing the health of children in general, and particularly child mortality is the availability, consistency and quality of existing data sources in several countries in sub-Saharan Africa. In the vast majority of the countries of Sub-Saharan Africa, the availability of effective registration systems that are capable of recording adequate information on births and deaths throughout the country are lacking. or even absent. The lack of vital registration systems justifies the use of data from population surveys as sources of production statistics on child mortality and evaluation of programs and interventions on the health of people in general and children under-five years in particular.

Therefore, many sources of data from the surveys have several methodological problems, particularly concerning the lack of standardization in survey methodology and methods of analysis, that limit the comparability of results (Boerma, Black, Sommerfelt, Rutstein, & Bicego, 1991). The use of Demographic Surveys and Health (DHS) as an alternative source of measuring health indicators of children under five years of age in low-and-middle-income countries has been established since the mid-1980s and data from these surveys are used to measure and assess progress in matters of health and child survival under five and also used to compare indicators across countries.

In the following paragraphs, we will present in more detail the DHS, highlighting the benefits and shortcomings of this data source in the measurement of health indicators of children under five.

3.2.1 DHS Data

Since the mid-80s, more than 300 surveys were conducted by the Demographic and Health Surveys programme (DHS) and over 90 countries were involved[2]. Standard DHS Surveys have large sample sizes (usually between 5,000 and 30,000 households) and typically are conducted about every 5 years, to allow comparisons over time.

The DHS are an important source of data for studies on the health of populations in developing countries who do not have a robust system for collecting information about the population. Since the 1980s, several DHS have been carried out in the countries of sub-Saharan Africa at regular time intervals (about every five years) and thus constitute an important source of data for examining the social and geographical differentials of the mortality of children in developing countries in a comparative approach.

Compared to the different types of collection of data on the health of populations in SSA countries, DHS has the advantage of using a representative sampling on a national or regional scale allowing for the generalization of the results. Similarly, DHS use a standard questionnaire and a plan of sampling and collection of similar data in different countries and over time making them comparable results.

DHS uses a stratified two-stage cluster sample technique and a comparable sample design in each country. The sampling cluster generally corresponds to a census enumeration area. A cluster usually consists of one or a few villages in the rural area, or neighbourhood in the urban environment.

Producing good quality demographic and health data and making it accessible to data users worldwide is one of the main aims of the Demographic and Health Surveys programme (Croft, 2008). Each round of survey data includes information on fertility and childhood mortality levels, use of family planning, and various maternal and child health indicators.

[2] http://www.dhsprogram.com/

Data was collected through face to face interviews. Three types of questionnaires were administered in each survey, namely; the Household, Man and Woman's questionnaires.

This is a cross-sectional study based on the data from the selected demographic health surveys. Detailed information on the sampling technique that was used in the selected surveys has been published somewhere (ICF International 2012). Briefly, all the DHSs for the selected countries used two-stage cluster sampling technique, where enumeration areas (EAs) are randomly selected from the most recent Population Census (sampling frame) with probability proportional to their size in the first stage. In the second stage the households within the selected EAs are then randomly selected with equal probability and then listed (Odimegwu, Chadoka and, & de Wet, 2014).

3.2.2 DHS Data on Children under-five-year-old mortality

Data on children's health are collected using the woman questionnaire. The approach used is the birth history which consists of asking women of reproductive age (15-49 years old) during a survey to provide full account of all their live births including the date of birth, survival status, age if currently alive, and age at death if died starting from her first child until the time of the survey. In general, to help women refresh their memory and be ready for the full birth history, questions on total children ever born and children who have died are asked first. These questions, referred to as summary birth history questions, also provide the basis for double-checking the accuracy of the full birth history. Such data have been widely collected by the World Fertility Survey programme in the 1970s and early 1980s, and more recently by the Demographic and Health Surveys project. Both infant and under-five mortality rates can be calculated from the data, dividing deaths for given ages and time periods by exposure to risk in terms of person-years of life lived by the reported children[3].

Data on birth history are very useful for the selection of children under five for the analysis of mortality. This method also presents many advantages:

[3] https://www.google.co.za/url?sa=t&rct=j&q=&esrc=s&source=web&cd=5&ved=0CDcQFjAEahUKEwiF14PytefIAhXF0hoKHVIEAaM&url=http%3A%2F%2Fwww.unicef.org%2Fmedia%2Ffiles%2FBACKGROUND_NOTE_ON_METHODOLOGY_FOR_UNDER-FIVE_MORTALITY_ESTIMATION_web.pdf&usg=AFQjCNHcCmPD3R_ztqN8WpQ8DH7EActJzw&bvm=bv.106130839,d.ZWU&cad=rja

- ✓ BH allow the calculation of child mortality indicators for specific time periods in the past (Nations & Division, 2013),
- ✓ BH allow estimation of levels and trends in childhood mortality;
- ✓ BH also allow analysis of age patterns of deaths and mortality disparities across selected socio-economic and demographic characteristics of interests;

It can also allow an external data quality assessment of the mortality data during the data collection process (Sullivan, Rutstein, & Bicego, 1994).

3.2.3 Data quality

While data from DHS are widely used to estimate child mortality rates in developing countries due to lack of, or poor, functioning civil registry, it should be noted that DHS suffer from a number of inconsistencies. Among the shortcomings commonly reported, include: events omissions problems and inaccuracies of information collected and misreporting of ages and dates (Boco & Bignami, 2007; Korenromp, Arnold, Williams, Nahlen, & Snow, 2004; Tabutin, 2006), the problem of recall and reporting of morbidity and child death depend on cultural factors, which may have a greater effect on the data (Boerma et al., 1991). Croft (2008) mentioned that the major sources of problems in DHS surveys and in many other survey programs are partial or incomplete reporting of information and inconsistent responses to different questions in the survey (Croft, 2008). There is evidence of considerable memory lapse of recalling events in the DHS surveys (Boerma et al., 1991). There is also the issue of selectivity because DHS does not provide information on the survival or death of children whose mother had died at the time of the interview.

Finally, it may be a truncation effect related to the fact that the questions are asked only of women aged 15-49 years old. It is obvious that these structural limitations may affect the estimates of child mortality due to the use of birth histories data from reproductive women. However, these shortcomings do not considerably affect the quality of the data for the analysis of the under-five mortality.

3.3 Selection of countries

This research used data from DHS conducted between 1990 and 2010 in sub-Saharan Africa countries. In order to analyse the inequalities in, and trends of, mortality and morbidity of children, we selected the countries that have realised 3 DHS during the 1990-2010 period. According to this criterion of selection, 26 countries have been included in our analysis in the following distribution:

- Eastern Africa: Malawi, Ethiopia, Kenya, Madagascar, Mozambique, Rwanda, Tanzania, Uganda, Zambia and Zimbabwe.
- Western Africa: Benin, Burkina Faso, Cote d'Ivoire, Ghana, Guinea, Mali, Nigeria, Niger, Senegal.
- Central Africa: Cameroon, Central-Africa, Congo, Gabon.
- Southern Africa: Namibia.

3.4 Methods

The study used econometric methods to estimate the concentration ratios such as dispersion, the Lorenz curve (Gini coefficient) and decomposition methods of a binary outcome (Blaide and Oaxaca decomposition, Thiel decomposition and Atkinson decomposition; Multilevel analysis, General Linear Medialization (GML). The decomposition of inequality constituted age, socio-economic status and by demographic and background factors. Some of these methods have been used in several studies (Pradhan & Arokiasamy, 2010; Van Malderen et al., 2013; Wagstaff, van Doorslaer, & Watanabe, 2003; Yiengprugsawan, Lim, Carmichael, Dear, & Sleigh, 2010; Yiengprugsawan, Lim, Carmichael, Sidorenko, & Sleigh, 2007).

3.4.1 The concentration index

The concentration index (CI) is a measure of the concentration of mortality or morbidity in various socioeconomic segments of the population. It is based on the concentration curve which plots on the x-axis, the cumulative percentage of the sample ranked by the socioeconomic variable starting with the poorest; and on the y-axis, the cumulative percentage of the ill-health variable (Chalasani, 2012). The 45-degree line in this plot is the 'line of equality,' which represents a completely equitable distribution of health in the population. This represents the case where, for example, half the mortality burden is borne by the poorer half of the population and the other half of the mortality burden is borne by the

richer half of the population. If mortality occurs disproportionately among the poor, then the curve usually falls above the line of equality. The concentration index is then defined as twice the area between the curve and the line of equality. When the curve lies above the line, the index would be negative indicating a greater concentration of the ill-health outcome among the poor. The CI is a convenient and intuitive measure of health inequality, and as evidenced by the studies mentioned earlier in the paper, it is quite popular.

3.4.2 Decomposing the concentration index

Type of decomposition used here attempts to identify the sources of wealth-based inequality in child health by examining wealth-based inequality in the determinants of child health. The concentration index of each outcome is parsed out into the contributions of various determinants of child health, where a contribution is the product of two parts: the responsiveness of the health outcome to a determinant, and the degree of inequality in that determinant (Chalasani, 2012). Many decomposition methods such as Blaide and Oaxaca decomposition, Thiel decomposition and Atkinson decomposition are used to analyse the sources of inequalities.

3.4.3 Multilevel analysis

The multilevel analysis is a method of analysis which takes into account the nature of the hierarchical data structure. It is a powerful method that isolates the effect attributable at each level in the explanation of the phenomenon under study. For the purpose of our study, we are obliged to use data from several countries and plus the addition of national data (the World Bank), multilevel analysis will be used firstly to explain the differences in mortality and morbidity in children under five years both national and sub-regional; and secondly, to measure the percentage of the total variation in mortality and child health inequalities due to variables at the macro level and also the part explained by the variables at the individual level.

3.4.4 Statistic package used

All analyses of the data that will be made in the context of this thesis will be done using Stata 13. The choice of this software is justified by its high flexibility and also because of the diversity of methods of analysis (especially the methods of decomposition and multilevel analysis), that it offers.

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Chapter 4: Decomposing wealth-based inequalities in Under-five mortality in West Africa

This chapter has been published in the Iranian Journal of Public Health: Aristide Romaric, BADO., and Sathiya Susuman Appunni. "Decomposing Wealth-Based Inequalities in Under-Five Mortality in West Africa." *Iranian journal of public health* 44.7 (2015): 920.

Abstract

Background: This study was aimed at analysing the inequalities in mortality of children under 5 years in West Africa by examining the determinants and contributing factors to the overall inequality concentration in these countries.

Method: The study used data from the DHS surveys conducted in seven countries in West Africa: Burkina Faso (2010), Benin (2006), Cote d'Ivoire (2011), Ghana (2008), Mali (2006), Nigeria (2008) and Niger (2012). The concentration index (CI), and Generalized Linear Model (GLM) with a logit link were used to access inequality.

Results: The results show that in all countries, the poorest Q1 have the highest proportions of deaths: Nigeria (31.4%), Cote d'Ivoire (30.4%) and Ghana (36.4%), over 30% of deaths of children under 5 years are among the children of the poorest (Q1) and the absolute differences of proportions Q1-Q5 are more than 20 points (25.8 in Ghana and 23.6 in Nigeria). The contributing factors of inequalities in child mortality were birth order, maternal age, parity and household size. Our findings showed that the intensity of inequality varies from one country to another.

Conclusion: The most important conclusion drawn from this study is, in order to reduce mortality in children under 5 years, it is crucial to reduce economic and social inequalities and improve the country's economic and social conditions. There is a need for monitoring and assessment of inequalities and causes of death and morbidity among children in the regions examined so as to understand the gaps and find ways to reduce them in West Africa countries.

Keywords: Concentration index Infant mortality, Child mortality, Under-five mortality, Family planning.

4.1 Introduction

The Millennium Development Goals (MDGs) arguably are the world's greatest commitments, as they represent a global agreement to reduce poverty and human deprivation at historically unprecedented rates through collaborative action (Hulme, 2009). Among the MDGs, the fourth goal (MDG 4) specifically calls on the international community to reduce mortality in children under 5 (U5) by two-thirds between 1990 and 2015 (Hulme, 2009). Therefore, the health of children under-five years in general and mortality in particular are a major priority for developing countries. Recent studies indicate that under-five mortality has decreased substantially over the last decades in both developed and developing countries (T. A. J. Houweling & Kunst, 2010; T. A. Houweling, Ronsmans, Campbell, & Kunst, 2007; McKinnon, Harper, Kaufman, & Bergevin, 2014; UNICEF, 2012). However, the fourth MDG goal will not be met by 2015 in many sub-Saharan countries in Africa in the light of progress made (UNDP, 2013). Despite the fall in the regional and global child mortality rate, deaths remain alarmingly concentrated in the poorest regions of the world, particularly sub-Saharan Africa- which has the highest regional rate of child mortality amongst under-fives. One child out of nine dies before their fifth birthday(UNICEF, 2012). Similarly, inequalities exist and remain between countries, within each country, between different sub-groups and socio-economic groups (Bhattacharya & Chikwama, 2012; Cleland, Bicego, & Fegan, 1992; Lauridsen & Pradhan, 2011; Minujin & Delamonica, 2004; Mustafa & Odimegwu, 2008; Razzaque, Streatfield, & Gwatkin, 2007), between the place of residence (Akoto & Tambashe, 2002; J. Fotso, 2006), between ethnicity (Adedini et al., 2012; Antai, 2011; Razzaque et al., 2007), between parental characteristics (Cleland et al., 1992) and children (Mustafa & Odimegwu, 2008).

Socioeconomic inequalities in childhood mortality are a major public health challenge in developing countries. Childhood mortality is systematically and considerably higher among lower socio-economic groups in developing countries (T. A. J. Houweling & Kunst, 2010). Reducing these inequalities by improving child survival up to the level of more advantaged groups within countries would substantially improve population health (T. A. J. Houweling & Kunst, 2010). Specific attention has been devoted to research on child health inequalities in developing countries (Adedini et al., 2012; Akinyemi, Bamgboye, & Ayeni, 2013; Akoto &

Tambashe, 2002; Amin, Shah, & Becker, 2010; Arifeen, 1989; Arokiasamy, Jain, Goli, & Pradhan, 2013; Arokiasamy & Pradhan, 2011; Asamoah, Agardh, & Ostergren, 2013; Barros & Victora, 2010; T. A. J. Houweling & Kunst, 2010; Kumar & Singh, 2013; O'Donnell, van Doorslaer, Wagstaff, & Lindelow, 2007; Pradhan & Arokiasamy, 2010; Wagsta, 2003; Wagstaff, van Doorslaer, & Watanabe, 2003). Some of these studies focus on sub-Saharan Africa and involve regional and multi-country studies on this topic. But in the case of West Africa, the literature reviewed indicates that research remains low even where this part of Africa has the highest rates of under-five mortality in the world. These countries are among the world's poorest countries(Fonds international de développement agricole., 2001). Hence, among the key concerns are: What are the determinants of inequalities in mortality among under-five in West Africa? Are there some variations between and within countries? To this end, the objective of this study is to examine the inequalities in mortality of children under 5 years in West Africa by analysing the determinants and contributing factors to the overall inequality concentration in these countries.

4.2 Study Design

Previous research has shown that several factors that explain child health inequalities in developing countries can be attributed to 1) Individual characteristics of parents and children; 2) The living conditions of households; 3) The geographical factors; and 4) national policies and reforms, particularly in the health sector.

In addition, past studies indicate that a mother's characteristics such as education, age during child delivery, parity, food habits and health status could influence the survival of the child (Adedini et al., 2012; Boco, 2011; J.-C. C. Fotso & Kuate-Defo, 2005; T. A. Houweling et al., 2007; Ssewanyana & Kasirye, 2012). Mother's education level was found to be strongly associated with child survival and was a determinant of inequalities in child health in sub-Saharan Africa (Cleland et al., 1992; Målqvist, Hoa, & Thomsen, 2012).

Houweling and Kunst (T. A. J. Houweling & Kunst, 2010) argued that maternal education is thought to exert influence through increased status and decision-making power of mothers within the household, increased willingness and ability to travel outside the community, more timely use

of health care, greater negotiating power with health care providers, increased knowledge, skills and identification with modern health systems and responsiveness to new ideas. Maternal education is estimated to be accounted for by its association with household wealth, and probably associated better living conditions and ability to pay for health services.

The socio-economic environment of households was also found to be an important factor contributing to child health inequalities. In fact, the living conditions of households have a direct influence on children's health through the quality of drinking water and hygiene in the household, including the use of health services, food, health practices and fashion life (T. A. J. Houweling & Kunst, 2010; Poel, Donnell, & Doorslaer, 2009; Wagstaff, 2002a). The poverty level of the household (Kanté, Helleringer, & Honorati Masanja, 2013; Pradhan & Arokiasamy, 2010; C. Van Malderen, Van Oyen, & Speybroeck, 2013; Wagstaff, 2002a), size and household composition (J.-C. C. Fotso & Kuate-Defo, 2005), the gender of the head of the households (Poel et al., 2009) have an impact on child mortality.

With respect to community factors, research shows that the contextual effects have an influence on children's health. Indeed, the availability and access to health centres, and availability of qualified staff are often limited or absent in rural and poor areas which thus increases health inequalities (T. A. J. Houweling & Kunst, 2010; Lauridsen & Pradhan, 2011; Wagstaff, 2002a, 2002b). Good hygiene practices are relatively difficult to be met under local conditions where water supply and sanitation are poor. Communities often have common values and norms, like peer pressure, which contributes significantly to shaping health behaviours. At both community and household level, the poor may be disadvantaged as they are more likely to live in remote places, far from health centres. This makes accessibility to health care very low(36). Several studies examine the effect of the type of residence (urban/rural) on childhood mortality inequalities(Akoto & Tambashe, 2002; Antai, 2011; Boco, 2011; J. Fotso, 2006; Poel et al., 2009). These studies showed that the location of residence (urban vs rural) had a significant influence on the child survival, and so residing in rural areas increased the probability of a child dying before the fifth birthday. Houweling and Kunst (T. A. J. Houweling & Kunst, 2010) study showed that at the country level, several factors can impact on the magnitude of mortality inequalities through multiple pathways. Indeed, these authors showed that policies at the country level can increase or decrease the inequalities between social groups and influence health policy for the poor. West

Africa is one of the poorest parts of the world where health indicators are still poorly reported. Under-five mortality remains high in the region, and as such the fourth MDG goal might not be met in many West African countries. Common causes of child mortality and morbidity include diarrhoea, acute respiratory infections, measles, and malaria. Studies have shown that many children in Nigeria mainly die from malaria, diarrhoea, neonatal tetanus, tuberculosis, whooping cough and broncho-pneumonia (Ogunjuyigbe, 2004).

4.3 Materials and methods

The study used data from Demographic and Health Surveys (DHS)[4] in seven West Africa countries, including Burkina Faso (DHS, 2010), Benin (DHS, 2006), Cote d'Ivoire (DHS, 2011), Ghana (DHS, 2008), Mali (DHS, 2006), Nigeria (DHS, 2008) and Niger (DHS, 2012).

The outcome variable used was the risk of under-five death (0–59 months), which is defined as the probability of dying between birth and the fifth birthday. Variable socio-economic status built from household assets is used as the main variable for measuring inequalities in mortality.

Selected variables

Child' sex: Male and Female

Birth order: 1st birth, 2nd-6th birth and 7th & +

Mother's age: 15-19, 20-24, 25-29, 30-34, 35-39, 40-44 and 45-49

Mother's Occupation: Not working, skilled manual and other occupation

Mother's education: No education, Primary, Secondary

Parity: 1-3, 4-6, 7 & +

Father's occupation: Agriculture, Sales, Skilled Manual and Other Occupation

Father's education: No education, Primary, Secondary, Higher and DK

Household's size: 1-3, 4-6, 7 &+

Household head's sex: Male and Female

Location of residence: Urban and Rural

[4] Data available for public through internet http://www.measuredhs.com

Wealth index: Q1 (Poorest), Q2 Poorer, Q3 Middle Q4 Rich and Q5 Richest

The socioeconomic variable was categorized into 5 categories: Q1 being the Poorest, Q2, Q3, Q4 and Q5 as the Richest. The independent variables included: sex of the child, birth order (1st, 2-6th, 7th and above), the mother's age at delivery (15-19), parity (1-3, 4-6, 7 and above), educational level (no education, primary, secondary and high) and occupation (not working, agriculture, sale, manual, other occupation) of the mother, educational level (no education, primary, secondary, highest and do not know (DK) and the occupation of the father (agriculture, skilled manual, other occupation), household size (1-3, 4-6, 7 and above), sex of household head and the middle of residence (urban vs rural).

Statistical analysis

The concentration index (CI) is employed in this paper to measure under 5 mortality inequalities.

CI quantifies the degree of income-related inequality in a health variable and is becoming a standard tool for the measurement of income-related health inequality (Liu, Gao & Yan, 2014).

Detailed information about the methodological tools used is presented in some publications (Hosseinpoor et al., 2006; C. Van Malderen et al., 2013; Carine Van Malderen et al., 2013; Yiengprugsawan, Lim, Carmichael, Dear, & Sleigh, 2010; Yiengprugsawan, Lim, Carmichael, Sidorenko, & Sleigh, 2007).

$$C = \frac{2}{n\mu}\left(\sum_{1}^{n} h_i R_i\right) - 1$$

Where h_i is the variable of interest for the ith person; μ is the mean or proportion of *h: n* is the number of persons; and if the *n* individuals are ranked according to their socioeconomic status, beginning with the most disadvantaged, then R_i is their relative rank, *i*-0.5/n. When there is no inequality (or when inequality is balanced and opposite for equal fractions of the income- ranked

population), the concentration index equals 0. If the variable of interest is concentrated at a lower (or higher) socioeconomic level, the concentration index becomes negative (or positive).

Generalized Linear Model (GLM) specifying binomial distribution and identity link was used to perform multivariate analysis. The coefficients from GLM were used subsequently to decomposing and computing the contribution of the independent variable to the concentration index. The method used is detailed somewhere (Hosseinpoor et al., 2006).

4.5 Results

Table 4.1 presents the proportions of deaths by poverty status and country. The results show that in all countries, the poorest Q1 have the highest proportions of deaths: Nigeria (31.4%), Cote d'Ivoire (30.4%) and Ghana (36.4%), over 30% of deaths of children under 5 years are among the children of the poorest (Q1) and the absolute differences of proportions Q1-Q5 are more than 20 points (25.8 in Ghana, 23.6 in Nigeria and Cote d'Ivoire has 19.3). For Burkina Faso (14.5), Benin (15.7) and Mali (12), the absolute differences in the proportions of deaths of children under-five years between the poorest and the richest is more than 10 points. Niger appears to have the low gaps between poorest and richest with an absolute difference of less than 1 (0.7). The overall concentration index was -0.12 for Burkina Faso in 2010, -0.07 for both Benin in 2006 and for Cote d'Ivoire in 2011. The concentration index was -0.03 for Ghana in 2008 and -0.10 for Mali in 2006. It was -0.12 and -0.07 respectively for Nigeria in 2008 and Niger in 2012.

Table 4.1: Proportion of deaths in children under 5 years by socioeconomic quintile and country

Country	Q1(Poorest)	Q2	Q3	Q4	Q5(Richest)	|Q5-Q1|	(Q5-Q1)/Q1	C(95%CI)	N1	N2
Burkina Faso	24.10	25.45	21.69	19.2	9.56	14.53	-0.60	-0.12(-0.14, -0.09)	15045	1328
Benin	25.56	22.47	23.91	18.23	9.83	15.72	-0.62	-0.07(-0.10; -0.04)	16075	1393
Cote d'Ivoire	30.39	25.41	19.61	13.54	11.05	19.34	-0.64	-0.07(-0.14; -0.01)	3644	362
Ghana	36.36	17.68	19.19	16.16	10.61	25.76	-0.71	-0.03(-0.11;0.05)	2992	198
Mali	22.77	24.43	21.82	20.21	10.77	11.99	-0.53	-010(-0.13; -0.08)	14238	1801
Nigeria	31.38	27.39	19.84	13.66	7.74	23.64	-0.75	-0.12(-0.14; -0.10)	28653	3206
Niger	17.36	22.7	20.5	22.8	16.63	0.73	-0.04	-0.07(-0.10; -0.03)	12558	956

N1=Number of births; N2=Number of deaths: Source: data from Demographic and Health Surveys (DHS) run in six countries in West Africa including Burkina Faso (DHS, 2010), Benin (DHS, 2006), Cote d'Ivoire (DHS, 2011), Ghana (DHS, 2008), Mali (DHS, 2006), Nigeria (DHS, 2008) and Niger (DHS, 2012). Q1Poorest; Q2 Poorer; Q3 Middle; Q4 Richer Q5 Richest

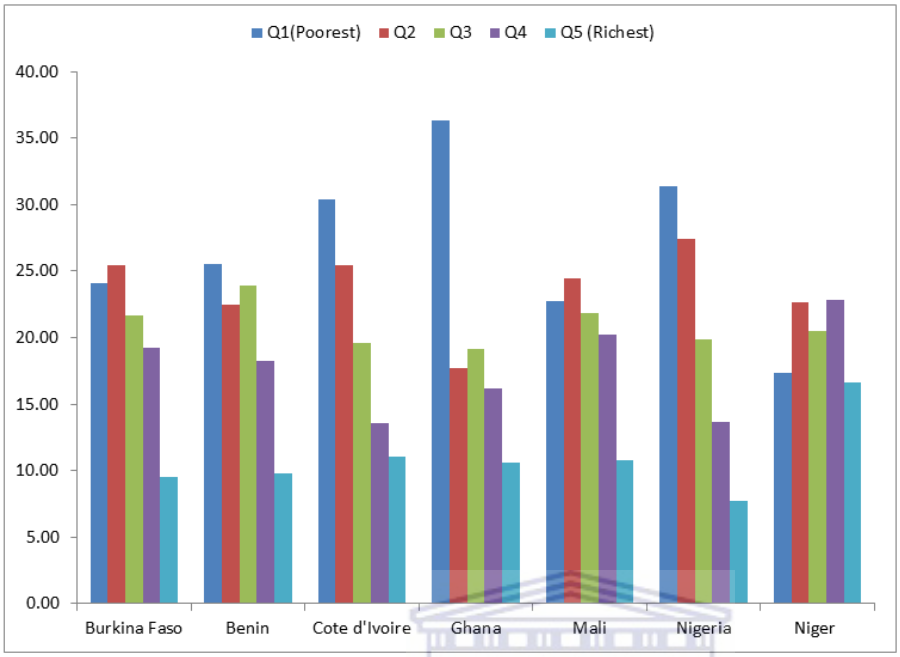
In all the countries concerned by this study, the value of the concentration index is negative which implies that mortality is concentrated among children from poor households (Q1=Poorest) than among children of wealthy households (Q5=Richest). Inequalities in mortality are higher in Burkina Faso, Nigeria and Mali whose concentration index was lower than -0.10. Inequalities in child mortality are less pronounced in Ghana, Niger and Cote d'Ivoire than elsewhere.

Figure 4.1 presents the proportions of deaths of children under-five years by quintile of socioeconomic and by country. The results of the Figure 4.1 show that the poorest are those with the highest death proportions.

Factors associated with child mortality

Table 4.2 shows the proportions of deaths for each determinant factor associated with child mortality. The results on factors associated with the mortality of children under the age of 5 years for each country are presented in Table 4.3. Birth order was significant in all countries in the study. Children with 7th and above were more likely to die before their fifth year than the first child. The variable sex of the child is significant for Nigeria and Cote d'Ivoire and the results showed that girls had less probability to die before their fifth birthday than boys.

Figure 4.1: Proportion of deaths (%) in children under-five years by socioeconomic quintile and country



The demographic characteristics of the mother such as age and parity have proved significant in the countries in the study. It appeared that the children of elderly mothers and mothers with high parity are more likely to die before their fifth birthday than those of the young mothers (15 and 19 years) who have low parity. The mother's occupation is only significant in Mali and Cote d'Ivoire. Contrary to our expectations, the mother's education level was not significant in some countries concerned as observed in the analysis. In Mali and Nigeria, the mother's education was significantly associated with child mortality of under-five years.

According to the father's characteristics, results showed that the father's occupation is significantly associated with under-five mortality in Benin and Nigeria while father's educational level is significant in Ghana, Mali and Niger. Thus, children whose fathers are educated had a lower probability of dying than those whose fathers were not going to school.

Household size seemed to be a determinant of under-five year's mortality in the countries concerned in our analysis. In all countries, the results showed that the probability of dying before the age of five years increased with household size. Thus, children living in large households are more likely to die before their fifth birthday. The results were similar in all countries. Exceptions are in Ghana and Cote d'Ivoire, where the variable sex of the household head was significantly

associated with under-five mortality and the results showed that children in households headed by women had a higher probability of dying before their fifth birthday than those belonging to households headed by a man.

Table 4.4 presents the concentration index for each health outcome by country. The proportions (presented in Table 4.2 above) are used to calculate the concentration index related to each factor (Table 4.4). A negative C_k means that the determining factor is more prevalent among the poorest households. To the values of the concentrations of variables, we see that the birth order, maternal age, parity, and household size are potential contributing factors to inequalities in mortality among children under five years.

The mortality of children under five years appears to be higher among children of high birth rank (Ck = -0.36 for Ghana, -0.20, Burkina and Benin. It is -0.21 for Cote d'Ivoire), among children whose mothers had high parity among children whose mothers are older and among children of large households.

Table 4.2: Repartition of death by Explanatory variables and countries

Variables	Burkina		Benin		Ghana		Mali		Nigeria		Niger		Cote d'Ivoire	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Child' sex														
Male	715	53.84	725	52.05	106	53.54	945	52.47	1,735	54.12	513	53.66	198	54.70
Female	613	46.16	668	47.95	92	46.46	856	47.53	1,471	45.88	443	46.34	164	45.30
Birth order														
1st	250	18.83	281	20.17	44	22.22	371	20.60	584	18.22	154	16.11	101	27.90
2nd-6th	834	62.80	884	63.46	121	61.11	1,031	57.25	1,895	59.11	537	56.17	201	55.52
7th & +	244	18.37	228	16.37	33	16.67	399	22.15	727	22.68	265	27.72	60	16.57
Mother's age														
15-19	74	5.57	62	4.45	4	2.02	148	8.22	188	5.86	43	4.50	49	13.54
20-24	283	21.31	266	19.10	39	19.70	440	24.43	675	21.05	203	21.23	91	25.14
25-29	365	27.48	440	31.59	41	20.71	421	23.38	818	25.51	250	26.15	83	22.93
30-34	261	19.65	282	20.24	41	20.71	361	20.04	612	19.09	204	21.34	49	13.54
35-39	203	15.29	219	15.72	46	23.23	255	14.16	508	15.85	158	16.53	59	16.30
40-44	95	7.15	96	6.89	19	9.60	131	7.27	257	8.02	69	7.22	23	6.35
45-49	47	3.54	28	2.01	8	4.04	45	2.50	148	4.62	29	3.03	8	2.21
Mother's Occupation														
Not working	246	18.52	152	10.91	23	11.62	608	33.76	1,020	31.82	695	72.70	90	24.86
Sales	211	15.89	562	40.34	68	34.34	334	18.55	1,017	31.72	176	18.41	117	32.32
Agriculture	706	53.16	577	41.42	80	40.40	-		635	19.81	27	2.82	121	33.43
Manual	132	9.94	84	6.03	12	6.06	126	7.00	355	11.07	35	3.66	4	1.10
Other occupation	33	2.48	18	1.29	15	7.58	733	40.70	179	5.58	23	2.41	30	8.29
Mother's education														
No education	1184	89.39	1110	79.68	86	43.43	1,598	88.73	1,871	58.36	824	86.19	249	68.78
Primary	107	8.06	232	16.65	53	26.77	161	8.94	721	22.49	92	9.62	94	25.97
Secondary &+	37	2.79	51	3.66	59	29.80	42	2.33	614	19.15	40	4.18	19	5.25
Parity														
1-3	497	37.42	530	38.05	84	42.42	693	38.48	1,170	36.49	286	29.92	171	47.24
4-6	494	37.20	552	39.63	70	35.35	580	32.20	1,074	33.50	321	33.58	113	31.22
7 &+	337	25.38	311	22.33	44	22.22	528	29.32	962	30.01	349	36.51	78	21.55
Father's occupation														
Agriculture	1039	78.24	877	62.96	111	56.06	1,275	70.79	1,535	47.88	567	59.22		
Sales	108	8.13	231	16.58	17	8.59	186	10.33	550	17.16	-	-		

Source: Demographic and Health Surveys (DHS) different countries in West Africa including Burkina Faso (DHS, 2010), Benin (DHS, 2006), Cote d'Ivoire (DHS, 2011), Ghana (DHS, 2008), Mali (DHS, 2006), Nigeria (DHS, 2008) and Niger (DHS, 2012). Q1Poorest; Q2 Poorer; Q3 Middle; Q4 Richer Q5 Richest

Skilled Manual	111	8.36	130	9.33	32	16.16	152	8.44	398	12.41	255	26.67		
Other Occupation	70	5.27	155	11.13	38	19.19	188	10.44	723	22.55	134	14.02		
Father's education														
No education	1145	87.14	804	58.30	83	42.56	1,495	83.15	1,500	47.41	815	85.25		
Primary	113	8.60	308	22.34	21	10.77	183	10.18	672	21.24	83	8.68		
Secondary	48	3.65	175	12.69	71	36.41	78	4.34	714	22.57	35	3.66		
Higher	3	0.23	16	1.16	9	4.62	11	0.61	223	7.05	6	0.63		
DK	5	0.38	76	5.51	11	5.64	31	1.72	55	1.74	17	1.78		
Household's size														
1-3	217	16.34	250	17.95	57	28.79	339	18.82	597	18.62	148	15.48	42	11.60
4-6	441	33.21	562	40.34	83	41.92	677	37.59	1,246	38.86	349	36.51	123	33.98
7 &+	670	50.45	581	41.71	58	29.29	785	43.59	1,363	42.51	459	48.01	197	54.42
Household head's sex														
Male	1249	94.05	1237	88.80	147	74.24	1,690	93.84	2,920	91.08	858	89.75	72	19.89
Female	79	5.95	156	11.20	51	25.76	111	6.16	286	8.92	98	10.25	290	80.11
Location of residence														
Urban	198	14.91	424	30.44	67	33.84	403	22.38	634	19.78	122	12.76	123	33.98
Rural	1130	85.09	969	69.56	131	66.16	1,398	77.62	2,572	80.22	834	87.24	239	66.02
Socio-economic status														
Q1 (Poorest)	320	24.10	356	25.56	72	36.36	410	22.77	1,006	31.38	166	17.36	110	30.39
Q2	338	25.45	313	22.47	35	17.68	440	24.43	878	27.39	217	22.70	92	25.41
Q3	288	21.69	333	23.91	38	19.19	393	21.82	636	19.84	196	20.50	71	19.61
Q4	255	19.20	254	18.23	32	16.16	364	20.21	438	13.66	218	2.80	49	13.54
Q5 (richest)	127	9.56	137	9.83	21	10.61	194	10.77	248	7.74	159	16.63	40	11.05
N	1,328	8.83	1,393	8.67	198	6.62	1,801	12.7	3,206	11.19	956	7.61	362	9.93

Table 4.3: Adjusted associations between infant mortality and its dominants

	Burkina		Benin		Ghana		Mali		Nigeria		Niger		Cote d'Ivoire	
Variables	Coef.	Pvalue	Coef.	Pvalue	Coef.	Pvalue	Coef.	Pvalue	Coef.	Pvalue	Coef.	Pvalue	Coef.	Pvalue
Child' sex (Male)	-0.138	0.019	-0.098	0.086	-0.106	0.491	-0.082	0.110	-0.150	0.000	-0.134	0.051	-0.230	0.042
Birth order (1st)														
2nd-6th	-0.064	0.565	-0.292	0.004	-0.453	0.076	-0.378	0.000	-0.022	0.748	-0.404	0.003	-0.259	0.150
7th & +	-0.893	0.000	-0.980	0.000	-1.180	0.014	-1.014	0.000	-0.665	0.000	-0.892	0.000	-0.816	0.026
Mother's age (15-19)														
20-24	-0.040	0.794	-0.105	0.507	1.057	0.094	0.250	0.024	0.185	0.055	0.645	0.001	-0.402	0.046
25-29	-0.005	0.976	-0.178	0.279	0.866	0.178	0.075	0.553	-0.051	0.616	0.520	0.011	-0.666	0.005
30-34	-0.472	0.011	-0.537	0.003	0.993	0.137	0.127	0.356	-0.216	0.051	0.366	0.095	-1.102	0.000
35-39	-0.499	0.012	-0.426	0.024	1.073	0.113	0.007	0.961	-0.211	0.073	0.429	0.064	-0.846	0.004
40-44	-0.709	0.001	-0.560	0.008	0.831	0.244	0.001	0.996	-0.265	0.042	0.308	0.226	-1.128	0.001
45-49	-0.066	0.795	-0.833	0.002	0.478	0.540	0.031	0.887	-0.129	0.373	0.449	0.135	-1.249	0.009
Mother's Occupation (Not working)														
Sales	-0.244	0.016	0.174	0.080	0.001	0.998	0.195	0.010	0.046	0.357	-0.062	0.500	0.317	0.039
Agriculture	-0.216	0.009	0.055	0.592	-0.267	0.346			-0.021	0.721	-0.308	0.135	0.063	0.684
Manual	0.111	0.353	0.059	0.688	-0.350	0.364	0.208	0.052	0.079	0.248	0.201	0.279	0.289	0.609
Other occupation	0.206	0.333	0.200	0.475	-0.116	0.752	0.213	0.001	0.080	0.393	0.081	0.733	0.373	0.111
Mother's education (No education)														
Primary	-0.179	0.117	0.057	0.498	0.205	0.327	0.000	0.998	-0.085	0.133	0.119	0.321	0.133	0.325
Secondary &+	-0.266	0.209	-0.302	0.080	0.089	0.710	-0.351	0.051	-0.195	0.005	0.209	0.288	-0.240	0.370
Parity (1-3)														
4-6	0.741	0.000	0.805	0.000	0.772	0.001	0.483	0.000	0.607	0.000	0.701	0.000	0.828	0.000
7 &+	1.945	0.000	1.776	0.000	2.176	0.000	1.530	0.000	1.745	0.000	1.673	0.000	2.054	0.000
Father's occupation (agriculture)														
Sales	-0.267	0.020	-0.133	0.166	0.175	0.603	-0.278	0.003	0.119	0.042	-0.437	0.677		
Skilled Manual	0.122	0.279	-0.206	0.069	-0.070	0.790	-0.116	0.260	0.090	0.177	-0.073	0.396		
Other Occupation	-0.197	0.238	-0.297	0.008	-0.273	0.312	-0.076	0.430	0.125	0.031	-0.013	0.906		
Father's education (No education)														
Primary	-0.201	0.064	-0.133	0.083	-0.254	0.348	-0.046	0.601	-0.024	0.674	-0.280	0.023		
Secondary	-0.092	0.617	-0.045	0.661	-0.863	0.000	-0.363	0.007	-0.027	0.671	-0.531	0.006		
Higher	0.124	0.845	-0.278	0.336	-0.968	0.028	-0.635	0.056	-0.150	0.105	-1.059	0.022		
DK	-0.157	0.738	-0.097	0.459	-0.018	0.959	0.053	0.791	0.072	0.631	0.232	0.378		

Household's size (1-3)														
4-6	-1.037	0.000	-0.849	0.000	-1.102	0.000	-0.940	0.000	-1.009	0.000	-1.135	0.000	-0.648	0.002
7 &+	-1.215	0.000	-1.128	0.000	-1.409	0.000	-1.320	0.000	-1.332	0.000	-1.534	0.000	-0.895	0.000
Household head's sex (Male)	0.312	0.019	0.270	0.005	0.140	0.472	0.359	0.001	0.241	0.001	0.295	0.015	-0.156	0.282
Location of residence(Urban)	0.122	0.247	0.085	0.217	-0.121	0.597	-0.009	0.909	0.210	0.000	0.522	0.000	0.082	0.581
Socio-economic status (Q1 (Poorest))														
Q2	0.036	0.674	0.008	0.920	-0.102	0.667	-0.022	0.776	-0.005	0.920	0.337	0.002	-0.122	0.429
Q3	-0.101	0.255	0.129	0.128	0.259	0.356	-0.207	0.008	-0.064	0.293	0.241	0.032	-0.167	0.342
Q4	-0.143	0.127	0.058	0.560	0.157	0.642	-0.172	0.042	-0.184	0.017	0.321	0.004	-0.277	0.195
Q5 (richest)	-0.329	0.025	-0.089	0.513	0.251	0.540	-0.290	0.021	-0.385	0.000	0.183	0.224	0.024	0.922
Intercept	-1.608	0.000	-1.743	0.000	-2.276	0.001	-1.351	0.000	-1.700	0.000	-2.822	0.000	-1.038	0.001

Source: Demographic and Health Surveys (DHS) different countries in West Africa including Burkina Faso (DHS, 2010), Benin (DHS, 2006), Cote d'Ivoire (DHS, 2011), Ghana (DHS, 2008), Mali (DHS, 2006), Nigeria (DHS, 2008) and Niger (DHS, 2012). Q1Poorest; Q2 Poorer; Q3 Middle; Q4 Richer Q5 Richest

Table 4.4: Decomposition analysis of concentration index of infant mortality by socioeconomic status

Variables	Burkina		Benin		Ghana		Mali		Nigeria		Niger		Cote d'Ivoire	
	C_k	Contr C	C_k	Contr C	Ck	Contr C	C_k	Contri C	C_k	Contr C	C_k	Contri C	C_k	Contri C
Child' sex (Female)	-0.006	0.004	-0.022	0.011	-0.006	0.005	0.005	-0.002	0.006	-0.004	0.002	-0.001	-0.002	0.002
Birth order (1st)														
2nd-6th	0.009	-0.004	0.000	0.001	-0.007	0.029	0.017	-0.030	0.021	-0.002	0.001	-0.004	0.005	-0.007
7th & +	-0.209	0.389	-0.203	0.343	-0.357	1.131	-0.149	0.264	-0.182	0.246	-0.076	0.246	-0.215	0.292
Mother's age (15-19)														
20-24	0.056	-0.005	0.018	-0.004	-0.032	-0.108	0.039	0.019	-0.058	-0.020	0.043	0.078	0.031	-0.031
25-29	0.034	-0.001	0.025	-0.015	0.029	0.084	0.038	0.005	0.052	-0.006	0.007	0.013	0.029	-0.045
30-34	-0.003	0.004	0.020	-0.023	0.106	0.353	-0.035	-0.007	0.068	-0.025	-0.026	-0.026	0.028	-0.042
35-39	-0.063	0.054	-0.032	0.022	-0.025	-0.101	-0.063	0.000	0.018	-0.005	0.000	0.000	0.001	-0.002
40-44	-0.118	0.068	-0.060	0.024	-0.124	-0.159	-0.105	0.000	-0.044	0.008	-0.015	-0.004	-0.153	0.111
45-49	-0.105	0.003	-0.185	0.033	-0.261	-0.081	-0.155	-0.001	-0.184	0.010	-0.104	-0.019	-0.025	0.007
Mother's Occupation (Not working)														
Sales	0.239	-0.105	0.200	0.148	0.271	0.002	0.193	0.055	0.103	0.013	0.146	-0.022	0.214	0.221
Agriculture	-0.111	0.144	-0.319	-0.077	-0.459	0.799		0.000	-0.307	0.011	-0.143	0.016	-0.373	-0.079
Manual	-0.142	-0.018	0.248	0.009	0.115	-0.039	0.109	0.013	0.082	0.006	0.029	0.003	0.025	0.001
Other occupation	0.466	0.027	0.590	0.016	0.391	-0.055	-0.188	-0.129	0.480	0.019	0.504	0.013	0.405	0.126
Mother's education (No education)														
Primary	0.335	-0.055	0.296	0.030	0.000	0.000	0.253	0.000	0.062	-0.011	0.288	0.043	0.069	0.024
Secondary &+	0.742	-0.062	0.656	-0.076	0.330	0.141	0.632	-0.041	0.458	-0.153	0.698	0.080	0.490	-0.062
Parity (1-3)														
4-6	-0.050	-0.155	-0.062	-0.207	-0.083	-0.364	-0.020	-0.024	-0.009	-0.016	-0.029	-0.090	-0.015	-0.040
7 &+	-0.205	-1.147	-0.208	-0.868	-0.366	-2.852	-0.146	-0.516	-0.177	-0.828	-0.078	-0.623	-0.232	-1.036

Father's occupation (agriculture)														
Sales	0.416	-0.102	0.371	-0.086	0.439	0.106	0.386	-0.088	0.188	0.034	0.986	0.000		
Skilled Manual	0.263	0.030	0.341	-0.069	0.273	-0.050	0.381	-0.029	0.249	0.025	0.178	-0.045		
Other Occupation	0.579	-0.068	0.388	-0.135	0.344	-0.290	0.378	-0.024	0.306	0.077	0.345	-0.008		
Father's education (No education)														
Primary	0.304	-0.060	0.116	-0.036	-0.185	0.082	0.111	-0.004	0.013	-0.001	0.221	-0.071		
Secondary	0.681	-0.026	0.430	-0.026	0.201	-1.018	0.523	-0.065	0.279	-0.015	0.530	-0.135		
Higher	1.000	0.003	0.798	-0.027	0.540	-0.390	0.762	-0.023	0.529	-0.050	0.962	-0.084		
DK	0.295	-0.002	0.212	-0.012	0.019	0.000	0.263	0.002	0.002	0.000	0.300	0.016		
Household's size (1-3)														
4-6	0.029	-0.115	0.026	-0.094	0.061	-0.457	0.046	-0.130	0.059	-0.208	-0.015	0.082	-0.025	0.056
7 &+	-0.036	0.249	-0.052	0.255	-0.205	1.366	-0.047	0.214	-0.072	0.362	0.007	-0.068	0.005	-0.023
Household head's sex (Female)	0.099	0.021	0.042	0.001	0.123	0.071	-0.216	-0.038	-0.200	-0.038	-0.176	-0.070	-0.282	0.355
Location of residence (Rural)	-0.155	-0.183	-0.178	-0.111	-0.298	0.385	-0.014	0.001	-0.011	-0.016	0.019	0.112	-0.003	-0.002

Source: Demographic and Health Surveys (DHS) different countries in West Africa including Burkina Faso (DHS, 2010), Benin (DHS, 2006), Cote d'Ivoire (DHS, 2011), Ghana (DHS, 2008), Mali (DHS, 2006), Nigeria (DHS, 2008) and Niger (DHS, 2012)

4.6 Discussion

Results of this study show that the inequalities of the mortality of children under-five remain in West African countries and gaps of under-five mortality between children from wealthy households and those living in the poorest household are still important, thus supporting findings of earlier studies (Antai, 2011; C. Van Malderen et al., 2013). Findings of this study show that the intensity of inequality varies from one country to another i.e. it is more concentrated in Burkina Faso, Nigeria and Mali and weakly concentrated in Ghana - showing that community or country level conditions can be potential sources of inequalities in mortality and health of children under five years (Adedini, Odimegwu, Bamiwuye, Fadeyibi, & De Wet, 2014; Boco, 2011; J.-C. C. Fotso & Kuate-Defo, 2005; T. A. J. Houweling & Kunst, 2010). Indeed, countries involved in this study are all West African countries, where political context, economic development and social policies are not the same. These differences could explain differences in inequality of child mortality as observed. Ssewanyana & Kasirye (Ssewanyana & Kasirye, 2012) argued that with regard to contextual factors driving health inequalities, political factors are highlighted as major drivers of both income and health inequalities.

Moreover, the findings also show that socio-economic inequalities of under-five mortality are related to child's characteristics (birth, gender), to mother's characteristics (age, the main occupation, parity), the characteristics of the father (education) and to household's characteristics (size, gender of household head, the standard of living of the household). These variables are listed in the conceptual frameworks developed for explaining inequality of child mortalities in developing countries (Mosley & Chen, 1984; O'Donnell et al., 2007; Wagstaff, 2002b). Furthermore, our findings show that the birth's order, mother's age, parity, mother's occupation and household's size are major contributors of inequalities of child mortalities by decomposition analysis of concentration index in the countries concerned by the study. Surprisingly, our results do not confirm a strong relationship between the mother's educational level and location of residence and inequalities in under-five mortality in the countries concerned. Such result was also found in recent research (Amouzou & Hill, 2004; Amouzou, Kozuki, & Gwatkin, 2014; Ssewanyana & Kasirye, 2012).

4.7 Conclusion

The most important conclusion drawn from this study is, in order to reduce mortality in children under 5 years, it is important to reduce economic and social inequalities and improve the country's economic and social conditions. Tackling under-five inequalities of child mortality could, therefore, be achieved through specific actions at the country level, such as family planning programs aimed at promoting the reduction of a number of births per women and by increasing women empowerment in economic activities.

Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Chapter 5: Determinants of Under-Five Mortality in Burkina Faso: A Concentration Dimension

Bado A., Sathiya Susuman A. "Determinants of under-five mortality in Burkina Faso: A concentration dimension", submitted to for publication.

Abstract

Background: The aim of this paper is to determine the factors associated with under-five mortality and their evolution from 1993 to 2010 and to analyse the contributors of socioeconomic inequalities in mortality of children under-five years during the same period.

Methods: The data used in this study were derived from the four rounds of Demographic and Health Survey (DHS) conducted in Burkina Faso in 1993, 1998, 2013 and 2010. Concentration measurement, logistics regression and Oaxaca-Blinder decomposition method were used to analyse data.

Results: The results show that inequalities between the rich and the poor in under-five mortality has increased from 1993 to 2010 with concentration index varied from -0.03 in 1993 DHS to -0.11 in 2010 DHS. Multivariate analysis revealed that being the first child (OR = 1.8 for 1993, 1.7 for 1998, 1.2 for 2003 and 1.3 for 2010) or a twin (OR=4.5 for 1993, 2.8 for 1998, 2.7 for 2003 and 4.8 for 2010) were also significantly associated with the probability of dying. The differences in the proportions of death between the two groups were de 3.1%, 2.9%, 2.8% and 3.7% respectively for 1992 DHS, 1998 DHS, 2003 DHS and 2010 DHS in favour of children from rich households. The results of the decomposition analysis of the Gap in Under-five mortality between the poor and rich groups found differences in the likelihood to die before the fifth birthday 0.04 in 1993, 0.03 in 1998, 0.02 in 2003 and 0.04 for 2010) in favour of the children of the rich household. The variable (parity) was the main contributor to the part of the inequality due to differences in group characteristics and that would be due to the fact that women from poor households have greater parity compared to those from rich households.

Conclusion: For a reduction in mortality and inequalities related to mortality, the implementation of actions in favour of poor households and promotion of family planning programmes for birth spacing will be required.

Keywords: Inequalities in Mortality, Concentration Measurement, Decomposition Method

5.1 Background

Reducing mortality in children under five is a priority on the international health agenda. In this sense, the fourth goal of the Millennium Development Goals (MDG) was devoted to the reduction of under-five mortality rate by two-thirds, between 1990 and 2015 (United Nations, 2013).

Africa recorded a decline in under-five mortality rate (U5MR), from 165 deaths per 1,000 live births in 1990 to 118 deaths per 1,000 live births in 2010, a reduction of 28 percent over 20 years. While some countries have already achieved the MDG 4, others are still lagging behind with an insufficient level of decline U5MR. Therefore, this reduction is considered insufficient to enable the continent to achieve the target by 2015 (Alkema & You, 2012; United Nations and African Union Commission, 2011) Burkina Faso is part of the latter group of countries.

The results of the demographic and health surveys (DHS 2010) show that the level of mortality of children under 5 years is declining in the last two decades from 177 deaths per 1000 births to 129 deaths per 1000 births between 1998 and 2010 (Institut National de la Statistique et de la Démographie (INSD) et ICF International, 2012). This can partly be explained by the policies and actions implemented in the country towards children's health (Becher et al., 2004; Becher, Kauermann, Khomski, & Kouyaté, 2009; Diallo & Meda, 2010). These activities included improvement in the health care system and the Integrated Management of Childhood Illness since 2005, the Integrated Management of HIV-related disease, the management of malnutrition the Tri-Assessment Emergency Treatment (ETAT) performed at district hospitals aimed at reducing infant and child mortality, immunization programs on polio, measles, and vitamin a supplementation, use of insecticide treated bed nets intermittent preventive malaria treatment, and adequate treatment of malaria, malaria home-based treatment, pneumonia, and diarrhoea episodes. Despite these interventions, the level of mortality of children under-five years is still high for goal 4 of the MDGs to be achieved. The health inequalities remain in urban and rural areas, and amongst socioeconomic strata. The aim of this paper is to determine the factors associated with under mortality and their evolution from 1993 to 2010 in Burkina Faso and to analyse the contributors of socioeconomic inequalities in children under-five years old mortality during the same period.

The recent studies on child health in developing countries have highlighted several factors that explain the mortality of children under-five years. These factors include poverty (Akoto &

Tambashe, 2002; Fotso & Kuate-Defo, 2005; Gwatkin, 2002; T. A. J. Houweling & Kunst, 2010; A. Wagstaff, 2002), the living conditions of households [8,13], and contextual factors and those related to the environment (S. A. Adedini, Odimegwu, Bamiwuye, Fadeyibi, & De Wet, 2014; Boco, 2011), characteristics of parents especially those of the mother and child's characteristics are also major factors that may expose children to a risk of mortality. The Mother' education level is one of the major contributors to mortality and inequalities in mortality among children of under-five years (Caldwell, 1979; Majumder, May, & Pant, 1997; Sathiya Susuman & Hamisi, 2012; Vallières et al., 2013). Children of low-educated mothers have a much higher chance of dying in childhood than those of richer and more educated mothers (T. a J. Houweling, Kunst, Moser, & Mackenbach, 2006).

In Burkina, studies showed that being a twin is the strongest risk factors for mortality (Becher et al., 2004). Becher et al., (2004) also showed that the age of the mother, birth spacing, and season of birth, village, ethnic group, and distance to the nearest health centre were strongly related to child mortality in Burkina Faso. Diarrheal diseases and diseases related to poor sanitation (Becher et al., 2004; Borghi, Guinness, Ouedraogo, & Curtis, 2002), respiratory diseases, malaria, measles, and malnutrition [22, 4, 7, 23, 24] are leading causes of child mortality in Burkina Faso.

5.2 Methods

5.2.1 Data

We used data from the rounds of Demographic and Health Surveys (DHS) done in Burkina Faso between 1993 and 2010. Four DHS have been conducted in 1993,1998-99, 2003 and 2010. Demographic and Health Surveys are cross-sectional household surveys, performed at regular intervals every five years in many countries. They are nationally representative and are based on large samples of households drawn in two stages based on administrative units, proportionally to the population of the sampling unit. These surveys constitute valuable resources for monitoring socioeconomic and health indicators and are useful in measuring socioeconomic inequalities and health inequity.

In 1993, a nationally representative sample of 5143 households and 6354 women aged 15-49 years were selected for the survey (Institut National de la Statistique et de la Démographie (INSD) and ORC Macro, 1993). For the 1998 DHS, 4812 households and 6445 women aged 15-49 years were selected for the survey (Institut National de la Statistique et de la Démographie (INSD) et ORC Macro, 1993) and for 2003 DHS, a sample of 9097 households and 12477 women was selected (Institut National de la Statistique et de la Démographie (INSD) et ORC Macro, 2004). In 2010, 14424 households and 17087 women were interviewed (Institut National de la Statistique et de la Démographie (INSD) et ICF International, 2012). Data on children under-five years analysed in this study are drawn from the information on birth histories collected from all the women aged 15-49 years from the 4 DHS mentioned above.

5.2.2 Variables of the study

The outcome variable of interest in our study is the child's survival (dead or alive) with is the probability of a child dying before their fifth birthday.

The predictor variables used in this study were as follows:

Socioeconomic status (wealth index) built using household assets. The wealth index was available in DHS dataset used. This variable was classified into three categories (poor, Middle and rich).

Mather's age at birth: this variable was created by subtracting the mother's age at the moment of the survey and the child's age at the moment of the survey.

The predictor variables related to the child were included sex, birth order, multiple births (twin or single).

Selected predictor variables related to mother and father used in this study included mother's age at birth, parity (number of children ever born to each woman), ethnicity, religion, marital status, mother education, mother's occupation, father's education and father's occupation).

Place of residence (urban or rural), household size and sex of the household head are also included in this study.

5.2.3 Statistical analysis

Concentration measurement, logistics regression and Oaxaca-Blinder decomposition method were used to analyse data in this study.

First, we analysed the inequality of under-five mortality using the concentration index (CI)(a Wagstaff, Paci, & van Doorslaer, 1991) using the wealth index as a ranking variable from the poorest to the richest household. The concentration index ranges between -1 and 1, and if it is positive then good health is concentrated among the higher income groups and vice versa. Among the methods used to assess health inequalities, CI is the most widely used and it has been used to assess inequalities related to many health outcomes (Jadidi, Mohammadbeigi, Mohammadsalehi, Ansari, & Ghaderi, 2015; Liu, Gao, & Yan, 2014; Tao, Henry, Zou, & Zhong, 2014; Xu et al., 2015).

Second, we used multivariate logistic regression analyses to calculate the adjusted odds ratio with 95% confidence interval for the association between under-five mortality and predictor variables. To examine how the socioeconomic factor (wealth index) influences child mortality, 3 different models were considered. The first model examines the effect of wealth index and child characteristics (predictor variables related to the child) on their mortality. In the second model, we considered variables in the first model and add those related to parent's characteristic. While Model 3 is the final model and which considers all the selected predictor variables in our analysis. All the analysis was conducted using the sample weight design and were done using Stata software.

Third, we used the extension application of Blinder decomposition technique to logit models (Fairlie, 2005; Jann, 2008) for the binary outcome to assess socioeconomic inequalities between poor and rich.

The Blinder-Oaxaca decomposition technique is widely used and it is especially useful for identifying and quantifying the separate contributions of group differences in measurable characteristics(Fairlie, 2005). In this current study, it is used to identify and quantify the mortality gap between rich and poor in Burkina Faso. Details of the method can be found elsewhere (Author, Source, Journal, Resources, & Url, 1973; Fairlie, 2005; Jann, 2008; Review, 1973). For this purpose, the wealth index was recorded as follows (poor and middle=1 and rich=0).

5.2.4 Ethical Considerations

This study used secondary data from the four Demographic and Health Survey of Burkina Faso. Prior using these data, an agreement was obtained from Macro International, which has allowed us to download the data on their Website.

5.3 Results

The concentration curves by year are shown in figure 5.1. The results show that the concentration indices are negative for the 4 DHS meaning that deaths are concentrated among children from poor households. The results show that the CI has increased in absolute terms between 1993 and 2010 from -0.03 to -0.11 (1993 DHS (CI = -0023, standard error (se) = 0.0417) in 1998 DHS (CI = 0.0447, se = 0.0448) in 2003 DHS (CI = -0.0688, se = 0.0236) and 2010 DHS (CI = -0.1149, se = 0.0402)). This result shows that inequalities between the rich and the poor in under-five mortality has increased between 1993 and 2010.

Figure 5.1: Concentration curves of socio-economic inequalities in under-five mortality in Burkina Faso

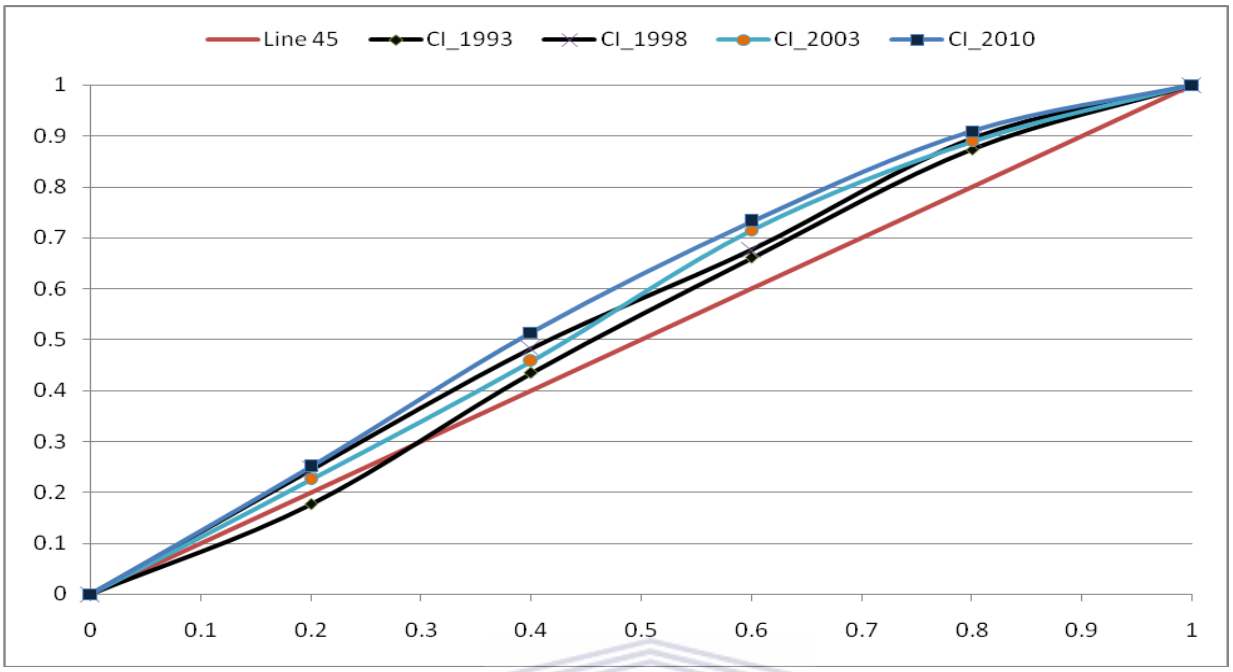

Table 5.1 presents the results of the bivariate analysis of child survival and the independent variables for each of the four DHS conducted in Burkina Faso. The wealth index, multiple birth (single vs twin), mother's age at birth, father's occupation, place of residence and household size were significantly associated with the survival of the child for each of the 4 DHSs. The ethnicity is only significantly associated with child mortality for 2003 and 2010 and religion is significantly associated for 1998, 2003 and 2010. With regard to women's parity, the results show that this variable is associated with under-five mortality in 2003 and 2010 and the percentage of mortality is higher amongst children of mothers with higher parity. The marital status of the mother is not significantly associated with child mortality. The mother's occupation is also associated with under-five mortality for three of the four DHS and mortality is higher amongst children of mothers who are farmers or doing manual work.

Table 5.1: Proportions of death by determinants in Burkina Faso,1993-2010

Variables	1993		1998		2003		2010	
	Death (%)	N (%)	Death (%)	N (%)	Death (%)	N (%)	Death (%)	N (%)
Wealth index	**		***		***		***	
Q1(Poorest)	327(12.9)	2530(100)	329(15.1)	2174(100)	486(14.5)	3358(100)	593 (11.0)	5392(100)
Q2 (Middle)	370(14.0)	2650(100)	370(16.5)	2238(100)	516(12.8)	4044(100)	482(9.4)	5128(100)
Q3(Wealthiest)	123(10.4)	1186(100)	233(12.9)	1805(100)	371(10.8)	3451(100)	298(6.1)	4856(100)
Child's gender	Ns		ns		ns		ns	
Boy	432(13.4)	3228(100)	489(15.4)	3171(100)	703(12.7)	5549(100)	732(9.4)	7800(100)
Girl	389(12.4)	3137(100)	443(14.5)	3047(100)	672(12.7)	5303(100)	642(8.5)	7575(100)
Birth order	***		***		ns		***	
1rst	193(16.5)	1171(100)	218(20.0)	1090(100)	276 (13.4)	2053(100)	258(9.1)	2847(100)
2-3	244(13.2)	1849(100)	243(13.2)	1838(100)	419(12.2)	3436(100)	403(8.0)	5056(100)
4-6	228(12.7)	2122(100)	278(13.7)	2032(100)	409(12.0)	3405(100)	455(8.8)	5142(100)
7 & +	156(12.4)	1224(100)	193(15.3)	1258(100)	270(13.8)	1958(100)	258(11.1)	2330(100)
Multiple birth	***		***		***		***	
Twin	79(35.1)	225(100)	55(30.9)	178(100)	85(26.8)	317(100)	173(28.9)	599(100)
Single	741(12.1)	6140(100)	877(14.5)	6040(100)	1289(12.2)	10534(100)	1200(8.1)	14776(100)
Mother's age at birth	***		***		**		**	
<20	210(17.3)	1212(100)	176(21.4)	823(100)	240 (15.3)	1567(100)	240(11.3)	2129(100)
20-34	492(11.6)	4241(100)	597(14.5)	4184(100)	887(12.2)	7296(100)	911(8.5)	10761(100)
35-49	118(12.9)	913(100)	159(13.1)	1211(100)	248(12.5)	1989(100)	223(9.0)	2485(100)
Parity	Ns		ns		***		***	
1-3	335(12.8)	2626(100)	368 (14.3)	2571(100)	543(11.1)	4897(100)	511(7.2)	7073(100)
4-6	276(12.1)	2283(100)	313(14.4)	2163(100)	494(13.3)	3707(100)	509(9.2)	5531(100)
7 &+	209(14.3)	1457(100)	250(16.8)	1484(100)	338(15.0)	2247(100)	353(12.7)	2771(100)
Ethnicity	Ns		ns		**		***	
Mossi	447(12.7)	3531(100)	521(14.6)	3566(100)	800(13.1)	6117(100)	591(7.7)	7677(100)
Bobo/Dioula/Senoufo	119(11.7)	1015(100)	64(14.1)	453(100)	145(12.0)	1213(100)	127(8.3)	1528(100)
Peul/Touareg/Bella	66(15.2)	435(100)	68(16.0)	424(100)	141(15.4)	916(100)	207(11.0)	1874(100)
Other Ethnicity	188(13.6)	1384(100)	279(15.7)	1775(100)	288(11.1)	2606(100)	448(10.4)	4297(100)
Religion	Ns		***		***		***	
Islam	479(13.4)	3578(100)	511(14.6)	3511(100)	922(13.6)	6797(100)	854(8.7)	9788(100)
Christian	207(12.1)	1714(100)	211(13.2)	1595(100)	262(10.0)	2621(100)	334(8.2)	4086(100)
Traditional/Other	134(12.5)	1074(100)	210(18.9)	1112(100)	190(13.2)	1434(100)	186(12.4)	1501(100)
Marital status	Ns		ns		ns		ns	
Married	801(12.9)	3608(100)	904 (14.6)	6076(100)	1334(12.7)	10501(100)	1334(8.9)	14956(100)
Not Married	20(12.7)	158(100)	28(19.7)	142(100)	40(11.4)	351(100)	39(9.3)	419(100)
Mother's education	Ns		ns		***		***	
Not Educated	742(13.1)	5653(100)	869 (15.2)	5704(100)	1256(13.1)	9574(100)	1239(9.5)	12974(100)
Educated	78(11.0)	712(100)	63 (12.3)	(100)514	118(9.2)	1278(100)	134(5.6)	2402(100)
Mother's Occupation	Ns		***		***		***	

Not working	305(12.3)	2474(100)	148(13.0)	1140(100)	82(10.1)	808(100)	289(10.2)	2821(100)
Sale	323(13.1)	2467(100)	259(14.0)	1854(100)	150(10.1)	1482(100)	204(6.8)	2979(100)
Agriculture	85(12.9)	661(100)	458(17.3)	2652(100)	1105(13.6)	8141(100)	735(9.0)	8144(100)
Manual	107(14.0)	764(100)	67(11.7)	572(100)	37(8.8)	420(100)	147(10.3)	1431(100)
Father's education	Ns		**		ns		***	
Not educated	695(13.1)	5332(100)	849 (15.3)	5553(100)	1202(12.9)	9289(100)	1187(9.5)	12485(100)
Primary	62(11.9)	522(100)	37 (11.7)	316(100)	78(11.0)	707(100)	124(7.2)	1726(100)
Secondary and higher	14(7.7)	181(100)	10 (7.8)	129(100)	43(9.2)	465(100)	44(4.7)	930(100)
Father Occupation	**		**		***		***	
Agriculture	661(13.3)	4968(100)	781(15.7)	4974(100)	1173(13.5)	8700(100)	1083(9.7)	11213(100)
Sales	65(14.1)	460(100)	55 (12.5)	440(100)	59(9.0)	658(100)	107(5.9)	1806(100)
Skilled	26(13.3)	195(100)	50 (12.3)	406(100)	17(9.4)	180(100)	114(9.5)	1199(100)
Other Occupation	68(9.2)	743(100)	46 (11.6)	398(100)	124(9.4)	1314(100)	69(6.0)	1157(100)
Residence	***		***		***		***	
Urban	86(9.5)	909(100)	58(9.5)	612(100)	125(9.0)	1386(100)	150(5.8)	2576(100)
Rural	734(13.5)	5457(100)	874 (15.6)	5605(100)	1249(13.2)	9466(100)	1223(9.6)	12799(100)
Household size	***		***		***		***	
01-Mar	91(22.4)	407(100)	106(25.4)	417(100)	202(22.6)	895(100)	222 (15.4)	1442(100)
04-Jun	209(12.6)	1654(100)	256 (15.5)	1648(100)	404(13.4)	3022(100)	455(8.0)	5671(100)
7 &+	521(12.1)	4304(100)	570 (13.7)	4153(100)	769(11.1)	6935(100)	697(8.4)	8263(100)
Sex of the household head	Ns		ns		ns		ns	
Male	798 (123.0)	6146(100)	903(15.1)	5983(100)	1319(12.8)	(100)10332	1299(9.0)	14405(100)
Female	22(10.0)	220(100)	29(12.4)	234(100)	55(10.6)	520(100)	75(7.7)	971(100)

Results from the multivariate analysis are presented in Table 5.3 and figure 5.2 and figure 5.3. Figure 5.1 (Model 1) presents the results of the effects of wealth index and child's characteristics on the probability of dying before their fifth birthday. The results show that the wealth index was significantly associated with the probability of under-five mortality for the 4 DHS. Children from poor households (OR = 1.3 for 1993, 1.2 for 1998, 1.4 for 2003 and 1.9 for 2010) and those of households of the second group of wealth index (OR = 1.4 for 1993 and 1998, 1.2 for 2003 and 1.6 for 2010) were more likely to die before their 5th birthday than rich households. Being the first born child (OR = 1.8 for 1993, 1.7 for 1998, 1.2 for 2003 and 1.3 for 2010) or being twins (OR=4.5 for 1993, 2.8 for 1998, 2.7 for 2003 and 4.8 for 2010) were also significantly associated with the probability of dying before the age of 5 years.

As the results of Model 2 (Figure 5.3) show that the wealth index lost its effect in the 4 DHS after controlling the effect of the mother's characteristics. However, it was noted that the mother's age at birth and parity were significantly associated with child mortality. Birth order and being twins

remained significantly associated with the probability of dying before the 5th birthday. The results of the model 3 (final model) examining the influence of all the predictor variables on the probability of dying before the 5th birthday were presented in Table 5.2. From these results, the probability of dying before 5 years depend on many factors, including birth order, birth interval, twin birth, mother's age at birth, parity, household size and sex of the household head. The results of the regression show that there is a slight variation of the determinants of under-five mortality by the DHS conducted in Burkina Faso in 1993, 1998, 2003 and 2010 respectively.

Parity appears as one of the major determinants of mortality of children under five. According to the four DHS, children from mothers with high parity are more likely to die before their fifth birthday. For 1993 and 1998, results show that a child born from a mother with seven and more children is 6.8 and 6.9 times more likely to die than a child born to a mother with 1-3 children. For 2003 and 2010 this risk for children born to mothers with a high number of children ever born of seven children and increased by a point (7.6 in 2003 and 7.7 in 2010) compared to 1993 and 1998. The risk of dying before the fifth birthday is also associated with the birth's order of the child. From the DHSs, it appears that the risk for the first child to die before his first birthday is likely higher than that for the second child. Being a twin also appears to be significantly associated with the risk of dying before the fifth birthday in Burkina Faso. The results of the multivariate logistic models show that the wealth index is a determining factor in the mortality of children under five in Burkina Faso but its effect diminishes and even fades after controlling for the effect of other covariates. But Its effect remains significantly associated with the probability of dying before the age of 5 years for the 2010 DHS.

Figure 5.2: Adjusted Odds Ratio (Model 1) of determinants of children under-five years old mortality

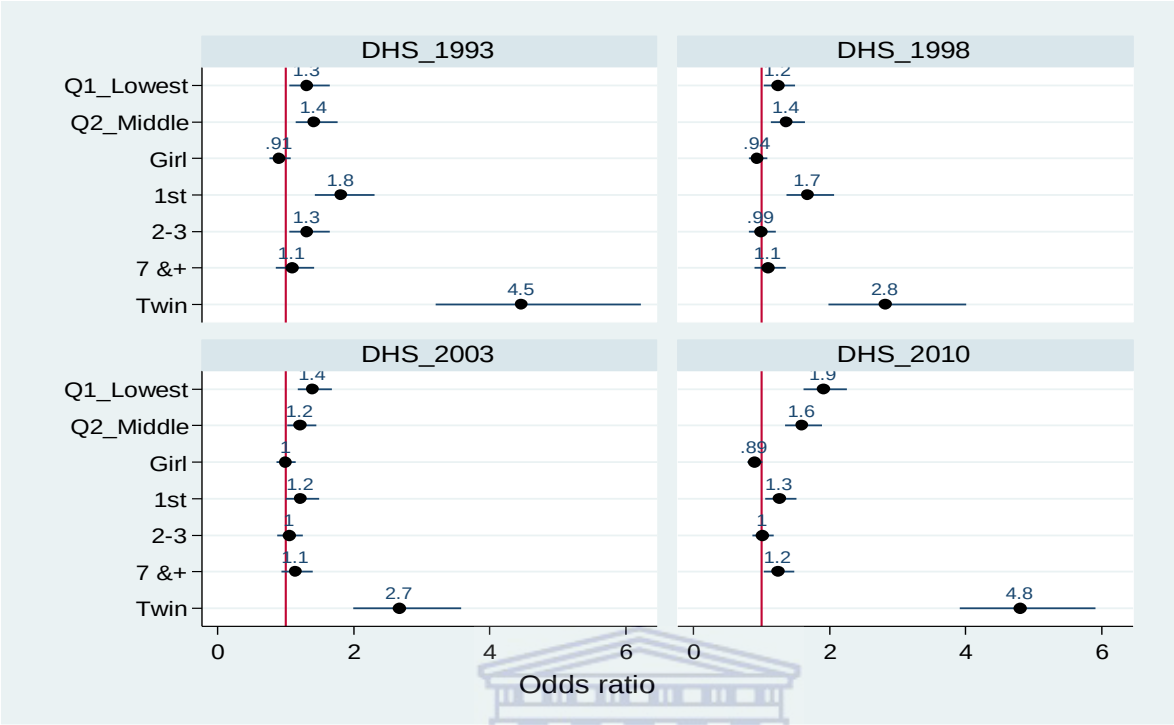

Table 5.2: Adjusted Odds Ratio (Model 3) of determinants of children under-five years old mortality in Burkina Faso, 1993-2010

Variables	1993		1998		2003		2010	
	Adj.OR	95% IC	Adj.OR	95% IC	Adj.OR	95% IC	Adj.OR	95% IC
Wealth index (Rich)								
Poor	1.03	[0.73; 1.44]	0.93	[0.74; 1.16]	1.03	[0.83; 1.27]	1.36**	[1.12; 1.66]
Middle	1.11	[0.81; 1.53]	1.09	[0.88; 1.34]	0.98	[0.80; 1.20]	1.27*	[1.05; 1.54]
Child's gender (Boy)								
Girl	0.89	[0.75; 1.06]	0.93	[0.8; 1.08]	1.01	[0.88; 1.16]	0.88*	[0.77; 0.99]
Birth order (4-6)								
1rst	4.29***	[2.70; 6.81]	3.81***	[2.5; 5.8]	2.67***	[1.82; 3.94]	2.25***	[1.58; 3.22]
2-3	3.06***	[2.21; 4.23]	2.27***	[1.69; 3.05]	2.51***	[1.92; 3.27]	2.37***	[1.87; 3.0]
7 & +	0.5**	[0.31; 0.76]	0.63*	[0.44; 92]	0.58**	[0.39; 0.87]	0.57***	[0.41; 0.78]
Twin birth (Single)								
Twin	3.98***	[2.82; 5.59]	2.48***	[1.72; 3.57]	2.43***	[1.78; 3.32]	4.47***	[3.62; 5.51]
Mother age (20-4)								
<20	1.47**	[1.11; 1.94]	1.48**	[1.12; 1.94]	1.38*	[1.07; 1.80]	1.49***	[1.18; 1.87]
35-49	1.07	[0.77; 1.47]	0.72*	[0.56; 0.93]	0.88	[0.69; 1.12]	0.8*	[0.65; 0.99]
Parity (1-3)								
4-6	3.17***	[2.27; 4.42]	3.26***	[2.39; 4.46]	3.43***	[2.62; 4.51]	3.28***	[2.57;4.19]
7 &+	8.28***	[4.84; 14.18]	7.98***	[4.98; 12.8]	8.70***	[5.47; 13,84]	9.47***	[6.47; 13,85]
Ethnicity(mossi)								
Bobo/Dioula/Senoufo	0.86	[0.66; 1.11]	0.85	[0.63;1.16]	0.89	[0.71; 1.12]	1.11	[0.87; 1.4]
Peul/Touareg/Bella	1.14	[0.81; 1.60]	1.04	[0.76; 1.41]	1.01	[0.78; 1.30]	1.05	[0.85; 1.29]
Other Ethnicity	1.08	[0.86; 1.35]	1.05	[0.88; 1.25]	0.78**	[0.65; 0.94]	1.22*	[1.04; 1.42]
Religion (Islam)								
Christian	0.93	[0.75; 1.16]	0.92	[0.75; 1.12]	0.73**	[0.61; 0,89]	0.95	[0.80; 1.12]
Traditional/Other	0.95	[0.73; 1.24]	1.34**	[1.09; 1.65]	1	[0.81; 1.24]	1.23	[0.99; 1.53]
Marital status (married)								
Not Married	1.11	[0.61; 2.03]	1.82*	[1.11; 2.98]	1.39	[0.87; 2.25]	1.64*	[1,06; 2.54]
Mother's education (not educated)								
Educated	1	[0.74; 1.36]	0.98	[0.71; 1.36]	1.14	[0.86; 1.50]	1.31*	[1.03; 1.67]
Mother's occupation (not Working)								
Sale	1.09	[0.89; 1.33]	1.19	[0.95; 1.51]	1.19	[0.81; 1.74]	0.76**	[0.61; 0.94]
Agriculture	1.06	[0.77; 1.44]	1.41**	[1.13; 1.176]	1.32	[0.93; 1.88]	0.78**	[0.66; 0.94]
Manual	1.23	[0.93; 1.62]	1.02	[0.73; 1.43]	1.04	[0.64; 1.72]	0.99	[0.78; 1.27]
Father's education (Not educated)								
Primary	0.88	[0.64; 1.21]	0.84	[0.60; 1.23]	1.05	[0.78;1.43]	0.91	[0.72; 1.15]
Secondary and higher	0.81	[0.45; 1.46]	0.79	[0.41; 1.52]	1.18	[0.71; 1.94]	0.74	[0.48; 1.13]
Father's occupation (agriculture)								
Sales	1.21	[0.86; 1.70]	0.87	[0.63; 1.22]	0.69*	[0.49; 0.97]	0.78	[0.61; 1.01]
Skilled	1.24	[0.78; 1.98]	0.95	[0.68; 1.34]	0.74	[0.39; 1.41]	1.17	[0.92; 1.5]
Other Occupation	0.81	[0.59; 1.12]	1.02	[0.71; 1.48]	0.76	[0.55; 1.04]	0.91	[0.64;1.30]
Residence (Rural)								
Urban	0.78	[0.57; 1.08]	0.68	[0.49; 0.94]	0.94	[0.68; 1.28]	0.93	[0.74; 1.17]

Household size (4-6)								
1-3	1.89***	[1.35;2.63]	1.7***	[1.27; 2.29]	2.28***	[1.76; 2.96]	2.78***	[2.17; 3.56]
7 &+	0.92	[0.74; 1.14]	0.73**	[0.60; 0.87]	0.68***	[0.57; 0.81]	0.84*	[071; 0.98]
Sex HH head (Male)								
Female	0.58*	[0.34; 0.97]	0.73	[0.47; 1.13]	0.61**	[0.42; 0.89]	0.64**	[0.48; 0.86]

Figure 5.3: Adjusted Odds Ratio (Model 2) of determinants of children under-five years old mortality in Burkina Faso, 1993-2010

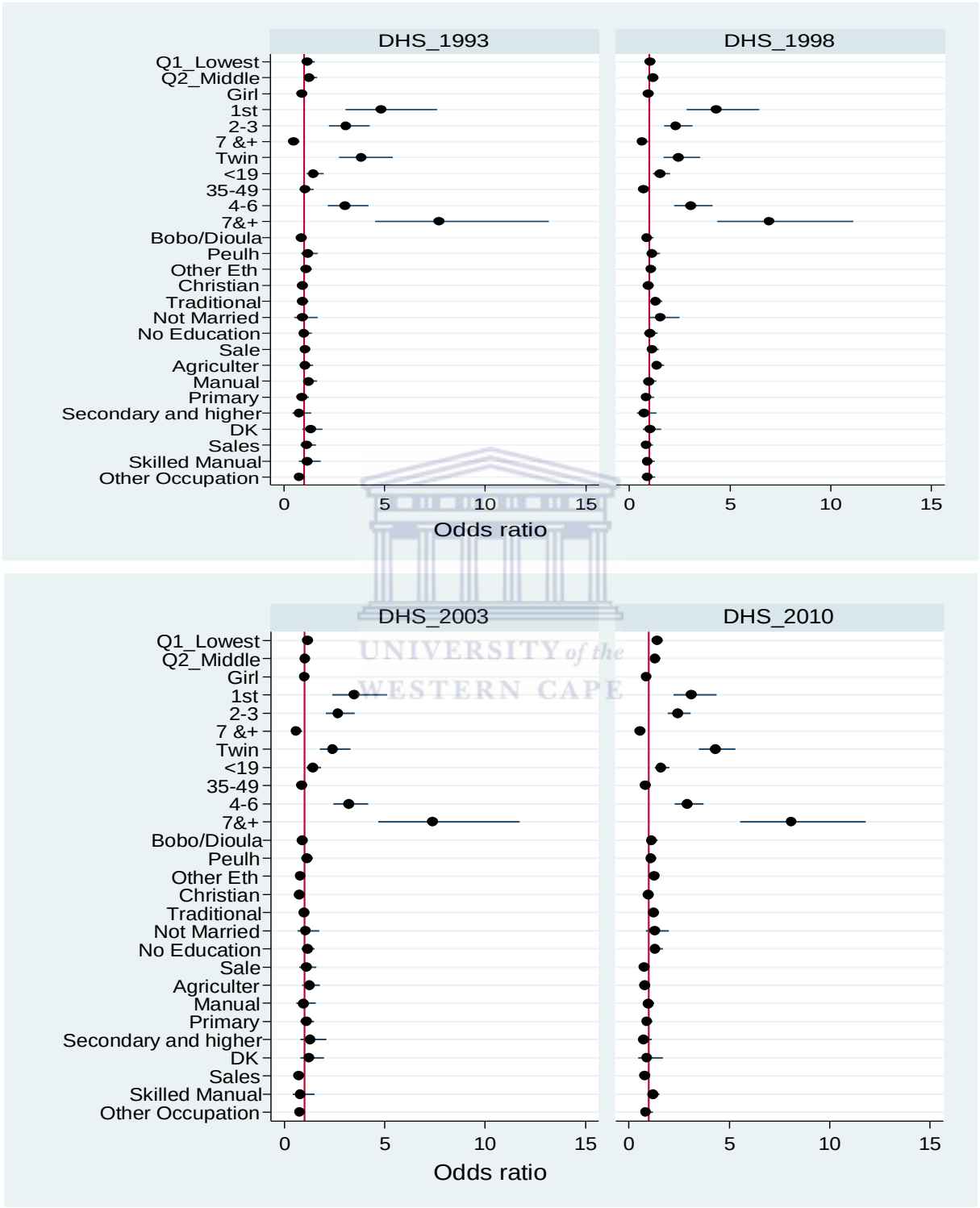

Figure 5.4 presents the proportions of the death of under-five years' children by wealth index (poor vs rich). The differences in the proportions of death between the two groups were de 3.1%, 2.9%, 2.8% and 3.7% respectively for 1992 DHS, 1998 DHS, 2003 DHS and 2010 DHS in favour of children from rich households. The results of the decomposition analysis of the Gap in Under-five mortality between the poor and rich groups are presented in table 5.4. The results show that 36.3% (1992 DHS), 85.9% (1998 DHS), 101.1 % (2003 DHS) and 40.6% (2010 DHS) of the inequality between children from poor and rich households were attributed to the differences in groups characteristics while 63.7% (1992 DHS), 14.1% (1998 DHS), -1.1% (2003 DHS) and 59.4% (2010 DHS) were attributed to Inequality due to differences in group processes. The proportion of the gaps in under-five years due to characteristics of individuals were higher in DHS 1998 and 2003 DHS compared to the percentage fund in 1992 DHS and 2010 DHS. For every four DHS parity was the main contributor to the part of the inequality due to differences in group characteristics and that would be due to the fact that women from poor households have greater parity compared to those from rich households while the multivariate results presented in Table 5.2 show that high parity is associated with a greater likelihood of death of children under five.

Figure 5.4: Proportion (%) of under-five deaths by wealth index (poor vs rich)

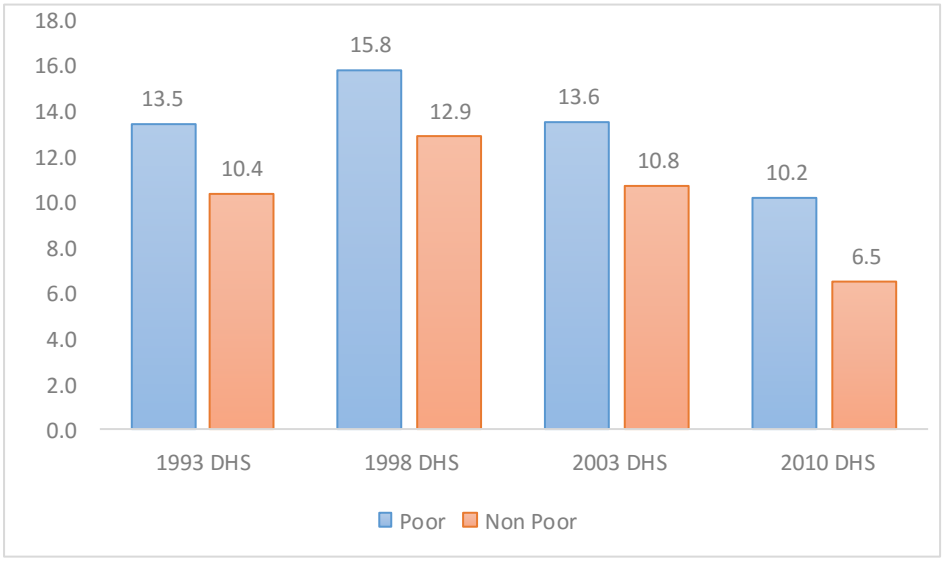

Table 5.3: Non-linear decomposition of the Gap in Under-five mortality between the poor and rich groups in Burkina Faso

Contributors	1992-93				1998-99			
	Contributions of group characteristics to poor/rich inequality	95% CI		% Contribution of group differences to gender inequality	Contributions of group characteristics to poor/rich inequality	95% CI		% Contribution of group differences to gender inequality
Child's gender (boy)								
Girl	-0.0001	-0.0011	0.0009	-0.29	0.0003	-0.0004	0.0011	0.98
Birth order (4-6)								
1rst	0.0001	-0.0011	0.0014	0.39	0.0023	-0.0001	0.0047	6.93
2-3	-0.0038	-0.0082	0.0007	-10.38	-0.0078	-0.0136	-0.0021	-23.77
7 & +	-0.0084	-0.0184	0.0015	-23.28	-0.0128	-0.0215	-0.0042	-38.91
Twin birth (Single)								
twin	0.0015	-0.0002	0.0032	4.16	0.0008	-0.0004	0.0021	2.58
Mother's age (20-24)								
mother_agegr_bth2	0.0011	-0.0005	0.0026	2.99	0.0018	-0.0008	0.0045	5.49
mother_agegr_bth3	-0.0004	-0.0038	0.003	-1.04	-0.0029	-0.0073	0.0015	-8.83
Parity (1-3)								
4-6	0.002	-0.0015	0.0056	5.66	0.0064	0.0017	0.0111	19.37
7 &+	0.0127	0.0003	0.025	35.03	0.0134	0.0049	0.022	40.74
Ethnicity(mossi)								
Bobo/Dioula/Senoufo	0.0011	-0.0016	0.0039	3.08	0.0002	-0.001	0.0014	0.65
Peul/Touareg/Bella	0.0014	-0.0015	0.0043	3.88	0.0007	-0.002	0.0034	2.08
Other Ethnicity	0.0021	-0.0014	0.0055	5.74	0.0013	-0.0006	0.0033	4.09
Religion (Islam)								
Christian	0	-0.0021	0.0022	0.13	-0.0005	-0.0017	0.0007	-1.49
Traditional/Other	-0.0013	-0.0191	0.0165	-3.53	0.0069	-0.0036	0.0174	20.85
Marital status (married)								
Not Married	-0.0009	-0.0026	0.0008	-2.46	-0.0015	-0.0038	0.0009	-4.45
Mother's education (no)								
Educated	-0.0051	-0.016	0.0059	-13.99	0.0033	-0.0061	0.0127	9.91
Mother's occupation not Working)								
Sale	-0.001	-0.0037	0.0017	-2.8	-0.0026	-0.0075	0.0024	-7.87
Agriculture	0.0058	-0.0016	0.0133	16.17	0.0073	-0.003	0.0176	22.18
Manual	0.0006	-0.0012	0.0024	1.61	0.0001	-0.0011	0.0013	0.32
Father's education level (No ed)								

Primary	0.0007	-0.0038	0.0053	2.07	0.0017	-0.0024	0.0058	5.14
Secondary and higher	0.0014	-0.0066	0.0094	3.91	0.003	-0.0041	0.01	9
Father's occupation (agriculture)								
Sales	0	-0.0069	0.0069	-0.06	0.0054	-0.0005	0.0114	16.53
Skilled	-0.0017	-0.0061	0.0026	-4.79	0.0005	-0.004	0.005	1.44
Other Occupation	0.0094	-0.0048	0.0235	25.93	0.0009	-0.00867	0.0105	2.74
D1	0.0132			36.6	0.0283			85.9
D2	0.0229			63.4	0.0046			14.1
Total inequality	0.0361			100	0.0329			100

D1 = Contribution to that part of inequality due to differences in group characteristics
D2= Contribution to that part of inequality due to differences in group processes

Table 5.3: Non-linear decomposition of the Gap in Under-five mortality between the poor and rich groups in Burkina Faso (Count.)

Contributors	2003				2010			
	Contributions of group characteristics to poor/rich inequality	95% CI		% Contribution of group differences to gender inequality	Contributions of group characteristics to poor/rich inequality	95% CI		% Contribution of group differences to gender inequality
Child's gender (boy)								
Girl	0.0000	-0.0002	0.0003	0.20	-0.0003	-0.0008	0.0002	-0.83
Birth order (4-6)								
1rst	0.0001	-0.0008	0.0010	0.53	-0.0004	-0.0026	0.0017	-1.14
2-3	-0.0043	-0.0075	-0.0011	-17.71	-0.0039	-0.0071	-0.0008	-10.39
7 & +	-0.0122	-0.0183	-0.0062	-50.55	-0.0121	-0.0187	-0.0054	-31.84
Twin birth (Single)								
twin	0.0009	0	0.0017	3.68	0.0001	-0.0004	0.0006	0.23
Mother's age (20-24)								
mother_agegr_bth2	0.0005	-0.0005	0.0016	2.15	0.0015	0.0002	0.0029	4.01
mother_agegr_bth3	-0.0019	-0.0042	0.0004	-7.78	-0.0015	-0.0034	0.0004	-3.85
Parity (1-3)								
4-6	0.0041	0.0014	0.0069	17.06	0.0039	0.0015	0.0062	10.17
7 &+	0.0145	0.0083	0.0207	59.75	0.0172	0.0103	0.0242	45.5
Ethnicity(mossi)								
Bobo/Dioula/Senoufo	0.0019	-0.0017	0.0054	7.69	-0.0005	-0.0018	0.0008	-1.43
Peul/Touareg/Bella	0.0017	0.0000	0.0033	6.92	-0.0008	-0.0047	0.0031	-2.09
Other Ethnicity	-0.0034	-0.0085	0.0016	-14.23	0.0005	-0.0005	0.0014	1.26
Religion (Islam)								
Christian	0.000	-0.0001	0.0001	-0.03	0.0000	-0.0002	0.0001	-0.08
Traditional/Other	0.0077	-0.0008	0.0162	31.74	0.0042	0.0001	0.0084	11.21
Marital status (married)								
Not Married	-0.0014	-0.0035	0.0006	-5.85	-0.0004	-0.0016	0.0007	-1.17
Mother's education (no)								
Educated	0.0032	-0.0038	0.0103	13.38	0.0035	-0.002	0.0089	9.19
Mother's occupation not Working)								
Sale	0.0019	-0.0054	0.0092	7.88	-0.001	-0.0054	0.0034	-2.59
Agriculture	0.0084	-0.0064	0.0233	34.79	0.0011	-0.0057	0.0079	2.89
Manual	-0.0019	-0.0046	0.0007	-7.96	-0.0005	-0.0014	0.0004	-1.26
Father's educ (No ed)								
Primary	-0.0011	-0.0039	0.0017	-4.48	0.0009	-0.0017	0.0035	2.33
Secondary and higher	-0.0014	-0.0065	0.0038	-5.64	0.0013	-0.0033	0.0059	3.49
Father's occupation (agriculture)								
Sales	0.0009	-0.0037	0.0054	3.52	0.0016	-0.0025	0.0057	4.35

Skilled	0.0000	-0.0014	0.0015	0.17	-0.0004	-0.0025	0.0016	-1.1
Other Occupation	0.0057	-0.00359	0.0149	23.4	0.0017	-0.0030	0.00648	4.55
D1	0.0245			101.1	0.0154			40.6
D2	-0.0003			-1.1	0.0225			59.4
Total inequality	0.02422			100	0.037886			100

D1 = Contribution to that part of inequality due to differences in group characteristics
D2= Contribution to that part of inequality due to differences in group processes

5.4 Discussion

In this article, we determined the factors associated with under-five mortality in Burkina Faso and their evolution from 1993 to 2010. We found that there has not been a large variation in the determinants of mortality for children under five years during the last two decades.

The results of our study showed that there is socioeconomic inequality in under-five mortality and the children from disadvantaged households were those who contributed more to the level of mortality. As unexpected, our findings showed that the inequalities between children from rich and poor households have increased from -0.0023 (1993) to 0.0402 (2010). During the same period, there was a reduction in the death rate of 60 points, from 187 deaths per 1000 (Institut National de la Statistique et de la Démographie (INSD) and ORC Macro, 1993) in 1993 to 129 deaths per 1000 in 2010 (Institut National de la Statistique et de la Démographie (INSD) et ICF International, 2012).

We would attempt to assume that the national reduction in mortality was due to the high reduction in mortality in the wealthy households than the poor households. Studies on socioeconomic inequalities in child mortality in developing countries found that the difference between infant mortality rates was in favour of the high socioeconomic group (Gwatkin, 2002; T. A. J. Houweling & Kunst, 2010; Imard et al., 2010; Kuate-Defo, 1996; Kumar & Singh, 2013). Our results showed that deaths were more concentrated among children from poor households but the results of multivariate analyses revealed that its effect dropped when variable related to mother 'characteristics were introduced into the model. Therefore, mother's characteristics such the number of children ever born (S. A. Adedini et al., 2012; S. Adedini, Odimegwu, Imasiku, & Ononokpono, 2014; Barbieri, 1991; Boco, 2011), mother's age a birth (Akinyemi, Bamgboye, & Ayeni, 2013), her educational level (Caldwell, 1979; Sathiya Susuman & Hamisi, 2012) are strong predictors of under-five mortality.

Our findings showed that the predictor variables of under-five mortality were the birth order, multiple births (twin or single), the woman's parity, mother's age at birth, household size and sex of the household head. Similar results have been found in the preceding studies conducted in Burkina Faso. Becher et al. [7] found that the twins were more likely to die than children from a singleton birth. They also showed that the time between the birth of the child and the birth of the

next younger sibling or older was associated with mortality. The results of our study showed that the mother's characteristics such as her parity, age at birth, educational level are determinants of mortality in children under-five years in Burkina Faso during the last two decades. These variables have played an important role in the probability of death for children under-five years in Burkina Faso. The results also show that the probability of dying before the fifth birthday is higher among children from mothers aged under 20 years than children from mothers aged 25-34. Another research conducted in sub-Saharan has found that mother's age is strongly associated with child survival and children from youngest mothers are more likely to die to compare to those from mothers aged 25-34 years (Kabubo-Mariara, 2010; Selemani et al., 2014). In Burkina Faso where age at marriage and age at first childbearing are early, it is necessary that measures be taken to increase these age and thus reduce child mortality.

5.5 Conclusion

In conclusion, there are considerable socioeconomic inequalities regarding under-five mortality in Burkina Faso. According to our findings, inequality was greater in 2010 compared to other years and children from poor households contribute more in terms of mortality in Burkina Faso. The present study also showed that a child's characteristics (twin, birth order) and mother's characteristics (parity, the age of mother at delivery, education the mother) were also predictors of under -five mortality in Burkina during the last two decades. Rural and poor women who do not have equal access to quality skilled care are the most affected. The gap in accessing skilled care is widest between urban and rural areas in Burkina Faso, and between rich and poor women. Most maternal and newborn deaths and illnesses can be prevented by access to quality skilled care during pregnancy, childbirth and postpartum/postnatal period. Timely access to emergency obstetric and newborn care. Access to family planning services to prevent unwanted pregnancy. To reduce the mortality and inequalities related to under-five mortality, specific actions should be taken to enhance access to health services for poor people and to promote family planning programs for births spacing among women.

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Chapter 6: Women's Education and Health Inequalities in Under-Five mortality in Selected Sub-Saharan African Countries, 1990 – 2015

Bado A., Sathiya Susuman A: "Women Education, Health Inequalities in Under-Five Mortality in sub-Saharan Africa, 1990 - 2015", (Accepted for publication) in Plos One. Manuscript Number: PONE-D-15-35776R1

Abstract

Background: The aim of the study was to analyse trends in the relationship between mother's educational level and mortality of children under the year of five in Sub-Saharan Africa, from 1990 to 2015.

Data and Methods: Data used in this study came from different waves of Demographic and Health Surveys (DHS) of Sub-Saharan countries. Logistic regression and Buis's decomposition method were used to explore the effect of mother's educational level on the mortality of children under five years.

Results: Although the results of our study in the selected countries show that under-five mortality rates of children born to mothers without formal education are higher than the mortality rates of children of educated mothers, it appears that differences in mortality were reduced over the past two decades. In selected countries for our study, we noticed a significant decline in mortality among children of non-educated mothers compared to the decrease in mortality rates among children of educated mothers during the period of 1990-2010. The results show that the decline in mortality of children under five years was much higher among the children born to mothers who have never received formal education—112 points drop in Malawi, over 80 in Zambia and Zimbabwe, 65 points in Burkina Faso, 56 in Congo, 43 in Namibia, 27 in Guinea, Cameroon, and 22 to 15 in Niger. However, we noted a variation in results among the countries selected for the study—in Burkina Faso (OR=0.7), in Cameroon (OR=0.8), in Guinea (OR=0.8) and Niger (OR=0.8). It is normally observed that children of mothers with 0-6 years of education are about 20% more likely to survive until their fifth year compared to children of mothers who have not been to school. Conversely, the results did not reveal significant differences between the under-five deaths of children born to non-educated mothers and children of low-level educated mothers in Congo, Malawi and Namibia.

Conclusion: The decline in under-five mortality rates, during last two decades, can be partly due to the government policies on women's education. It is evident that women's educational level has resulted in increased maternal awareness about infant health and hygiene, thereby bringing about a decline in the under-five mortality rates. This reduction is due to improved supply of health care programmes and health policies in reducing economic inequalities and increasing access to health care.

Keywords: Maternal education, Under-five mortality, Buis's decomposition, Sub-Saharan Africa, Demographic and Health Survey

6.1 Introduction

The mortality rate of children under the age of five years is a key indicator of a child's well-being, including health and nutrition status. It is also a key indicator of the extent of survival social and economic development interventions that must be implemented for the child's overall well-being (United Nations Children's Fund, 2014). Millennium Development Goal 4 (MDG 4) calls for reducing the under-five mortality rate by two-thirds between 1990 and 2015. During the last two decades, the Sub-Saharan African countries have witnessed a consistent decline in the under-five mortality (K. Hill, You, Inoue, & Oestergaard, 2012; Rutstein, 2000). The number of deaths among children under-five years of age has decreased annually, from 13 million in 1990 to 9 million in 2007. The global annual rate of reduction has been increasing notably, from 1.2% in 1990–1995 to 2.3% in 1995–2000 and 3.7% in 2000–2005 (United Nations Children's Fund, 2014) to 3.9 percent in period 2005–2012 .

Tremendous efforts have been made to improve the access to healthcare for children in developing countries, thereby leading to the decline in mortality rates. Efforts have been underway since the early 1980s to strengthen healthcare systems in the developing countries (A. G. Hill, MacLeod, Joof, Gomez, & Walraven, 2000; Smith Paintain et al., 2014). The increase in the supply of primary healthcare facilities and services to the local community through the contracting of community health workers (Amouzou et al., 2014; Nandi & Schneider, 2014; Smith Paintain et al., 2014) has improved the healthcare scenario for children in developing countries. Likewise, certain interventions have greatly contributed towards improving the health of children, thereby reducing infant mortality in countries with limited income. These interventions include malaria prevention through a large scale distribution of impregnated mosquito nets with long-lasting insecticide (Antonio-Nkondjio, Demanou, Etang, & Bouchite, 2013); indoor residual spraying; and programmes against diarrheal diseases, respiratory infections and malnutrition.

Several countries in Sub-Saharan Africa have implemented user fees reduction or user fees exemption to reduce the overall burden of direct payments for health services, and/or to benefits priority user groups that avail priority services(Witter, 2010). Pregnant women and children under-five years of age are often the beneficiaries of such fee reduction programmes, which are mainly implemented in countries like Senegal, Ghana, Mali, Niger, Benin, Burkina Faso, Burundi, Kenya, Madagascar, North Sudan, Nepal and Sierra Leone (Witter, 2010). These user fee policies have certainly contributed towards saving the lives of

children in many Sub-Saharan African countries. Studies in Niger (Amouzou, Habi, & Bensaïd, 2012) and in Burkina Faso (Ridde, Heinmüller, & Haddad, 2010) have shown that the exemption of fees has resulted in improved usage of healthcare services; reduced economic inequality and under-five mortality rates (Johri, Ridde, Heinmüller, Sossa, & Haddad, 2013); and improved access of poor families to basic amenities like health, nutrition, and educational services. Similarly, cash-transfer programmes in several Southern and East African countries also improved survival of children under five years, increased usage of preventive services, improved immunisation coverage, and encouraged healthy behaviours, thereby producing a good outcome (Adato & Bassett, 2009; Gilmour, Hamakawa, & Shibuya, 2013; Leroy, Ruel, & Verhofstadt, 2009; Miller, Tsoka, & Reichert, 2011; Robertson et al., 2013).

Despite these declines and progress, Sub-Saharan African countries are far from reaching the MDG 4. The Sub-Saharan African countries still record the highest under-five mortality rates (Bhutta et al., 2010) and over 4.4 million of these deaths are primarily caused due to infectious diseases, which can be avoided by practicing healthy habits (Bhutta et al., 2010). Accounting for only 15% of the world's population, the Sub-Saharan African countries have more than 41% of children younger than five years, and countries like Nigeria, DR Congo and Ethiopia are among the top 10 countries in the world that record maximum under-five deaths. Although under-five mortality rate and malnutrition are continuing to decline in most Sun-Saharan African countries large inequalities between poor and better-off children exist both between and within these countries(A Wagstaff, 2004). Evidence also shows alarming disparities in under-five mortality rates within countries. Additionally, the risks of under-five mortality increase for children born to uneducated mothers in remote areas or poor households. Survey data show that the under-five mortality rates for the poorest fifth of the population average around twice as high as the average rates for the richest fifth. These inequalities, which appear to be widening, call into question the strategies for child mortality reduction relied upon until date (A Wagstaff, 2004).

The variables that are used to measure health inequalities in developing countries include educational (PA Braveman, Cubbin, & Egerter, 2005; Paula Braveman, Egerter, & Williams, 2011) level of the mother, socioeconomic status (Adam Wagstaff & Doorslaer, 2000; Adam Wagstaff, 2002) and place of residence (urban vs. rural) (WHO Commission on Social Determinants of Health, 2008). While recent studies have focused on inequalities related to socioeconomic status, very few recent studies have examined inequalities in under-five

deaths and maternal education level. Most of these studies were conducted in the 1980s and early 1990s, during which several Sub-Saharan African countries witnessed the introduction of educational reforms that aimed at increasing the educational level of women and girls. The studies of Caldwell (J C Caldwell, 1979, 1994) and Hobcraft (John Hobcraft, 1993) revealed the significance of maternal education in determining of child health, spurring extensive studies in developing countries on the subject. These latter studies also confirmed maternal education to be a very strong and consistent predictor of reduced child morbidity and mortality. The existing literature highlights that female education has been a key to reducing infant and child mortality and fertility rate; increasing consumption of health services; and improving socioeconomic status (Ouedraogo, 1994). Additionally, maternal education increases a mother's awareness of good health care practices, children's illnesses, and availability of health services, and hence is considered as a factor that may positively affect a child's health. The authors (John Hobcraft, 1993; Ouedraogo, 1994) have argued that education could change attitudes and behaviours of women, thereby enabling them to attain greater autonomy and efficiency. The authors also emphasise on the fact that educated mothers have a greater ability to identify healthcare services for treating their child's illnesses; higher receptivity to new health-related information; familiarity with modern medical culture; access to financial resources and health insurance; better decision-making power; and increased self-worth and self-confidence.

Several empirical studies (Bicego & Boerma, 1993; J C Caldwell, 1979, 1994; Muhuri, 1995; Wang et al., 2013) have confirmed the positive effects of mother's education on a child's survival. However, the results of some studies are mixed. A few studies show a very low impact of education on child's health, while other studies have shown that there is no link between the educational level of mother and a child's health (Desai & Alva, 1998). This finding implies that although mother's educational level influences the health and survival of the child, the effect may vary from one country to another and from one context to another. In investigating the pathways of influence, research confirms that the causal linkages between maternal education and child's health are far from clear, and the relationship between these two factors is simply not a reflection of a co-occurrence of education with other socioeconomic variables (Aslam & Kingdon, 2012; Desai & Alva, 1998; John Hobcraft, 1993).

Using data from selected Sub-Saharan countries of several birth cohorts, this study aimed to analyse trends in the relationship between the mother's educational level and inequalities in

under-five mortality over the past two decades in Sub-Saharan African countries (1990 to 2015). This study also aimed to evaluate the effect of maternal educational level on the mortality rate of children under five years of age. The study hypothesises that inequalities in under-five mortality related to mother's educational level has declined over the last two decades in Sub-Saharan Africa, and the gap in the risks of under-five deaths between children born to *best* educated mothers and children born to *less* educated mothers is narrowing other time.

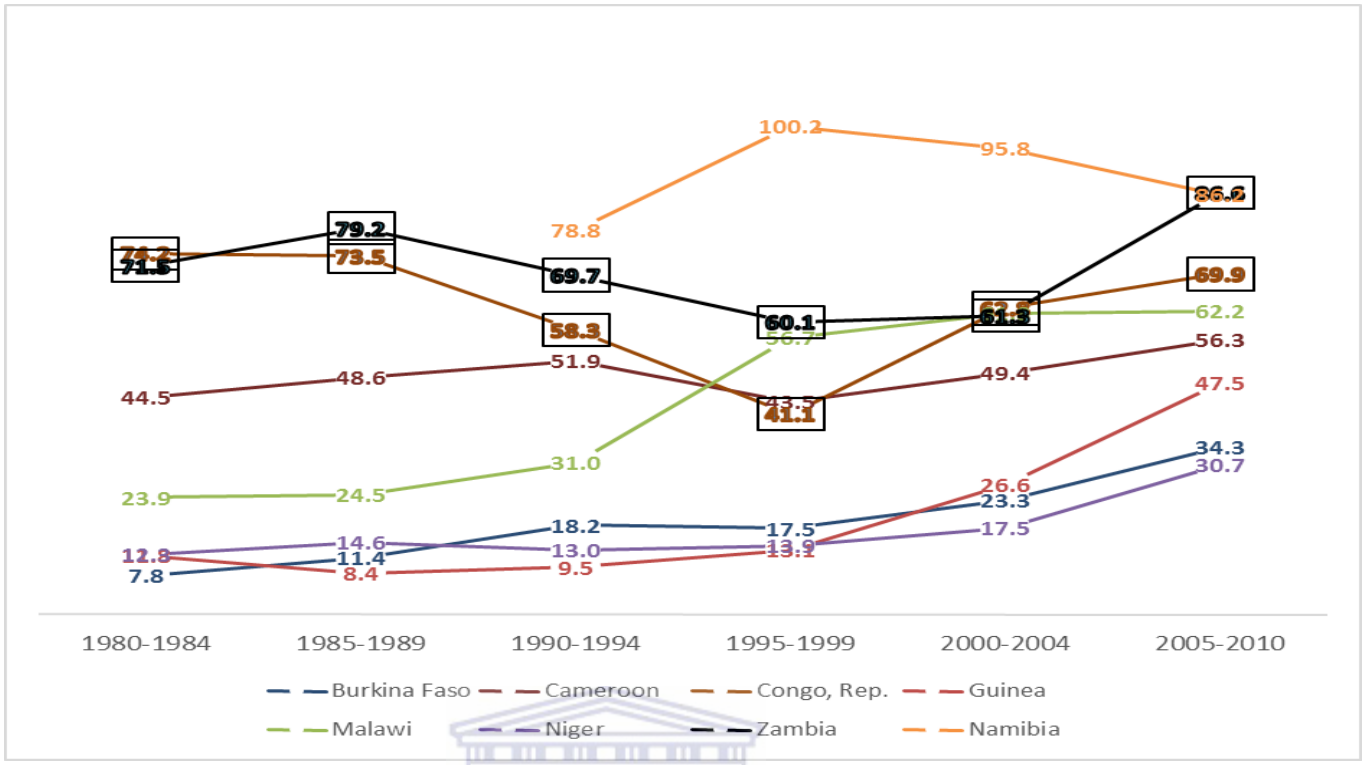
6.2 Methods

6.2.1 Data

Huge progress has been made over the last decades to improve the literacy status of adult women around the Sub-Saharan Africa (Undesa, 2010). While gender disparities in adult literacy rates remain wide in Sub-Saharan Africa due to many factors including culture and lack of infrastructures, evidences indicate that some progress has been made at regional and country levels to improve the literacy level of women (Undesa, 2010).

Figure 6.1 presents the trend of female primary education completion rates in the countries selected for this study. The results show that although the level of women's education has greatly improved during the period 1980-2010, there is a slower increase in the West African countries. The results show that the rate of increase in female education has been 30.7% in Niger, 34.3% in Burkina Faso and 47.5% in Guinea, for the period 2005-2010, compared to other countries that record an increase of above 56%.

Figure 6.1: Trend of female primary completion rate



Source: Data from World Bank (http://data.worldbank.org/)

Data used in this study come from different waves of DHS of Sub-Saharan countries (**Table 6.1**), including Burkina Faso, Niger, Guinea, Cameroon, Congo, Malawi, Zambia, and Namibia. The countries were selected according to a sub-regional basis selecting at least two countries from each sub-region of the Sub-Saharan Africa (Western Africa, Central Africa, Eastern and Southern Africa). The selected countries have already realised at least two DHS rounds in the period 1990-2015.

First, DHS waves of survey data of each selected country were pooled, and then data from all the countries were pooled for the purpose of analysis. DHS data were collected using a standardised questionnaire, which was used in all the countries and for different waves of DHS. This offers an advantage for data analysis and comparison of results across countries. This study used birth history data from DHS.

Table 6.1 Selected countries names and years 1990-2015

Sub-Saharan	Country	1990-1999	2000-2009	2010-2015
Western Africa	Burkina Faso	1993	2003	2010
	Niger	1992	2006	2011
	Guinea	1992	2003	2007
Central Africa	Cameroon	1991	2004	2011
	Congo	-	2005	2011
Eastern Africa	Malawi	1992	2000	2010
	Zambia	1996	2007	-
Southern Africa	Namibia	1992	2007	2013

Source: Demographic and Health Surveys (DHS) latest data sets

Table 6.2 given below presents the number of children under five years and the survival status of each birth cohort by country. The birth history (birth cohort) dataset contained information on the date of birth of all the children born to a woman during her lifetime, starting from the first child to the total number of children born at the time of the survey. Additionally, information on child's survival (dead or alive) was available in these datasets (Schoumaker, 2013). Birth histories were collected from a sample of women aged 15–49, at the time of the survey. The complete birth histories (including date of the birth and survival status of each child born to these women until the time of survey) of women aged 15 to 49 years old is considered to be useful data for computing child mortality indicators. DHS data are cross-sectional data, and therefore the survey data represents the entire population. In this context, the information collected during the study included demographic, socioeconomic, and maternal and child health data. The sample design of these surveys is a nationally representative sample and a stratified two-stage cluster design.

Table 6.2 Numbers of children under five years old and the survival status per birth-cohorts per country

Country	Generation	Alive	Dead	Total	$_5q_0$
Burkina Faso	1986-1989	1909	367	2276	161.2
	1990-1999	10355	1664	12019	138.4
	2000-2009	18497	2062	20559	100.3
	2010-2013	2162	90	2252	40.0
Niger	1986-1989	-	-	-	-
	1990-1999	4166	548	4714	116.2
	2000-2009	13832	1607	15439	104.1
	2010-2013	5748	327	6075	53.8
Guinea	1986-1989	-	-	-	-
	1990-1999	4960	790	5750	137.4
	2000-2009	8314	1078	9392	114.8
	2010-2013	3601	252	3853	65.4
Cameron	1986-1989	2084	230	2314	99.4
	1990-1999	3652	350	4002	87.5
	2000-2009	13987	1579	15566	101.4
	2010-2013	3251	160	3411	46.9
Congo	1986-1989	-	-	-	-
	1990-1999	-	-	-	-
	2000-2009	9527	725	10252	70.7
	2010-2013	3647	142	3789	37.5
Malawi	1986-1989	1470	380	1850	205.4
	1990-1999	10900	1816	12716	142.8
	2000-2009	27505	2670	30175	88.5
	2010-2013	2015	90	2105	42.8
Zambia	1986-1989	2832	563	3395	165.8
	1990-1999	12250	2096	14346	146.1
	2000-2009	8717	870	9587	90.7
	2010-2013	-	-	-	-
Namibia	1986-1989	1439	136	1575	86.3
	1990-1999	5215	314	5529	56.8
	2000-2009	6687	406	7093	57.2
	2010-2013	3614	156	3770	41.4

Source: Demographic and Health Surveys (DHS) latest data sets

6.2.2 Ethics statement

The datasets used in this study were obtained from the DHS programme after authorization was received to download the dataset on the website (https://dhsprogram.com/data/available-datasets.cfm).

6.2.3 Variables

The dependent variable of this study is the child survival status (alive or dead) during the duration of the survey. The wealth indexes, the mother's educational level, and the place of residence (rural/urban) are the main explanatory variables that assess the inequalities in child mortality. Households were grouped into five categories of wealth index (poorest, poor, middle, rich and richest). In terms of maternal education, we categorised the mothers into three groups (not attended school, 1-6 years of education and more than 6 years of education). The other covariate variables included sex and birth order of the child, parity, mother's age during childbirth and the size of the household.

6.2.4 Statistical methods:

Descriptive and multivariate analyses

First, the study used concentration index as well as absolute and relative ratios of mortality rates to measure inequality in health. The concentration index ranges between -1 and 1, and a negative value in this study means the deaths are more concentrated among children born to *less* educated mothers. Two logistic regression models were built to estimate the effect of mother educational level on the probability of a child to die before reaching his fifth birthday: Model 1 gave the unadjusted effect and Model 2 gave the adjusted effect of the co-variables.

Decomposition analysis

This study used the method proposed by Buis (Buis, 2010) which decomposes the total association between a categorical, discrete or continuous exposure variable, and an outcome from a direct effect and an indirect effect. The decomposition method proposed by Buis is described in his article published in 2010. In the current study, it is assumed that the dependent variable Y represents the child's mortality and X represents the mother's educational level. X is the main dependent variable by which we seek to quantify the direct effect, and Z is the indirect effect of the effect of all other covariates in our study. OR is considered as the risk of child to die before reaching his fifth birthday.

$$\ln(OR_{x=1,z|x=1}) - \ln(OR_{x=0,z|x=0}) = \ln(OR_{x=0,z|x=1}) - \ln(OR_{x=0,z|x=0}) + \ln(OR_{x=1,z|x=1}) - \ln(OR_{x=0,z|x=1)} \quad ...(1)$$

From equation 1, the total effect $(\ln(OR_{x=1,z|x=1}) - \ln(OR_{x=0,z|x=0}))$ is the sum of the direct effect $(\ln(OR_{x=0,z|x=1}) - \ln(OR_{x=0,z|x=0}))$ and direct effect $(\ln(OR_{x=1,z|x=1}) - \ln(OR_{x=0,z|x=1)}))$

After transformation of the equation (1), we obtain the equation (2) below where:

$\ln(\frac{OR_{x=1,z|x=1}}{OR_{x=0,z|x=0}})$ is the total effect, $\ln(\frac{OR_{x=0,z|x=1}}{OR_{x=0,z|x=0}})$ and $\ln(\frac{OR_{x=1,z|x=1}}{OR_{x=0,z|x=1}})$ are respectively the indirect and direct effect.

$$\ln(\frac{OR_{x=1,z|x=1}}{OR_{x=0,z|x=0}}) = \ln(\frac{OR_{x=0,z|x=1}}{OR_{x=0,z|x=0}}) + \ln(\frac{OR_{x=1,z|x=1}}{OR_{x=0,z|x=1}}) \quad \text{.....(2)}$$

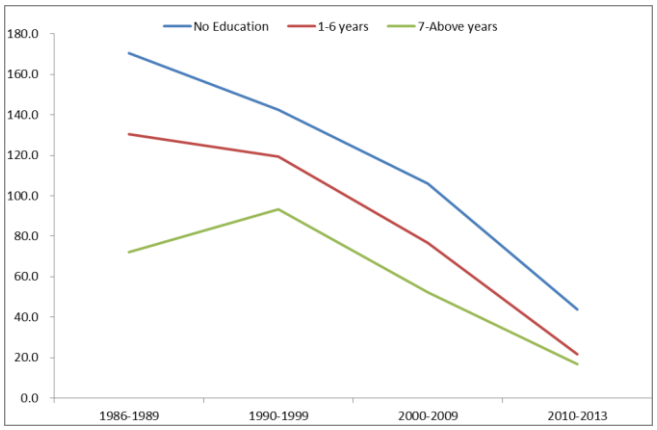
6.3 Results

Trend of Mother's educational level and under-five mortality inequalities

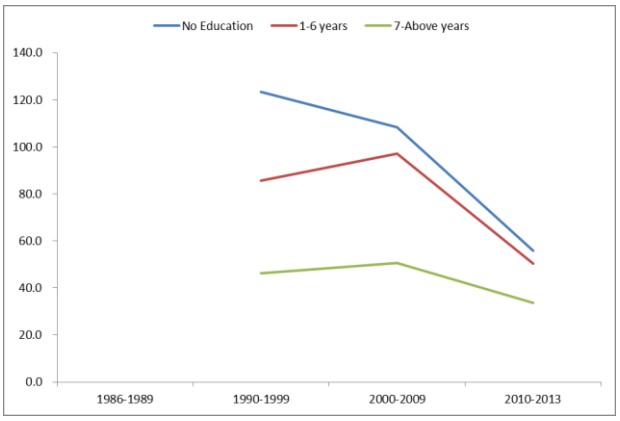
Figure 2 depicts the trend of under-five mortality rate and maternal education level by birth cohorts of children. The results reveal that, in general, children of mothers who did not attend school have a higher rate of death compared to mothers with formal education. However, mortality rate differentials are reduced from the older birth-cohort of children (1986-1989) to the younger birth-cohort of children in each country. The results also show a variation among the countries (Figure 2). Cameroon, Burkina Faso, Niger and Guinea are countries showing large inequalities in mortality by education level of the mother. Indeed, in these countries, the concentration index is less than -0.10 (-0.19 for the birth cohort of 1986-1989, -0.10 for the birth cohort of 1990-1999 and -0.11 to -0.20 for birth cohort of 2000-2009 and birth cohort of 2010-2013). This shows that the high concentration of deaths is among children born to mothers without aby formal education.

Figure 6.2 Trends of under-five mortality rate and the education level of the mother

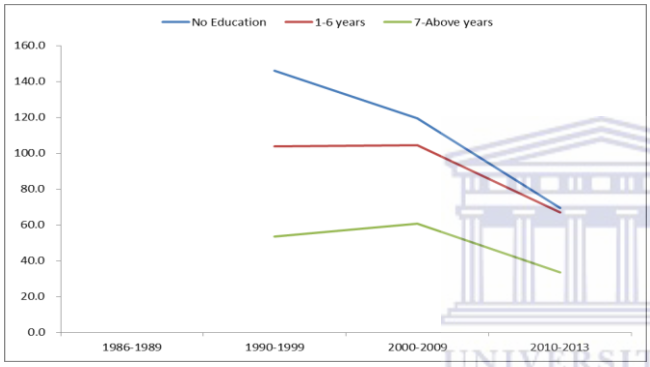
Burkina Faso



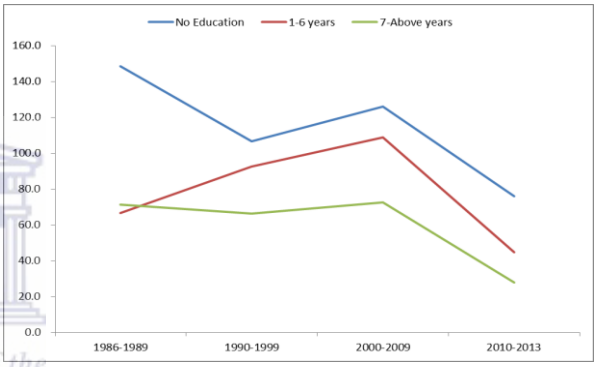
Niger



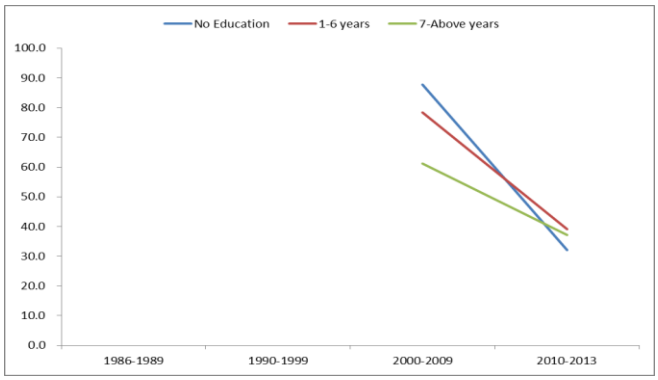
Guinea



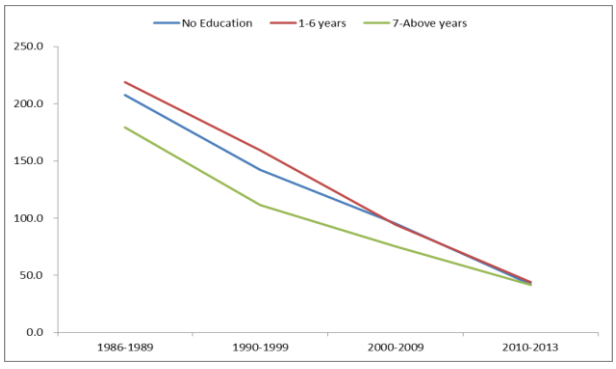
Cameroon



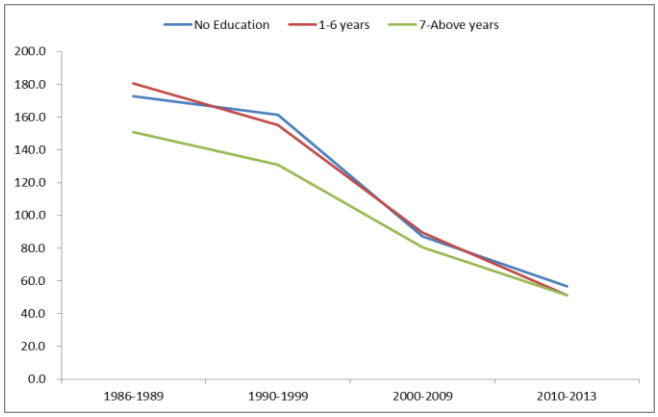
Congo



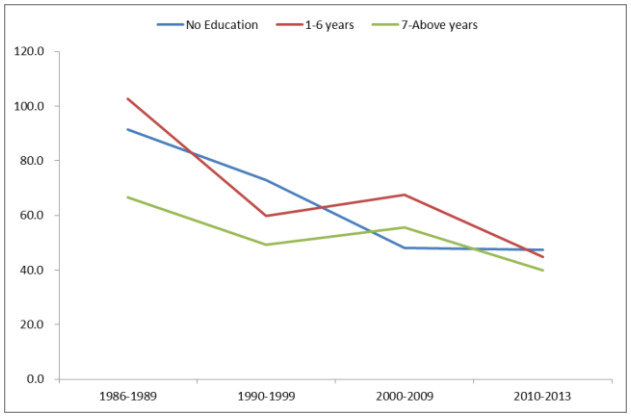
Malawi



Zambia



Namibia



The absolute differences in under-five mortality rates between children of more educated mothers (seven years and above) and children of uneducated mothers in Cameroon are 99.4, 87.5, 101.5 and 47 points respectively for birth cohorts of 1986-1989, 1990-1999, 2000-2009 and 2010-2013. In Burkina Faso, the absolute differences have decreased from 98.4 points for children of the birth-cohort of 1986-1989 to 27 points for children of the youngest birth cohort (born after 2009).

These differences account for less than 25 points in Namibia. The under-five year mortality concentration indices for children born between 1990 and 1999 in Niger and Guinea are a proximally -0.05, whereas it is -0.04 for those in the 2000-2010 birth cohort. These results show a high concentration of risk of mortality among children of non-educated mothers. The trend of the under-five mortality rate and the level of education of mothers in Malawi have moved from a situation of high mortality rate with a high concentration of mortality risk among children of non-educated mothers to a situation of low mortality rate. The inequalities of under-five mortality by mother's educational level have greatly decreased in Zambia from the oldest birth cohort to the youngest birth-cohort.

Mother's educational level and reduction of under-five mortality

Table 6.3 presents the comparative results of the under-five mortality rates of birth cohort according to different levels of mother's education. The results show that the decline in mortality of children under five years was much higher among the children of mothers who had not been to school. The findings show a 112 points drop in Malawi, over 80 in Zambia and Zimbabwe, 65 points in Burkina Faso, 56 in Congo, 43 in Namibia, 27 in Guinea and Cameroon, and 22 to 15 in Niger. With regards to mothers with 1-6 years of education, the declines in mortality rates for children under five years were less compared to the groups of children born to non-educated mothers. The findings reported significant differences in under-five mortality comparison between the older birth cohort and younger birth cohort. These differences were 125 points for Malawi, 91points for Zambia, 54 points for Burkina Faso, and 40 points for Congo. However, the study reported an upward trend for Cameroon (-42 points), Niger (-11 points), and Guinea (-8) points. A downward trend was noticed for children born to educated mothers. There was a significant difference in decline in under-five mortality rates between old birth cohort and the young birth cohort 104.4 points difference in Malawi, more than 40 points difference in Zambia and 24 points in Congo. The declines were not significant in Burkina Faso, Niger, Guinea, Cameroon and Namibia.

Table 6.3: Comparison of the mortality rates of children under five years old by birth-cohorts in the selected countries

Country	Mother's educational level	1986-1989	1990-1999	2000-2009	2010-2013	Difference (per 1000)	*z-test*	*P-value*
Burkina Faso (1986-1989 vs 2000-2009)	No Education	170.5	142.4	105.9	43.7	64.6	8.49	0.001
	1-6 years	130.4	119.4	76.8	21.6	53.6	2.93	0.003
	≥7 years	72.1	93.4	52.4	16.7	19.7	0.87	0.386
Niger (1990-1999 vs 2000-2009)	No Education		123.3	108.5	55.8	14.8	2.6	0.009
	1-6 years		85.7	97.1	50.3	-11.4	-9.88	0.001
	≥7 years		46.4	50.6	33.8	-4.2	-0.24	0.809
Guinea (1990-1999 vs 2000-2009)	No Education		146.1	119.6	69.3	26.5	4.36	0.001
	1-6 years		103.7	104.5	67.1	-0.8	3.11	0.002
	≥7 years		53.6	60.7	33.4	-7.1	-0.43	0.668
Cameroon (1986-1989 vs 2000-2009)	No Education	148.6	106.5	126.2	75.9	22.4	1.79	0.073
	1-6 years	66.6	92.7	108.9	44.6	-42.3	-3.69	0.001
	≥7 years	71.4	66.3	72.5	27.9	-1.1	0.48	0.629
Congo (2000-2009 vs 2010-2013)	No Education			87.84	32	55.84	3.55	0.001
	1-6 years			78.46	39.17	39.29	-28.64	0.001
	≥7 years			61.23	37.08	24.15	-32.43	0.001
Malawi (1986-1989 vs 2009)	No Education	207.4	142.3	95.1	42.3	112.3	9.75	0.001
	1-6 years	218.8	159.5	94.2	43.9	124.6	8.99	0.001
	≥7 years	179.5	111.6	75.1	41.5	104.4	7.48	0.001
Zambia (1986-1989 vs 2000-2009)	No Education	172.8	161.2	87.1	56.6	85.7	6.001	0.001
	1-6 years	180.6	155.3	89.7	51.3	90.9	9.38	0.001
	≥7 years	150.7	130.9	80.7	51.1	70	8.2	0.001
Namibia (1986-1989 vs 2000-2009)	No Education	91.5	73	48.1	47.3	43.4	2.75	0.006
	1-6 years	102.6	59.8	67.5	44.8	35.1	2.81	0.005
	≥7 years	66.6	49.3	55.5	40	11.1	1.12	0.263

Source: Demographic and Health Surveys (DHS) data sets

Effects of mother's educational level on inequalities in under-five mortality

Table 6.4 shows the multivariate results. The study aimed to examine the gross effect of maternal education on child mortality, and subsequently obtain the net effect after controlling for other covariates. An analysis of gross effects in Model 1 shows that the mother's educational level is significantly associated with the likelihood of under-five mortality in the selected countries of our study. Model 2 presents the adjusted OR.

In all these cases, children of more educated mothers are not likely to die before the age of five (OR=0.4 in Guinea and in Niger, OR=0.5 in Burkina Faso and Cameroon, OR=0.7 in Malawi and Congo, and OR=0.8 in Zambia and Namibia) compared to children born to mothers without any formal education.

With regards to Burkina Faso (OR=0.7), Cameroon (OR=0.8), Guinea (OR=0.8) and Niger (OR=0.8), children of mothers with 0-6 years of education are about 20% more likely to survive until their fifth birthday compared to children of non-educated mothers. There are no significant differences between children of mothers with 0-6 years of education and those of mothers who have not been educated who die before their 5th birthday in Congo, in Malawi and in Namibia.

The results (Model 2 in Table 4) depict the net effects (the adjusted OR after controlling the confounding variables. As in the case of Model 1, the results vary by country. With the exception of Namibia and Congo, where the mother's educational level loses its significance, the mother's educational level is significantly associated with under-five mortality in other countries. While there is a 50% to 20% likelihood that children born to educated mothers might not die before their fifth birthday, it might not be the case for under-five children of mothers without any formal education.

Table 6.4 shows that although the effect of maternal education declined in Burkina Faso while controlling the effect of the covariate, the impact of maternal education on under-five mortality still remains significant. However, there is no significant difference in mortality between children of mothers with 1-6 years of education and children born to non-educated mothers. Variables such as the birth cohort, maternal age during childbirth, the birth interval, multi-births, the child's sex, and place of residence are proved to be significantly associated with the mortality of children under-five years. Children born between 1990 and 1999 (OR=0.8; 95%CI (0.7; 1.0), 2000-2009 (OR=0.6, 95%CI = 0.5, 0.7) and after 2009 (OR =0.2

95% CI (0.2; 0.3)) have a lower risk of dying before five years than children born before 1990. Children born to mothers aged 20-34 were (OR =0.7; 95%CI (0.6; 0.8)) 30% less likely to die before their fifth birthday compared to children born to mother aged less than 20 years. The children delivered at a single birth (OR = 0.3 95%CI (0.2; 0.3)) were 70% less likely to die before their fifth birthday compared to children born from multiple births. Male children (OR = 1.1, 95%CI = (1.0; 1.2)) and those rural residents (OR = 1.2, 95%CI (1.0; 1.3)) are more likely to die before their fifth birthday than female children and those living in urban areas.

With regards to Niger, the results of the final model show that maternal education has dropped slightly but still remains significant after the introduction of control variables. It appears that children born between 2000 and 2009 (OR = 0.9, 95%CI (0.8, 1.0)), and post 2009 (OR=0.5, 95%CI (0.4; 0.5)) were less likely to die before the age five compared to children born between 1990 and 1999. Also, the risk of mortality reduced for children born to f mothers who delivered between 20 -34 of age (OR = 0.7, 95%CI (0.6, 0.8)) and maintained more than 24 months of birth interval. However, this was not the case for children born to young mothers (≤19 years) and children of first-time mothers. The results also show that, compared to twins, non-twins (OR = 0.2, 95%CI (0.2; 0.3) had about 80% less risk of dying before reaching their fifth birthday.

Like mother's educational level, the variables that were significantly associated with under-five mortality rate in Guinea included birth cohort, parity, and maternal age at delivery, inter-birth interval, and type of birth (twin vs. single), the child's sex and socioeconomic status. The observed relationships are similar compared to those found in Burkina Faso and Niger. In Cameroon, the variables significantly associated with mortality were birth cohort, parity of the mother, the mother's age at delivery, inter-birth interval, type of birth, the sex of the child and, the socioeconomic status. While in Congo, birth cohort, the type of delivery, and socioeconomic status were significantly associated with the mortality of children under five years. In Malawi and Zambia, in addition to the mother's educational level, the birth cohort, inter-birth interval, the type of delivery, and the child's sex were significantly associated with under-five mortality. The maternal age at birth, birth interval, multi or single birth, socioeconomic status were determinants of mortality in children under five years in Namibia.

Direct and indirect effects of mother's educational level on under five mortality

Table 6.5 and Figure 6.3 show the decomposition results of the direct and indirect effect of mother's education on under-five mortality. The results show that the direct effect of mother's educational level varies between 35% (in Namibia) to 79% (in Congo). The direct effect of mother's educational level is not significant in Namibia and Congo. In the case of Namibia, the education of the mother is not a determinant of mortality in children under five years of age.

However, more than three-fourths difference in mortality was observed among children of educated mothers, with seven years of education, and children of non-educated mothers. The differences accounted were 78.3% in Burkina Faso, 73.6% in Malawi and 71.5% in Guinea. This difference is greater than half for Zambia (66.0%), Cameroon (63.7%) and Niger (52.3%). These differences could be due to the direct effect of the educational level of the mother.

Figure 6.3: Direct and indirect effect of the education of the mother and under-five mortality

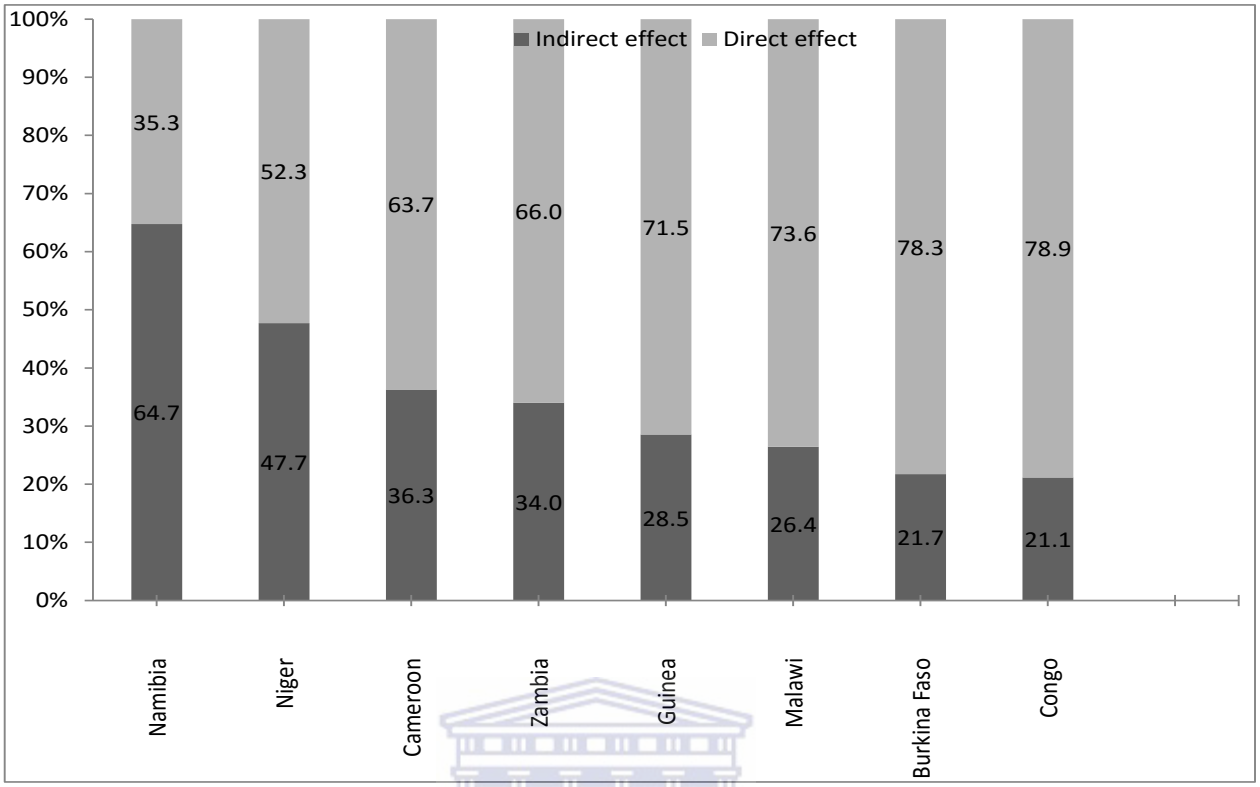


Table 6.4: Effects of selected factors assisted with under five mortality

Factors	BF		Cameroun		Malawi	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
	OR(95%CI)	OR(95%CI)	OR(95%CI)	OR(95%CI)	OR(95%CI)	OR(95%CI)
Mother's educational						
No Education	1	1	1	1	1	1
1-6 years	0.7***(0.6 -	0.9*(0.8 - 1.0)	0.8***(0.7 -	0.8**(0.8 - 0.9)	0.9(0.9 - 1.0)	1.1(1.0 - 1.1)
≥7 years	0.5***(0.4 -	0.8*(0.6 - 1.0)	0.5***(0.5 -	0.7***(0.6 -	0.7***(0.6 -	0.8***(0.7 -
Birth-cohort						
1986-1989		1		1		1
1990-1999		0.8*(0.7 - 1.0)		0.9(0.8 - 1.1)		0.7***(0.6 -
2000-2009		0.6***(0.5 -		1(0.9 - 1.2)		0.4***(0.3 -
2010-2013		0.2***(0.2 -		0.5***(0.4 -		0.2***(0.1 -
Parity						
1-3		1		1		1
4-6		1.4***(1.2 -		1.2**(1.1 - 1.4)		1.2***(1.1 -
≥7		1.7***(1.5 -		1.6***(1.4 -		1.4***(1.2 -
Mather' age at birth						
<=19		1		1		1
20-34		0.7***(0.6 -		0.7***(0.7 -		0.8***(0.7 -
35-49		0.7***(0.6 -		0.7***(0.5 -		0.8***(0.7 -
Birth Interval						
1st Birth		1		1		1
<24 Months		1.3***(1.1 -		1.4***(1.2 -		1.1(1.0 - 1.2)
24-35 Months		0.8***(0.7 -		0.8***(0.7 -		0.6***(0.5 -
36-47 Months		0.5***(0.5 -		0.6***(0.5 -		0.5***(0.4 -
≥48 Months		0.4***(0.3 -		0.6***(0.5 -		0.5***(0.5 -
Multi-Birth						
Twin		1		1		1
Single		0.3***(0.2 -		0.3***(0.3 -		0.2***(0.2 -
Child' sex						
Female		1		1		1
Male		1.1*(1.0 - 1.2)		1.1**(1.0 - 1.2)		1.2***(1.1 -
Residence place						
Urban		1		1		1
Rural		1.2* (1.0 - 1.3)		1(0.9 - 1.1)		1.1(1.0 - 1.2)
Socioeconomic status						
Poorest		1		1		1
Poorer		1(0.9 - 1.1)		0.8***(0.7 -		1.1(1.0 - 1.2)
Middle		1(0.9 - 1.1)		0.8**(0.7 - 0.9)		1.1(1.0 - 1.2)
Richer		0.9(0.8 - 1.0)		0.8**(0.6 - 0.9)		1.1(1.0 - 1.2)
Richest		0.8***(0.7 -		0.6***(0.5 -		0.9(0.8 - 1.0)
Constant	0.1***(0.1 -	0.9(0.7 - 1.2)	0.1***(0.1 -	0.6***(0.4 -	0.1***(0.1 -	1.2(1.0 - 1.5)
N	37,096	37,096	25,276	25,276	46,842	46,842

Source: Demographic and Health Surveys (DHS) data sets

Continued... Table 6.4: Effects of selected factors assisted with under five mortality

Factors	Zambia		Niger		Namibia	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
	OR(95%CI)	OR(95%CI)	OR(95%CI)	OR(95%CI)	OR(95%CI)	OR(95%CI)
Mother's educational level						
No Education	1	1	1	1	1	1
1-6 years	0.9* (0.8 - 1.0)	1(0.9 - 1.1)	0.8*(0.7 - 1.0)	1(0.9 - 1.1)	1.1(0.9 - 1.3)	1.1(0.9 - 1.3)
≥7 years	0.8***(0.7 -	0.8**(0.8 - 1.0)	0.4***(0.3 -	0.7*(0.5 - 0.9)	0.8**(0.7 - 0.9)	1(0.8 - 1.3)
Birth-cohort						
1986-1989		1				1
1990-1999		0.5***(0.5 -		1		0.7***(0.6 -
2000-2009		0.3***(0.3 -		0.9*(0.8 - 1.0)		0.7**(0.6 -
2010-2013		-		0.5***(0.4 -		0.5***(0.4 -
Parity						
1-3		1		1		1
4-6		1.2***(1.1 -		1.4***(1.2 -		1.4***(1.2 -
≥7		1.3**(1.1 - 1.4)		1.8***(1.6 -		1.5**(1.2 -
Mather age at birth						
<=19		1		1		1
20-34		0.8**(0.8 - 0.9)		0.7***(0.6 -		0.8*(0.6 - 1.0)
35-49		0.7***(0.6 -		0.7***(0.5 -		0.8(0.6 - 1.0)
Birth Interval						
1st Birth		1		1		1
<24 Months		1.1(1.0 - 1.3)		1(0.8 - 1.1)		1.4*(1.1 - 1.7)
24-35 Months		0.7***(0.6 -		0.7***(0.6 -		0.9(0.8 - 1.2)
36-47 Months		0.6***(0.5 -		0.5***(0.4 -		0.8(0.6 - 1.1)
≥48 Months		0.6***(0.5 -		0.4***(0.3 -		0.9(0.7 - 1.1)
Multi-Birth						
Twin		1		1		1
Single		0.3***(0.2 -		0.2***(0.2 -		0.2***(0.2 -
Child' sex						
Female		1		1		1
Male		1.2***(1.1 -		1.1*(1.0 - 1.2)		1.1(1.0 - 1.3)
Residence place						
Urban		1		1		1
Rural		0.9**(0.8 - 1.0)		1.4***(1.2 -		0.9(0.8 - 1.1)
Socioeconomic status						
Poorest		1		1		1
Poorer		1(0.9 - 1.1)		1.2**(1.1 -		1.1(0.9 - 1.4)
Middle		1(0.9 - 1.2)		1.2*(1.0 - 1.4)		1(0.8 - 1.2)
Richer		1(0.9 - 1.2)		1.3***(1.1 -		1(0.8 - 1.2)
Richest		0.7***(0.6 -		1(0.8 - 1.2)		0.7*(0.5 - 0.9)
Constant	0.1***(0.1 -	1(0.8 - 1.3)	0.1***(0.1 -	0.5***(0.4 -	0.1***(0.1 -	0.4***(0.3 -
N	41,082	34,674	26,203	26,203	17,953	17,953

Source: Demographic and Health Surveys (DHS) data sets

Continued….Table 6.4: Effects of selected factors assisted with under five mortality

Factors	Guinea		Congo	
	Model 1	Model 2	Model 1	Model 2
	OR(95%CI)	OR(95%CI)	OR(95%CI)	OR(95%CI)
Mother's educational level				
No Education	1	1	1	1
1-6 years	0.8**(0.7 - 0.9)	0.9(0.8 - 1.1)	0.9(0.7 - 1.2)	1(0.8 - 1.2)
≥7 years	0.4***(0.3 - 0.5)	0.6***(0.4 - 0.7)	0.7*(0.6 - 0.9)	0.8(0.6 - 1.0)
Birth-cohort				
1986-1989				
1990-1999		1		
2000-2009		0.8***(0.7 - 0.9)		1
2010-2013		0.5***(0.4 - 0.6)		0.5***(0.4 - 0.6)
Parity				
1-3		1		1
4-6		1.4***(1.2 - 1.6)		1.2*(1.0 - 1.5)
≥7		2.0***(1.7 - 2.3)		1.4*(1.1 - 1.9)
Mather age at birth				
<=19		1		1
20-34		0.8**(0.7 - 0.9)		0.8(0.6 - 1.0)
35-49		0.7**(0.6 - 0.9)		0.9(0.7 - 1.3)
Birth Interval				
1st Birth		1		1
<24 Months		1(0.8 - 1.2)		1.1(0.8 - 1.5)
24-35 Months		0.7***(0.6 - 0.9)		0.8(0.7 - 1.1)
36-47 Months		0.6***(0.5 - 0.7)		0.7*(0.6 - 1.0)
≥48 Months		0.4***(0.3 - 0.4)		0.7**(0.5 - 0.9)
Multi-Birth				
Twin		1		1
Single		0.3***(0.3 - 0.4)		0.2***(0.2 - 0.3)
Child' sex				
Female		1		1
Male		1.2***(1.1 - 1.3)		1.1(0.9 - 1.3)
Residence place				
Urban		1		1
Rural		1.1(0.9 - 1.3)		1(0.8 - 1.2)
Socioeconomic status				
Poorest		1		1
Poorer		0.9(0.8 - 1.1)		1.1(0.9 - 1.4)
Middle		0.9(0.8 - 1.0)		1.2(1.0 - 1.6)
Richer		0.8**(0.7 - 0.9)		1.1(0.8 - 1.5)
Richest		0.7***(0.5 - 0.8)		0.9(0.6 - 1.3)
Constant	0.1***(0.1 - 0.1)	0.6***(0.5 - 0.8)	0.1***(0.1 - 0.1)	0.4***(0.2 - 0.6)
N	18,985	18,985	14,036	14,036

Source: Demographic and Health Surveys (DHS) data sets

Table 6.5: Decomposition of Direct and Indirect effect of mother's educational level on under five years old mortality

	Coef.	Std. Err.	% of Effect	P>z	95% CI	
Burkina Faso						
≥7 years /No education						
Total	-0.69	0.09	100.0	0.001	-0.87	-0.50
Indirect Effect	-0.15	0.04	21.7	0.001	-0.22	-0.08
Direct **effect** of mother educational level	-0.54	0.10	78.3	0.001	-0.73	-0.34
Niger						
≥7 years /No education						
Total	-0.83	0.11	100.0	0.001	-1.05	-0.62
Indirect Effect	-0.40	0.04	47.7	0.001	-0.48	-0.32
Direct **effect** of mother educational level	-0.44	0.12	52.3	0.001	-0.67	-0.20
Guinea						
≥7 years /No education						
Total	-0.93	0.16	100	0.001	-1.24	-0.62
Indirect Effect	-0.26	0.04	28.5	0.001	-0.35	-0.18
Direct **effect** of mother educational level	-0.66	0.17	71.5	0.001	-0.99	-0.33
Cameroon						
≥7 years /No education						
Total	-0.66	0.06	100.0	0.001	-0.78	-0.55
Indirect Effect	-0.24	0.04	36.3	0.001	-0.32	-0.17
Direct **effect** of mother educational level	-0.42	0.07	63.7	0.001	-0.56	-0.29
Congo						
≥7 years /No education						
Total	-0.29	0.12	100	0.013	-0.52	-0.06
Indirect Effect	-0.06	0.04	21.1	0.153	-0.15	0.02
Direct **effect** of mother educational level	-0.23	0.13	78.9	0.065	-0.48	0.02
Malawi						
≥7 years /No education						
Total	-0.38	0.04	100.0	0.001	-0.45	-0.30
Indirect Effect	-0.10	0.01	26.4	0.001	-0.13	-0.07
Direct **effect** of Mother educational level	-0.28	0.04	73.6	0.001	-0.36	-0.20
Zambia						
≥7 years /No education						

Total	-0.24	0.06	100	0.001	-0.36	-0.12
Indirect Effect	-0.08	0.03	34.0	0.002	-0.13	-0.03
Direct **effect** of mother educational level	-0.16	0.07	66.0	0.018	-0.29	-0.03
Namibia						
≥7 years /No education						
Total	-0.24	0.09	100.0	0.006	-0.41	-0.07
Indirect Effect	-0.16	0.03	64.7	0.001	-0.22	-0.09
Direct **effect** of mother educational level	-0.09	0.10	35.3	0.408	-0.29	0.12

Source: Demographic and Health Surveys (DHS) latest data sets

6.4 Discussion

The study results clearly show the influence of maternal education on under-five mortality while decomposing the direct and indirect effect of maternal education on mortality of children under five years. The results of our study have shown that the trend of mortality rates by level of mother's education varies from one country to another and we did not get the same trends in all the countries. The trend of under-five mortality by level of mother's education is similar in Burkina Faso, Niger and Guinea high mortality among children of non-educated mothers, low mortality risk among children of educated mothers (≥7 years schooling), and an intermediate position for children of mothers with 1-6years of education. The trend for other countries is not consistent with this finding. The heterogeneity of the results reveals the importance of unobserved factors which may affect maternal education and child health simultaneously (Maïga, 2011). Additionally, the inconsistency in findings also highlights the importance of contextual effects for explaining the demographic events such as under-five mortality (Kravdal, 2002; Mcguire & Stephenson, 2015). These include the health policies implemented across selected countries; the presence, access and affordability of healthcare services; the availability of community services; a mother's health status and awareness.

Country specific results confirm the existence of a difference in mortality rates between children of mothers who have been to school and children of mothers without formal education. However, these results varied across countries. The results confirm an inverse relationship between mother's educational level and the risks of under-five mortality (John C Caldwell, 1994; J Hobcraft, 1993; Tulasidhar, 1993). With the exception of Namibia, the results showed that children of educated mothers (seven years or more of education) are less likely to die before reaching their fifth birthday compared to children of less educated mothers. These results are in line with the results of previous studies on infant mortality in developing countries (Basu & Stephenson, 2005; Bicego & Boerma, 1993; Muhuri, 1995; Tulasidhar, 1993).

Our study also analysed the trend of the under-five mortality of birth cohorts of children born between 1986 and 2013. The results showed a significant decline in mortality among children of mothers without formal education (between 14 points in Niger and Malawi 112 points), while the decrease was less pronounced among children born to mothers with 1-6 years of education (-42 points in Cameroon to 124 points in Malawi), and among children of mothers with seven or more years of schooling. The largest decline among children of non-educated

mothers could be explained by the reduction of geographical and financial barriers to accessible healthcare for children under-five year of age in many countries.

The remoteness of health centres is identified as an unfavourable factor for accessing to healthcare services for children, especially in rural areas (Houweling, Kunst, & Mackenbach, 2003; Houweling & Kunst, 2010; Oyefara, 2014; Rutherford, Mulholland, & Hill, 2010). The current study also identifies the need to reduce delivery costs of healthcare services for promoting the use of maternal and child services, especially for children from poor households (Lagarde & Palmer, 2011; Ridde & Slim, 2009). The multivariate results, after controlling for other variables, showed that the effect of educational level of the mother is an important determinant of child mortality in several countries. These analyses also showed the importance of variables such as the generation of child birth, parity of the mother, the mother's age at delivery, inter-birth interval, the type of birth, the sex of the child and the household socioeconomic status.

6.5 Conclusion

The study demonstrates that mothers' educational attainment is an important determinant of child mortality, and the results confirmed that children of more educated mothers have lesser risk of dying before their fifth birthday compared to children born to mothers without formal education. The analysis of the trend in mortality educational level of the mother showed a significant reduction in mortality gaps between children of mothers with more than seven years of education and children of non-educated mothers. These observed reductions are certainly the result of programmes and policies designed for reducing unequal access to health care and improving the supply of health care, especially, to the most underprivileged communities. If universal access of women to school could induce a reduction in under-five mortality rates in Sub-Saharan countries, it is clear that it should be accompanied by access to policies and healthcare programmes, which can reduce the gaps between children of educated mothers and non-educated mothers.

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Chapter 7: Trends and Risk Factors for Childhood Diarrhoea in sub-Saharan Countries (1990-2013): Assessing the Neighbourhood Inequalities

Bado, A. R., Susuman, A. S., & Nebie, E. I. (2016). Trends and risk factors for childhood diarrhea in sub-Saharan countries (1990–2013): assessing the neighborhood inequalities. *Global health action*, *9*. doi: 10.3402/gha.v9.30166

Abstract

Background: Diarrheal diseases are a major cause of child mortality and one of the main causes of medical consultation for children in sub-Saharan countries. This paper attempts to determine the risk factors and neighbourhood inequalities of diarrheal morbidity among children under five years old in selected countries in sub-Saharan Africa over the period of 1990-2013.

Methods: Data used come from the Demographic and Health Survey (DHS) waves conducted in Burkina Faso (1992–93, 1998–99, 2003, and 2010), Mali (1995, 2001, 2016, and 2012), Nigeria (1990, 1999, 2003, 2008, and 2013), and Niger (1992, 1998, 2006, and 2012). Bivariate analysis was performed to assess the association between the dependent variable and each of the independent variables. Multilevel logistic regression modelling was used to determine the fixed and random effects of the risk factors associated with the diarrheal morbidity.

Results: The findings showed that the proportion of diarrheal morbidity among children under five years old varied considerably across the cohorts of birth from 10 to 35%. There were large variations in the proportion of diarrheal morbidity across countries. The proportions of diarrheal morbidity were higher in Niger compared to the countries of Burkina, Mali, and Nigeria. The risk factors of diarrheal morbidity varied from one country to another, but the main factors included: child's age, size of the child at birth, the quality of the main floor material, mother's educational level and her occupation, type of toilet, and place of residence. The analysis shows an increasing trend of diarrheal inequalities according to DHS rounds. In Burkina Faso, the value of the intra-class correlation coefficient (ICC) was 0.04 for 1993 DHS, while it was 0.09 in 2010 DHS; in Mali, the ICC increased from 0.04 in 1995 to 0.16 in 2012; in Nigeria, ICC increased from 0.13 in 1990 to 0.19 in 2013; and in Niger, ICC increased from 0.07 in 1992 to 0.11 in 2012.

Conclusion: This suggests the need to fight against diarrheal diseases on both the local and community levels across villages.

Keywords: Diarrheal morbidity; neighbourhood inequalities; under-five mortality; sub-Saharan Africa; Demographic and Health Survey.

7.1 Background

The morbidity and mortality related to diarrheal diseases in children under five are still sizeable and persistent in low-income countries, especially in sub-Saharan Africa, and pose a significant, long-standing public health concern. Diarrheal disease is one of the leading causes of morbidity and mortality in less-developed countries, especially among children under five years of age (Fewtrell et al., 2005). Fischer Walker et al (Fischer Walker et al., 2013) estimated that in 2010, about 1,731 billion episodes of diarrhoea in children younger than five were recorded worldwide. Every year, nearly 760,000 children under five continue to die from diarrheal disease, and the majority of these deaths have been identified as being avoidable (Fischer Walker et al., 2013; Ramanaiah, Salam, Arumugam, & Prabhu, 2015). The burden of diarrheal morbidity lies largely in the developing world, where water and living conditions remain poor (Eshete, 2008). In 2011, Fischer Walker et al (Fischer Walker et al., 2013) showed that nearly three-quarters of diarrheal mortality and pneumonia mortality are concentrated in 15 high-burden countries, and among these 15 countries, 10 were from sub-Saharan Africa, namely Angola, Burkina Faso, Democratic Republic of the Congo, Ethiopia, Kenya, Mali, Niger, Nigeria, Tanzania, and Uganda. Therefore, aggressive efforts to reduce child mortality must be through the reduction or elimination of diarrheal morbidity and mortality among children under five years, especially in low- and middle-incomes countries (Parashar, Bresee, & Glass, 2003). The United Nations' Millennium Development Goal 4, which aims to decrease the child mortality rate by two-thirds between 1990 and 2015, will not be achievable if morbidity and mortality caused through diarrhoea are not curbed (Popoola & Mchunu, 2015; Santosham et al., 2010).

The fight against diarrheal diseases in children under five were the subject of several international interventions as well as regional and national interventions in low- and middle-income countries (Rahman et al., 2014; Walker, Fontaine, Young, & Black, 2009). In the late 1970s and early 1980s, international initiatives were implemented to reduce diarrheal mortality in children under five years in developing countries (Santosham et al., 2010). These actions included: the promotion of the use of oral rehydration therapy, coupled with programs to educate caregivers on its appropriate use (UNICEF & WHO, 2009) supplementation with zinc, which has been shown to reduce the duration, severity, and complications associated with diarrhea; the promotion of hygiene; and access to drinking water in households.

Indeed, diarrheal diseases remain linked largely to living conditions, poverty, lack of hygiene, and lack of drinking water in households and in the neighbourhood. The differences among cities, villages, neighbourhoods, and countries with a purified water supply, sanitation,

drainage, and waste removal are the factors of inequalities in morbidity and mortality from diarrheal disease (11). The neighborhoods with inadequate provisions of water or sanitation and with unsanitary living conditions are often more likely to suffer the burden of diarrheal disease and record higher rates of mortality of children under five (Assogba et al., 2012; Bartlett, 2003; Chan & Lake, 2013). The results of earlier studies have shown that lack of sanitation, availability and supply of drinking water, lack of proper septic tanks and toilets, especially in urban suburbs, are generally expected to increase the risk of diarrheal morbidity and mortality and the infant mortality rate (Awasthi & Agarwal, 2003; Gebru, Taha, & Kassahun, 2014; Wyrsch et al., 1998). Similarly, the poor economic status, food scarcity, non-hand washing with soap, and kind of water storage were identified as risk factors for diarrheal morbidity and mortality (Joshi et al., 2011; Kunii, Nakamura, Abdur, & Wakai, 2002; Melo et al., 2008).

Earlier studies on risk factors of morbidity and mortality due to diarrhea have highlighted a large group of factors related to socioeconomic status, living conditions for children, and factors related to aetiology. Among the socioeconomic variables, household poverty level, a high number of people living in the household (Kunii et al., 2002) or a high number of children under five in the household, maternal age, education, and working status (Hatt & Waters, 2006) were the risk factors for morbidity and mortality from diarrheal diseases as reported in previous studies. The child's characteristics that were found to be significantly associated with the risk of diarrheal morbidity and mortality included: age of child, gender, type of breast-feeding used, underweight, and acute malnutrition. Malnutrition and low socioeconomic status are the factors that lead to the risk of mortality due to morbidity and diarrheal morbidity.

Aim:

This paper attempts to determine the risk factors and neighborhood inequalities of diarrheal morbidity among children under five years old in selected countries in sub-Saharan Africa over the period of 1990-2013. Measurements of trends in diarrheal morbidity among children under five years are important to assess the progress toward Millennium Development Goal 4 (MDG), which targets the reduction of child mortality by two-thirds from 1990-2013.

7.2 Methods

7.2.1 Study design

This study is a comparative cross sectional. Four countries have been selected to be in this

study: Burkina Faso, Mali, Nigeria, and Niger. These countries are all located in West Africa, one of the poorest parts of the world, where the indicators of morbidity and mortality of children are the most disturbing in the world. According to Fischer Walker et al. (2013), these four countries were among the top 10 countries of the world that accounted for more than 52% of childhood deaths from diarrhea and pneumonia. One of the reasons that motivated the choice of these countries is that, during the period of 1990 to 2013, each country has made at least the fourth rounds of Demographic and Health Survey (DHS). The availability of data on diarrheal morbidity in children under five years, as well as information on household hygiene, type of drinking water sources used in the household, and type of sanitation used in each database from the different rounds of DHS, offers an opportunity to analyze the trend of the morbidity of diarrhea in children under five in these countries. The data allow the research to make a comparative analysis among countries selected for this study.

7.2.2 Data source

Data used come from the Demographic and Health Survey (DHS) waves conducted in Burkina Faso (1992–93, 1998–99, 2003, and 2010), Mali (1995, 2001, 2016, and 2012), Nigeria (1990, 1999, 2003, 2008, and 2013), and Niger (1992, 1998, 2006, and 2012). The data were obtained from the MEASURE DHS. Each of these surveys collected information from a representative sample at the national level. The DHS is based on a stratified, two-stage cluster sample. A cluster usually consists of one or a few villages in the rural area or a neighborhood in the urban environment. This type of sampling allows us to take into account the contextual effect for studying the determinants of diarrhea morbidity in the countries selected for the study.

Three types of questionnaires were administered in each survey, namely, the Household, Man, and Woman questionnaires. In this paper, we used the data for birth history information of all women age 15 to 49 interviewed for the different surveys. The birth history data set contains information on the date of birth of all the children a woman has had in her life, starting from her first child until the time of the survey. Information on child survival (dead or alive) was also collected.

Table 7.1: Years of Survey and Population of Children under Five Years by Country

Country	Year of survey	1990-1995	1996-2001	2002-2008	2009-2012	2013
Burkina Faso	1992, 1998, 2003, 2010	5,096	5,071	9,361	13,716	
Mali	1995, 2001, 2006, 2012	5,231	11,055	12,388	9,582	
Nigeria	1990, 1999, 2003, 2008, 2013	6,823	3,139	5,163	25,446	28,596
Niger	1992, 1998, 2006, 2012	5,592	4,243	8,209	11,602	

7.2.3 Variable specification

Diarrhea is a syndrome that can be caused by different bacterial, viral, and parasitic pathogens. In West African countries, studies show that diarrheal morbidity is caused mainly by Escherichia coli, Shigella spp., and rotavirus (Bonkoungou et al., 2012; Sambe-Ba et al., 2013).

The variables used in this study for the explanation of diarrheal morbidity in children under five have been selected according to the conceptual framework of risk factors for diarrhea incidence in developing countries as proposed by Genser et al (Genser, Strina, Teles, Prado, & Barreto, 2006). This conceptual framework proposes five groups of variables considered as determinants of diarrhea morbidity. The socioeconomic status of households (the standard of living in the household, the number of people in the household, age of mother, occupation, and level of education) comprises the first group of variables. The second group of variables is related to the hygiene of the immediate environment of the household. This group of variables includes the drinking water source and type of toilet used in the household. Weight at birth, breast-feeding duration, anthropometric measurements, and age and sex of the child represent the third group of potential determinants of diarrheal morbidity.

- ✓ *Dependent variable*

The main variable of our study is the fact of having had diarrhea in the last two weeks among children under five preceding the survey. This variable was collected during each round of DHS. During the interview, to assess the prevalence of diarrheal diseases in children under five years old, mothers were asked whether their children had had diarrhea in the two weeks preceding the survey and if there was blood in the stool. The dependent variable then is dichotomous: yes, if the child had an episode of diarrhea in the last two weeks, and no, otherwise.

✓ *Independent variables*

Four groups of variables are taken into account in the analysis models. The first includes variables related to socioeconomic status of the household (the number of people in household; presence of electricity in the course of ownership of radio, television, refrigerator, bicycle, and motorcycle in the household; and the level of the mother's education and her age). The source of drinking water, type of toilet, and floor material quality are the variables related to hygiene and quality of the immediate environment of the household. Demographic information for the child include age, weight at birth, sex, and status regarding measles vaccine.

7.2.4 Data analysis

Data analysis was carried out using STATA software Version 13.1 (StataCorp. 2013. Stata Statistical Software: Release 13. College Station, TX: StataCorp LP). Two types of analysis were used: a bivariate analysis and a multilevel logistic regression modelling. Bivariate analysis for each independent variable was performed against the dependent variable to elicit the impact of each factor on diarrheal morbidity. The dependent variable was dichotomous, and to reflect the hierarchical structure of the data, a two-level multilevel logistic regression model, with individuals at level-1 and the local area (PSU) at level-2, was used to assess the effect of each variable independently on the dependent variable while controlling for the cofounders.

✓ **Specification of the model**

$\ln(\frac{p_{ij}}{1-p_{ij}})=\beta_0+\beta_1 x_{1ij}+\beta_2 x_{2ij}+....+\beta_n x_{nij}+\omega_j$, the random effects vector $\omega_j$is distributed as $N(0,\sigma_\omega^2)$,

where x_1 to x_n represents the explanatory variables for the probability that a child age less than five years i from a PSUj has suffered from diarrheal disease. β_0 is the intercept and $\beta_{(1 \text{ to } n)}$ are the fixed effect (coefficients) for the explanatory variables included in the model. ω_j is the PSU-level random-effect.

✓ **Intra-class correlation and neighbourhood inequalities measurement**

The random effect (ω_j) measures the variation between neighborhoods in the proportion of diarrheal morbidity among children under five years old. To quantify the neighborhood inequalities in diarrheal morbidity, we calculated the intra-class correlation (ICC), which is the percentage of the total variance among the neighborhoods. The ICC is the proportion of the total variance of diarrheal morbidity among children under five years at the neighborhood level

(PSU). The ICC quantified the inequalities or the contextual effect of diarrheal morbidity (Castro, 2002; Merlo, Yang, Chaix, Lynch, & Råstam, 2005).

7.3 Results

Figure 7.1 presents the prevalence of diarrheal morbidity by cohort across countries. There are variations by country and by cohort. The highest prevalence of diarrheal morbidity is among children in Niger while the lowest proportions were recorded among children in Nigeria.

The proportions of children under five who suffered from diarrheal diseases were higher in Niger (36.4%, 95% confidence interval [CI]= [34.9; 37.8]) among children of the 1995-to-1999 birth cohort compared to other countries. In Nigeria, the proportions of diarrheal morbidity were (14.7% [12.5; 16.9] for the 1990-to-1994 birth cohort; 13.6% [12.6; 14.6] for 1995 to 1999) compared with the prevalence of other countries for the same birth-cohort of children. For all countries, the results showed that diarrheal morbidity proportions among children under five are declining from 1995 to 2009. In Niger, although, the results show an overall decrease of diarrheal morbidity, there is an increase in the last birth-cohort (2010-2015) compared to the previous birth-cohorts (2005-2009 and 2000-2004).

Figure 7.1: Diarrheal Morbidity Prevalence by Cohort and Country

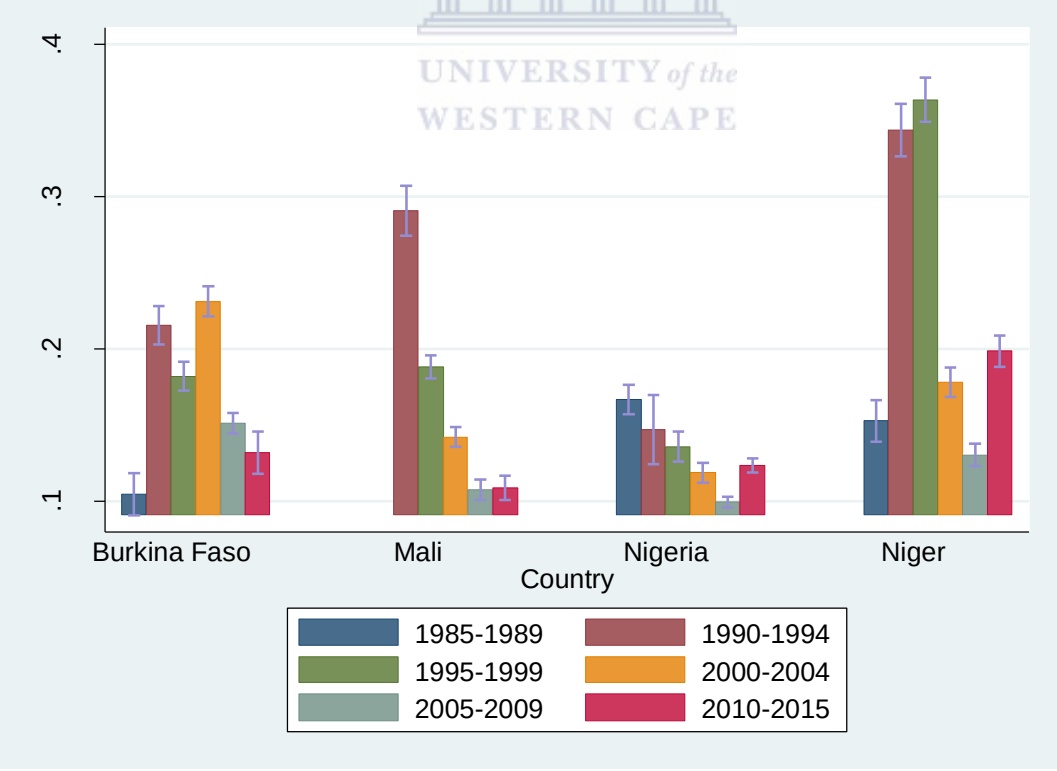


Table 7.2 presents the results of the descriptive analysis of diarrheal morbidity. The results by countries show that the child-level variables (sex of the child, age, size of the child at birth, and

had a measles vaccine) are significantly associated with diarrheal morbidity as variables. However, there are differences among countries. As for Burkina Faso, only the child-level variables are significant. For most of the four DHSs, Mali, Nigeria, and Niger, the variables related to the immediate environment and hygiene (type of toilet, quality of main floor material, and source of drinking water) are associated significantly with diarrheal morbidity in children under five years. The children from the households using a traditional latrine or who don't have a toilet and those from the households with poor quality of main floor material, and using a tube well or borehole, are more likely to suffer from diarrheal disease compared to the children from households using improved toilets and have a good quality of main floor material and who are using piped water as their main source of drinking water.

Among the economic variables: having electricity in the household and ownership of a television and refrigerator significantly reduce the risk diarrheal morbidity in children under five in Mali, Niger, and Nigeria. The children living in rural areas and those of mothers who have not been to school are more at risk for diarrheal disease in Mali, Nigeria, and Niger compared to children living in urban areas and whose mothers are educated. The occupation of the mother also is associated significantly with diarrheal disease in children under five in Mali, Nigeria, and Niger.

Table 7.2: Determinant Variables in Bivariate Analysis (cf. Appendix 1 for full table)

Country	1990-1995	1996-2001	2002-2008	2009-2012	2013
Burkina Faso	1993	1999	2003	2010	
	-Quality of the main floor *** -Sex of the child ** -Child age (mth) *** -Has measles vaccine***	-Child age (mth) *** -Has measles vaccine*** -Type of toilet	-Household size*** -Has a refrigerator * -Has bicycle in the HH* -Child age (mth) *** -Has measles vaccine*** -Size of the child at birth*** -Sex of the child **	-Household size*** -Age of the mother** -Mother's educational level** -Has a refrigerator * -Has bicycle in the HH* -Child age (mth) *** -Size of the child at birth***	
Mali	1995	2001	2006	2012	
	-Age of the mother * -Place of residence *** -Mother's occupation** -Mother's education level *** -Has electricity*** -Has television *** -Type of toilet *** -Quality of main floor material *** -Sources of drinking water ** -Child age (mth) *** -Size of the child at birth***	-Household size *** -Age of the mother *** -Place of residence *** -Mother occupation*** -Has electricity *** -Has a television *** -Has a refrigerator *** -Has a bicycle *** -Has a motorcycle *** -Type of toilet*** -Quality of main floor material *** -Sources if drinking water*** -Child's age (mth)*** -Has measles vaccine*** - Size of the child at birth***	-Household size ** -Place of residence *** -Mother occupation*** -Has electricity *** -Has television *** -Has a bicycle** -Has a motorcycle ** -Quality of main floor material *** -Sources if drinking water*** -Child's age (mth)*** - Size of the child at birth***	-Mother occupation*** -Mother's education level *** -Quality of main floor material ** -Sources if drinking water*** -Sex of the child* -Child's age (mth)*** -Has measles vaccine** - Size of the child at birth*	
Nigeria	1990	1999	2003	2008	2013

	-Age of the mother *** -Place of residence *** -Mother's occupation *** -Mother's education *** -Has electricity *** -Has a television *** -Has a refrigerator *** -Has a bicycle *** -Type of toilet *** -Quality of the main floor material*** -Sources of drinking water *** -Sex of the child*** -Child's age (mth) *** -Has measles vaccine*** - Size of the child at birth***	-Sex of the head of the HH*** -Mother's occupation *** -Mother's education *** -Has electricity *** -Has a television *** -Has a refrigerator *** -Type of toilet *** -Quality of the main floor material*** -Child's age (mth) ***	-Age of the mother * -Place of residence *** -Mother's education *** -Has electricity *** -Has a television *** -Has a refrigerator *** -Has a bicycle *** -Has a motorcycle* -Type of toilet *** -Quality of the main floor material*** -Sources of drinking water *** -Sex of the child* -Child's age (mth) *** -Has measles vaccine*** - Size of the child at birth***	-Household size *** -Sex of the head of the HH*** -Age of the mother *** -Place of residence *** -Mother's education *** -Mother's education *** -Has electricity *** -Has a television *** -Has a refrigerator *** -Has a bicycle *** -Has a motorcycle*** -Type of toilet *** -Quality of the main floor material*** -Sources of drinking water *** -Sex of the child** -Child's age (mth) ** -Has measles vaccine*** - Size of the child at birth***	-Household size *** -Sex of the head of the HH*** -Age of the mother *** -Place of residence *** -Mother's education *** -Mother's education *** -Has electricity *** -Has a television *** -Has a refrigerator *** -Has a bicycle *** -Type of toilet *** -Quality of the main floor material*** -Sources of drinking water *** -Child's age (mth) *** -Has measles vaccine*** - Size of the child at birth***
	1992	1998	2006	2012	
Niger	-Household size ** -Age of the mother* -Place of residence*** -Mother's occupation*** -Mother's education level*** -Has electricity*** -Has a television*** -Has a refrigerator** -Has a motorcycle** -Type of toilet** -Quality of the main floor material*** -Sources of drinking water** -Child's age (mth)*** -Has a measles vaccine*** - Size of the child at birth***	-Place of residence*** -Mother's occupation*** -Mother's education level*** -Has electricity*** -Has a television*** -Has a refrigerator*** -Has a motorcycle*** -Quality of the main floor material*** -Sources of drinking water*** -Child's age (mth)***	-Household size ** -Age of the mother*** -Place of residence*** -Mother's occupation*** -Mother's education level*** -Has electricity*** -Has a television*** -Has a refrigerator*** -Has bicycle*** -Type of toilet*** -Quality of the main floor material*** -Sources of drinking water*** -Child's age (mth)*** -Has a measles vaccine*** - Size of the child at birth***	-Household size *** -Age of the mother*** -Place of residence*** -Mother's education level*** -Has electricity* -Has a television*** -Type of toilet* -Quality of the main floor material** -Sources of drinking water*** -Child's age (mth)*** -Has a measles vaccine*** - Size of the child at birth***	

**=p-value<0.05; **=p-value*

Table 7.3 presents the results of multivariate analysis. In all four countries, age of the child is associated significantly with diarrheal disease among children under five years. The risk of diarrheal morbidity among children under five has a U shape according to the child's age (Appendix 2). Compared to children of 0 to 6 months, the odds ratio is between 1.5 and 3.7 for children whose age is between 7 and 36 months, while after 37 months, the risk of diarrheal disease is reduced (OR <1) (Appendix 2).

The results of the four DHSs conducted in Burkina Faso (Table 3) show that variables related to the child level are those most significantly associated with diarrheal morbidity in children under five years. Male children, those who had a low birth weight, and those age 7 to 36 months are more likely to have a diarrheal morbidity compared to female children and those who had a normal birth weight. The quality of main floor material, the type of toilet, the mother's occupation, had measles vaccine, and household sizes were associated significantly

with diarrheal morbidity for the Burkina DHS. The child's age and occupation of the mother are the two significant variables for the four rounds of DHS in Mali. Children of mothers who trade or have agriculture as their main activity are more likely to suffer from diarrheal morbidity compared to children of mothers without a primary occupation. Low weight at birth and rural residence are likely to increase the likelihood of a diarrheal disease in children under five in Mali. Children living in rural areas were 1.3 (2001 DHS) and 1.5 (2006 DHS) more likely to have a diarrheal disease compared to children living in urban areas (Appendix 2).

The effect (Table 3) of variables quality of the main floor material, the types of toilet, and the source of drinking water in Mali is significant for the explanation of diarrheal morbidity in children under five. Children in households using traditional toilets and those of households without toilets are at higher risk for diarrheal disease compared to children from households using a flush toilet or upgraded latrine. Regarding Nigeria, the variables related to the child (age, sex, and weight at birth) are factors associated with diarrheal morbidity in children under five. The results also find that variables related to the mother (occupation and education level) and socioeconomic variables (electricity in the household and the possession of goods such as refrigerators and televisions) are associated with diarrheal morbidity.

Age of the child and birth weight are significantly associated with diarrheal disease in children under five in Niger. Children who had a low birth weight are between 1.2 to 1.4 times more likely to have a diarrheal disease compared to children who had a normal birth weight (Appendix 2).

Table 7.3: Significant Variables from the Multi-Level Logistic Regression (cf. Appendix 2 for full table)

Country	1990-1995	1996-2001	2002-2008	2009-2012	2013
Burkina Faso	1993	1999	2003	2010	
	-Quality of the main floor material** -Sex of the child** -Child's age (mth)*** - Size of the child at birth**	-Mother's occupation** -Child's age (mth)***	-Household size** -Has a bicycle* -Sex of the child** -Child's age (mth)*** -Has a measles vaccine* - Size of the child at birth**	-Mother's occupation** -Type of toilet* -Child's age (mth)*** - Size of the child at birth***	
Mali	1995	2001	2006	2012	
	-Mother's occupation** -Mother's education level * -Quality of the main floor material*** -Child's age (mth)*** - Size of the child at birth*	-Household size* -Place of residence* -Mother's occupation** -Has a bicycle** -Type of toilet** -Sources of drinking water** -Child's age (mth)***	-Place of residence** -Mother's occupation* -Child's age (mth)*** -Has a measles vaccine* - Size of the child at birth**	-Mother's occupation*** -Type of toilet* -Child's age (mth)***	
Nigeria	1990	1999	2003	2008	2013
	-Place of residence** -Mother's occupation** -Mother's education level * -Has electricity* -Has a refrigerator* -Type of toilet** -Sex of the child** -Child's age (mth)*** - Size of the child at birth*	-Mother's occupation* -Mother's education level * -Child's age (mth)***	-Mother's occupation* -Mother's education level * -Quality of the main floor material** -Sex of the child* -Child's age (mth)*** - Size of the child at birth**	-Mother's education level * -Has electricity* -Has a television* -Type of toilet** -Quality of the main floor material** -Sources of drinking water** -Sex of the child*** -Child's age (mth)*** - Size of the child at birth**	-Type of toilet** -Child's age (mth)*** - Size of the child at birth**
Niger	1992	1998	2006	2012	
	-Sex of the head of the HH* -Place of residence* -Mother's occupation** -Mother's education level ** -Child's age (mth)*** - Size of the child at birth**	-Mother's occupation** -Quality of the main floor material* -Child's age (mth)***	-Mother's occupation** -Mother's education level* -Child's age (mth)*** - Size of the child at birth*	-Household size* -Mother's occupation** -Quality of the main floor material** -Child's age (mth)*** - Size of the child at birth*	

**=p-value<0.05; **=p-value <0.01; ***=p-value <0.001*

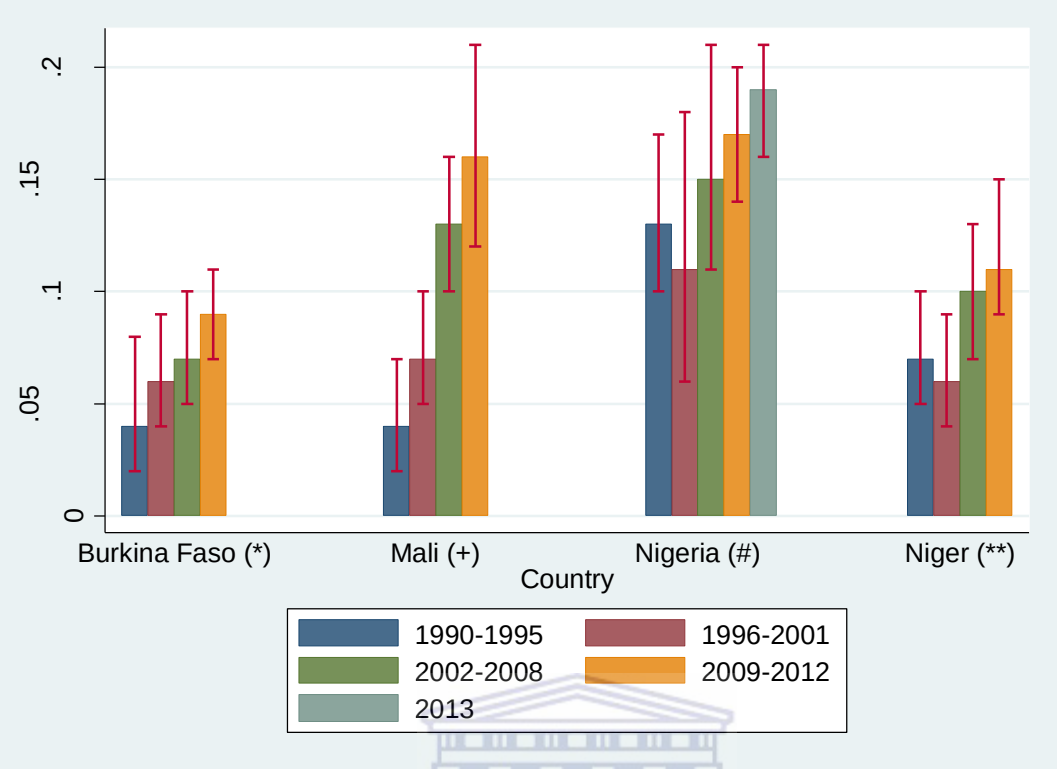
Table 7.4 and Figure 7.2 present the random effect estimates of the multilevel regression analysis of diarrheal morbidity of each country. The ICC value allows us to analyse the neighbourhood disparities in diarrheal morbidity. As shown in Figure 7.2, Nigeria (0.19) and Mali (0.16) are the countries where we observe large neighbourhood disparities in diarrheal morbidity in children under five. Low diarrheal morbidity inequalities are recorded in Burkina Faso (0.09). The analysis shows an increasing trend of diarrheal inequalities according to DHS rounds. In Burkina Faso, the value of the ICC was 0.04 for the 1993 DHS, while it was 0.09 in 2010 DHS; in Mali, the ICC increased from 0.04 in 1995 to 0.16 in 2012; in Nigeria, ICC increased from 0.13 in 1990 to 0.19 in 2013; and in Niger, ICC increased from 0.07 in 1992 to 0.11 in 2012. These results show that the neighbourhood disparities of diarrheal morbidity among children under five years have increased in all four countries.

Table 7.4: Random Effects of the Multilevel Logistic Regression

Country	Random Effects	**1990-1995**	**1996-2001**	**2002-2008**	**2009-2012**	**2013**
Burkina	***Community Level SD***	0.39 (0.29; 0.54)	0.46 (0.36; 0.58)	0.50 (0.43; 0.59)	0.56 (0.49; 0.65)	
	ICC[1]	0.04 (0.2; 0.08)	0.06 (0.04; 0.09)	0.07 (0.05; 0.10)	0.09 (0.07; 0.11)	
Mali	***Community Level SD***	0.37 (0.28; 0.50)	0.50(0.43; 0.59)	0.70 (0.60; 0.80)	0.80 (0.70; 0.93)	
	ICC	0.04 (0.02; 0.07)	0.07 (0.05; 0.10)	0.13 (0.10; 0.16)	0.16 (0.12; 0.21)	
Nigeria	***Community Level SD***	0.71 (0.60; 0.84)	0.63 (0.47; 0.84)	0.77 (0.6; 0.9)	0.82 (0.75; 0.91)	0.87 (0.80; 0.95)
	ICC	0.13 (0.10; 0.17)	0.11 (0.06; 0.18)	0.15 (0.11; 0.21)	0.17 (0.14; 0.20)	0.19 (0.16; 0.21)
Niger	***Community Level SD***	0.50(0.40; 0.60)	0.43 (0.35; 0.56)	0.60 (0.51; 0.70)	0.65 (0.56; 0.75)	
	ICC	0.07 (0.05; 0.10)	0.06 (0.04; 0.09)	0.10 (0.07; 0.13)	0.11(0.09; 0.15)	

ICC[1] = intraclass correlation coefficient

Figure 7.2: Trend of Intra-class Correlation by Country



(*) =Burkina DHS 1993, 1999, 2003, 2010
(+)=Mali DHS 1995, 2001, 2006, 2012
(#)=Nigeria DHS 1990, 1999, 2003, 2008, 2013
(**)= Niger DHS 1992, 1998, 2006, 2012

7.4 Discussion

Main findings

The findings showed that the proportion of diarrheal morbidity among children under five years old varied considerably across the cohorts of birth from 10 to 35%, and we also observed large variations in the proportions of diarrheal morbidity across countries. The proportions of diarrheal morbidity are higher in Niger compared to Burkina, Mali, and Nigeria, where lower proportions were reported. Studies showed that mortality due to diarrheal diseases among children under five in low- and middle-incomes countries has declined about 30% over the past two decades (Fischer Walker et al., 2012).

Our results showed that risk factors of diarrheal morbidity varied from one country to another, but the main factors included: child's age, size of the child at birth, the quality of the main floor material, mother's education and her occupation, type of toilet, and place of residence. We observed high neighborhood disparities in diarrheal morbidity in Nigeria and Mali and low neighborhood disparities in Niger and Burkina Faso.

Strengths and limitations

Previous studies on risk factors for diarrheal morbidity and mortality in low- and middle-income countries often were interested in individual factors. This study used data from all DHS rounds conducted in Burkina Faso, Mali, Nigeria, and Niger during the 1990-to-2013 period, corresponding to cohorts of children born between 1986 and 2013. The use of these rounds of DHS data allowed the researchers first to study the trend of the prevalence of diarrheal morbidity among children under five years and, second, to make a comparative analysis across countries. One of the strengths of this study is to have investigated and quantified the magnitude of neighborhood inequalities in diarrheal morbidity in the selected countries of our study. Diarrheal morbidity in the DHS was captured by asking mothers if their children had had diarrhea in the two weeks preceding the survey and, if so, whether there was blood in the stool. This methodology, based on the mother's statement, contained deficiencies related to problems of recall (two weeks) on the one hand and, on the other, the problems associated with the uncertainty of the mother's statement on the state of her child's health.

Interpretation of the results

Previous studies have shown that during the last three decades, thanks to the introduction of

oral rehydration solutions and zinc supplementation in the treatment of diarrhea, the prevalence of diarrheal diseases has been reduced drastically in low-income countries (Ramanaiah et al., 2015; Santosham et al., 2010). Santosham et al (2010) showed that with the distribution of oral solutions, the number of child deaths due to diarrhea dropped from 4.6 million in 1980 to 3.3 million in 1990 and to 1.3 million in 2008. These significant declines recorded in the different countries would be the result of action undertaken since the late 1970s to fight against diarrheal diseases through the introduction of drugs and, especially, through awareness and promotion of hygiene. Important activities have been undertaken including: training of health workers, participation of religious leaders, educational campaigns in schools, and modifications to the use of oral rehydration formulations to fit local traditions and beliefs. Mass media campaigns have been set up around the world, and many political leaders and celebrities have endorsed the use of oral rehydration solution (Santosham et al., 2010). In the Niger, we found an increased proportion of diarrheal morbidity among the children born after 2010. This result was not expected given the politic against diarrheal diseases through the distribution of oral rehydration salts, with low-osmolarity salts introduced in 2006 in Niger(Page et al., 2011).

We found that child's age is a risk factor of diarrheal morbidity, and its effect is significant for all countries and for each of the rounds of DHS. The results showed that children age 7 to 36 months are more likely to experience diarrheal disease than children of 0 to 6 months, and after 36 months, the risk of suffering from a diarrheal disease becomes low. Similar results were found in Ethiopia (Regassa, Birke, Deboch, & Belachew, 2008), Iraq(Siziya, Muula, & Rudatsikira, 2009) , Egypt (Miller, 2015), Turkey(Bozkurt, Özgür, & Özçirpici, 2003), and India (Awasthi & Agarwal, 2003; Lakshminarayanan & Jayalakshmy, 2015). It seems that children age 6 to 36 months have an immune system not yet sufficiently developed to protect against the diseases compared to children age less than 6 months who benefit directly from their mother's immune system (Siziya et al., 2009). We also found that children with a small size (low weight) at birth are more likely to have been reported as having been associated with diarrheal morbidity than children who had a large size at birth. Results of earlier studies have shown that malnutrition and underweight in children are risk factors in diarrheal morbidity (Cheung, Jalil, Yip, & Karlberg, 2001; Mohammod J. Chisti et al., 2007; Mohammod J. Chisti, Pietroni, Smith, Bardhan, & Salam, 2011; Mohammod Jobayer Chisti et al., 2009).

According to the results of the present study, in Burkina Faso (1993 and 2003 DHS) and in

Nigeria (1990, 2003, and 2003 DHS), male children are more likely to have been reported as being associated with diarrheal morbidity than female children. Similar results were found in previous studies (Bozkurt et al., 2003; Dessalegn, Kumie, & Tefera, 2012; Kumar & Subitha, 2012; Lakshminarayanan & Jayalakshmy, 2015; Melo et al., 2008; Siziya et al., 2009). This result is not surprising as the results of both morbidity and mortality studies of children under five in sub-Saharan countries often have found an excess mortality in male children in early life (Bado & Appunni, 2015; Case, 2004; Wells, 2000). Studies carried out in developing countries reveal that mother's education level is an important factor of diarrheal morbidity and death among children under five years old, and children from less-educated mothers are more likely to experience diarrheal diseases than children of more-educated mothers(Howard, de Pee, Sari, Bloem, & Semba, 2007; Nakawesi, Wobudeya, Ndeezi, Mworozi, & Tumwine, 2010; Siziya et al., 2009).

Maternal education and her occupation are factors that provide information about the level of autonomy of the woman who could empower herself to take care of her child. The effect of the quality of the immediate environment as a risk factor in diarrheal morbidity in children under five years was revealed as significant in previous studies (Dessalegn et al., 2012; Kumar & Subitha, 2012; Mbonye, 2004; Mekasha & Tesfahun, 2003; Regassa et al., 2008). We found that the poor quality of main floor material (in Burkina, Mali, Niger, and Nigeria), the type of latrine used (in Mali and Nigeria), and the source of drinking water (in Mali and Nigeria) are associated significantly with the risk of diarrheal morbidity.

Our study found high neighborhood inequalities in diarrheal morbidity in the selected countries, while the results showed a decline in the overall prevalence of diarrhea morbidity among children under five. These neighborhood inequalities show that the decline in prevalence of diarrheal morbidity hides huge disparities among neighborhoods and villages in the countries under study. These results inform us that in some villages or neighborhoods in big cities, the prevalence of diarrheal diseases has lowered greatly, while for some neighborhoods or villages, the proportions of diarrheal morbidity are still high. Neighborhood inequalities observed may be explained in part by the quality of the immediate environment and the poor quality of the drinking water experienced in some villages and suburbs around large cities.

7.5 Conclusion

In this study, we identified a decrease in the proportions of diarrheal morbidity among children under five in Burkina Faso, Mali, Nigeria, and Niger during the period between 1990 and 2013. However, we have observed a growing trend of inequalities among neighborhoods and villages of countries selected for the study. This result shows that the decline in the prevalence of diarrheal morbidity is not uniform in the different villages and neighborhoods, and in some places, children under five still suffer from the burden of diarrheal disease. This suggests the need to fight against diarrheal diseases on both the local and community level across villages and countries. Successful implementation of an integrated plan requires the commitment of families, health-care providers, and key actors in water and sanitation.

7.6 References

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7.7 Appendices

Appendix 1: Determinant Variables in Bivariate Analysis

	Burkina Faso							
Variable	**1993**		**1998**		**2003**		**2010**	
	No	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**
n	***4089***	***1010***	***4,056***	***1,015***	***7,485***	***1,876***	***11,685***	***2,031***
Household size		**ns**	**ns**			*******		*******
1-3	78.7	21.3	78.7	21.3	72.6	27.4	81.3	18.7
4-6	79.3	20.7	81.6	18.4	80.8	19.2	85.6	14.4
7&+	80.7	19.3	79.4	20.6	80.3	19.7	85.5	14.5
Sex of the head of		**ns**		**ns**		**ns**		**ns**
Male	80.0	20.0	80.0	20.0	80.11	19.89	85.3	14.8
Female	83.8	16.3	80.5	19.5	76.82	23.18	84.4	15.6
Age of the mother		**ns**		**ns**		**ns**		******
15-19	76.2	23.8	76.9	23.1	76.5	23.5	80.0	20.0
20-24	79.5	20.6	78.0	22.1	78.6	21.4	84.2	15.8
25-29	80.4	19.6	80.6	19.4	81.0	19.0	85.6	14.4
30-34	81.1	18.9	81.1	18.9	80.5	19.5	85.9	14.1
35-39	81.8	18.2	80.6	19.4	80.3	19.7	86.0	14.0
40-44	79.6	20.4	82.8	17.2	81.2	18.8	85.6	14.4
45-49	78.2	21.8	78.1	22.0	78.9	21.1	88.5	11.5
Place of residence		**ns**		**ns**		**ns**		**ns**
Urban	81.4	18.6	80.3	19.7	80.2	19.8	84.7	15.3
Rural	79.6	20.5	79.9	20.1	79.9	20.1	85.3	14.7
Mother Occupation		**ns**		**ns**		**ns**		**ns**
Not working	81.5	18.5	82.6	17.4	77.8	22.2	86.4	13.6
Sale	78.9	21.1	79.7	20.3	79.7	20.3	84.9	15.1
Agriculter	78.5	21.5	78.8	21.2	80.4	19.6	85.3	14.8
Manual	81.4	18.6	80.6	19.4	77.9	22.1	83.4	16.6
Mother's education level		**ns**		**ns**		**ns**		******
No Education	80.0	20.0	80.1	19.9	80.0	20.0	85.6	14.4
1-6 years	79.3	20.7	78.5	21.5	78.1	22.0	82.6	17.4
7&+ years	85.2	14.8	80.9	19.1	83.1	16.9	84.4	15.6
Has Electricity		**ns**		**ns**		**ns**		**ns**
No	79.8	20.2	79.8	20.3	79.8	20.2	85.2	14.8
Yes	83.4	16.6	83.5	16.5	82.4	17.6	84.8	15.2
Has Television		**ns**		**ns**		**ns**		**ns**
No	79.9	20.1	79.9	20.1	79.7	20.3	85.2	14.8
Yes	83.4	16.6	81.6	18.4	82.3	17.7	85.3	14.7
Has Refrigerator		**ns**		**ns**		*****		*****
No	80.0	20.0	80.0	20.0	79.8	20.2	85.1	14.9
Yes	85.1	15.0	79.0	21.1	85.2	14.8	87.6	12.4
Has Bicycle		**ns**		**ns**		*****		*****
No	80.1	19.9	77.9	22.1	77.6	22.4	83.0	17.0
Yes	80.2	19.8	80.4	19.6	80.4	19.6	85.5	14.6
Has Motorcycle		**ns**		**ns**		**ns**		**ns**
No	79.3	20.7	79.9	20.1	79.5	20.5	84.9	15.1
Yes	81.6	18.5	80.1	19.9	81.2	18.8	85.7	14.3
Immediat environment and								
Type of toilette		**ns**		**ns**		**ns**		**ns**
Flush/upgraded latrin	85.7	14.3	72.4	27.6	72.4	27.6	78.9	21.1
Traditional latrines	80.7	19.3	78.8	21.2	79.4	20.6	84.9	15.1
Lack of toilet	79.8	20.2	80.7	19.4	80.2	19.8	85.5	14.6
Other type	78.3	21.7	74.7	25.3	81.4	18.6	85.1	14.9
Quality of Main floor		*******		**ns**		**ns**		**ns**
Poor	78.6	21.5	79.9	20.2	79.5	20.5	85.8	14.2
Middle	82.6	17.4	80.5	19.5	80.8	19.2	84.5	15.5
Rich	82.6	17.4	75.0	25.0	79.4	20.6	83.2	16.8
Sources of drinking water		**ns**		**ns**		**ns**		**ns**

Piped/Public tap/stan	80.5	19.5	79.1	20.9	79.7	20.3	84.4	15.6
Tube well or borehole	80.0	20.0	80.3	19.7	80.5	19.5	85.6	14.4
Well	83.5	16.5	79.6	20.4	79.7	20.3	85.1	14.9
Spring/river/lake/other	78.7	21.3	77.2	22.8	80.0	20.0	85.0	15.1
Child level variables								
Sex of the child		**		ns		***		ns
Female	81.75	18.25	80.3	19.7	81.3	18.7	85.4	14.6
Male	78.65	21.35	79.7	20.3	78.7	21.3	85.0	15.0
Age in months		***		***		***		***
0-6	82.07	17.93	85.1	14.9	84.3	15.8	89.1	10.9
07-12	71.22	28.78	67.8	32.2	68.8	31.2	76.4	23.6
13-18	64.49	35.51	68.4	31.6	68.2	31.8	73.4	26.7
19-24	74.64	25.36	71.4	28.6	71.2	28.8	78.7	21.3
25-30	74.79	25.21	75.0	25.1	73.4	26.6	80.7	19.3
31-36	78.91	21.09	77.5	22.5	81.6	18.4	85.5	14.6
37-42	85.79	14.21	83.6	16.4	84.4	15.6	90.1	9.9
42-48	86.78	13.22	87.4	12.7	87.4	12.6	92.4	7.6
48-59	93.62	6.38	92.4	7.6	91.4	8.7	94.6	5.4
Has Measles vaccine		***		***		***		ns
No	77.42	22.58	78.4	21.6	78.1	21.9	85.4	14.7
Yes	82.12	17.88	81.7	18.3	81.7	18.4	85.1	14.9
Size of child at birth		ns		ns		***		***
Large	80.52	19.48	78.7	21.3	78.3	21.8	83.2	16.8
Average	81.2	18.8	81.5	18.5	81.3	18.7	86.7	13.3
Small	77.19	22.81	78.6	21.4	77.8	22.2	83.1	16.9
DK (Don't know)	81.75	18.25	92.9	7.1	89.3	10.7	93.8	6.3

**=p-value<0.05; **=p-value <0.01; ***=p-value <0.001, ns= no significant*

Appendix 1: Determinant Variables in Bivariate Analysis (Count…)

	Mali							
Variable	**1995**		**2001**		**2006**		**2012**	
	No	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**
n	***3,857***	***1,374***	***8,872***		***10,938***	***1,450***	***8,738***	***844***
Household size		**ns**		***		**		**ns**
1-3	76.0	24.1	75.3	24.7	85.6	14.4	90.1	9.9
4-6	72.7	27.3	80.3	19.7	88.9	11.1	91.2	8.8
7&+	74.1	26.0	81.2	18.8	88.3	11.7	91.3	8.7
Sex of the head of household		**ns**		**ns**		**ns**		**ns**
Male	73.8	26.2	80.2	19.8	88.5	11.5	91.1	8.9
Female	73.1	26.9	81.3	18.7	86.3	13.7	92.3	7.7
Age of the mother		*		***		**ns**		**ns**
15-19	76.7	23.3	76.7	23.3	86.4	13.6	89.1	10.9
20-24	75.0	25.0	79.9	20.1	87.9	12.1	90.9	9.1
25-29	75.4	24.7	81.6	18.4	88.3	11.7	91.6	8.4
30-34	71.9	28.2	79.5	20.5	88.7	11.3	91.9	8.1
35-39	72.2	27.8	81.2	18.8	88.8	11.2	90.4	9.6
40-44	68.9	31.1	79.4	20.6	89.7	10.3	91.4	8.6
45-49	64.7	35.3	84.7	15.4	88.8	11.2	94.4	5.6
Place of residence		**		***		***		**ns**
Urban	76.3	23.7	85.3	14.8	91.5	8.5	90.3	9.7
Rural	72.6	27.4	78.9	21.1	86.9	13.1	91.5	8.5
Mother Occupation		**		***		***		***
Not working	76.1	23.9	80.6	19.4	90.8	9.24	94.0	6.0
Sale	72.2	27.8	82.5	17.5	88.3	11.66	87.8	12.2
Agriculter	70.4	29.6	79.4	20.6	-	-	87.6	12.4
Manual	74.4	25.6	76.8	23.3	86.0	14.04	89.2	10.9
Mother's education level		***		**ns**		**ns**		***
No Education	72.4	27.6	79.9	20.1	88.1	12.0	91.7	8.3
1-6 years	79.5	20.5	81.6	18.4	88.9	11.1	89.2	10.8
7&+ years	85.0	15.0	83.7	16.3	90.9	9.1	88.4	11.6
Has Electricity		***		***		***		**ns**
No	73.1	26.9	79.6	20.4	87.5	12.5	91.5	8.5
Yes	82.6	17.4	86.1	14.0	92.5	7.5	90.4	9.6
Has Television		***		***		***		**ns**
No	72.7	27.3	79.3	20.7	87.3	12.7	91.4	8.6
Yes	83.8	16.2	85.8	14.2	91.4	8.7	90.7	9.3
Has Refrigerator		***		***		*		**ns**
No	73.4	26.7	79.9	20.1	88.2	11.8	91.3	8.7
Yes	85.2	14.8	86.5	13.5	91.8	8.2	89.5	10.5
Has Bicycle		**ns**		***		**		**ns**
No	73.3	26.7	78.0	22.0	89.1	10.9	91.2	8.8
Yes	74.3	25.7	82.3	17.7	87.5	12.5	91.2	8.8
Has Motorcycle		**ns**		***		**		**ns**
No	73.2	26.8	79.5	20.5	87.7	12.3	91.2	8.8
Yes	75.7	24.3	82.7	17.3	89.3	10.7	91.2	8.8
Immediat environment and hygiene								
Type of toilette		***		***		**ns**		**ns**
Flush/upgraded latrin	88.6	11.4	86.6	13.4	92.1	7.9	92.5	7.6
Traditional latrines	75.2	24.8	81.3	18.7	88.3	11.7	91.2	8.8
Lack of toilet	69.2	30.8	75.3	24.7	88.0	12.0	90.2	9.8
Other type	84.9	15.2	81.5	18.5	89.2	10.8	90.1	9.9
Quality of Main floor material		***		***		***		**
Poor	71.6	28.4	79.2	20.9	87.7	12.3	91.7	8.3
Middle	81.9	18.1	85.6	14.4	90.1	9.9	90.0	10.0
Rich	82.0	18.0	82.5	17.5	91.6	8.4	88.8	11.2
Sources of drinking water		**		***		***		***
Piped/Public tap/stan	75.1	25.0	84.6	15.4	91.1	8.9	89.4	10.6
Tube well or borehole	73.8	26.2	79.2	20.8	-	-	92.3	7.7
Well	63.1	36.9	80.4	19.6	87.5	12.6	91.6	8.4

Spring/river/lake/other	81.8	18.2	73.6	26.4	87.5	12.5	93.9	6.2
Child level variables								
Sex of the child		**ns**		**ns**		**ns**		*****
Female	74.6	25.4	81.0	19.1	88.7	11.3	91.8	8.2
Male	72.9	27.1	79.6	20.4	87.9	12.1	90.6	9.4
Age in months		*******		*******		*******		*******
0-6	84.5	15.6	82.8	17.2	93.2	6.8	92.5	7.5
07-12	68.5	31.5	69.0	31.0	79.9	20.1	85.8	14.2
13-18	65.9	34.1	71.5	28.5	80.4	19.6	84.7	15.3
19-24	69.7	30.3	73.4	26.6	81.0	19.1	88.8	11.2
25-30	74.0	26.0	77.5	22.6	86.8	13.2	90.1	9.9
31-36	75.0	25.0	80.0	20.0	89.4	10.6	92.5	7.5
37-42	-	-	85.6	14.4	90.3	9.8	93.3	6.7
42-48	-	-	86.1	13.9	94.7	5.3	94.4	5.6
48-59	-	-	90.1	10.0	95.3	4.7	94.8	5.2
Has Measles vaccine		**ns**		*******		**ns**		******
No	74.5	25.5	78.1	21.9	87.7	12.3	92.3	7.8
Yes	72.5	27.5	83.3	16.7	88.8	11.2	90.5	9.5
Size of child at birth		*******		*******		*******		*****
Large	73.2	26.8	80.9	19.1	88.8	11.2	90.7	9.3
Average	75.2	24.8	81.5	18.5	88.9	11.1	91.0	9.1
Small	69.9	30.1	76.8	23.2	85.4	14.6	92.5	7.6
DK (Don't know)	87.7	12.3	82.3	17.7	93.3	6.7	94.4	5.6

**=p-value<0.05; **=p-value <0.01; ***=p-value <0.001, ns= no significant*

Appendix 1: Determinant Variables in Bivariate Analysis (Count…)

	Nigeria									
Variable	**1990**		**1999**		**2003**		**2008**		**2013**	
	No	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**
n	***5,704***	***1,119***	***2,648***	***491***	***4,234***	***929***	***22,801***	***2,645***	***25,628***	***2,968***
Household size		**ns**		**ns**		**ns**		*******		*******
1-3	80.8	19.3	85.3	14.7	81.9	18.1	89.1	10.9	89.1	11.0
4-6	84.2	15.8	85.6	14.4	82.5	17.5	90.9	9.1	91.0	9.0
7&+	83.6	16.4	83.0	17.1	81.6	18.4	88.5	11.5	88.5	11.5
Sex of the head of		**ns**		*******		**ns**		*******		*******
Male	83.5	16.6	83.9	16.1	81.7	18.3	89.3	10.7	89.4	10.6
Female	85.5	14.5	89.2	10.8	85.2	14.8	92.7	7.3	91.6	8.4
Age of the mother		*******		**ns**		*****		*******		*******
15-19	76.1	23.9	83.6	16.4	77.3	22.7	85.0	15.0	85.8	14.2
20-24	82.5	17.5	82.7	17.3	80.1	19.9	88.9	11.1	88.2	11.8
25-29	83.3	16.7	86.1	13.9	82.3	17.7	90.1	9.9	89.7	10.3
30-34	85.5	14.5	84.4	15.6	82.3	17.7	90.5	9.5	90.6	9.5
35-39	85.4	14.6	83.3	16.7	84.6	15.4	90.1	9.9	90.0	10.0
40-44	86.9	13.1	85.3	14.7	85.2	14.8	89.6	10.4	92.0	8.0
45-49	78.1	21.9	87.5	12.5	80.4	19.6	89.1	11.0	89.2	10.8
Place of residence		*******		**ns**		*******		*******		*******
Urban	90.1	9.9	85.5	14.5	85.2	14.8	91.1	8.9	91.0	9.0
Rural	79.9	20.1	83.9	16.1	80.2	19.8	89.0	11.0	88.9	11.1
Mother Occupation		*******		*******		**ns**		*******		*******
Not working	81.4	18.6	83.5	16.5	81.3	18.8	89.4	10.7	88.3	11.7
Sale	83.0	17.1	85.2	14.8	81.2	18.8	88.9	11.1	90.4	9.6
Agriculter	85.5	14.5	81.2	18.8	84.5	15.6	91.0	9.0	90.6	9.4
Manual	89.7	10.3	88.1	11.9	83.5	16.6	89.7	10.3	89.4	10.6
Mother's education		*******		*******		*******		*******		*******
No Education	80.6	19.4	81.5	18.5	77.2	22.8	86.6	13.4	87.5	12.5
1-6 years	85.4	14.6	86.0	14.0	84.7	15.4	90.9	9.2	89.9	10.1
7&+ years	91.6	8.4	87.9	12.1	88.2	11.8	93.9	6.1	92.3	7.7
Has Electricity		*******		*******		*******		*******		*******
No	79.8	20.2	83.0	17.0	79.4	20.6	88.0	12.0	88.0	12.0
Yes	90.4	9.6	86.3	13.8	85.0	15.1	92.1	8.0	91.4	8.6
Has Television		*******		*******		*******		*******		*******
No	81.1	18.9	83.6	16.4	80.1	19.9	88.0	12.0	87.9	12.1
Yes	90.5	9.5	86.6	13.4	86.5	13.5	93.1	7.0	91.9	8.1
Has Refrigerator		*******		*******		*******		*******		*******
No	82.4	17.6	83.8	16.2	81.0	19.0	89.0	11.0	89.0	11.0
Yes	90.3	9.8	87.6	12.4	87.2	12.8	94.0	6.0	92.7	7.4
Has Bicycle		*******		**ns**		*******		*******		*******
No	84.6	15.4	84.6	15.4	84.0	16.0	90.3	9.7	89.9	10.1
Yes	81.3	18.7	83.7	16.3	79.1	20.9	87.9	12.1	88.7	11.3
Has Motorcycle		**0.324**		**0.2**		**0.043**		**0.001**		**0.066**
No	83.4	16.6	84.7	15.3	81.5	18.5	89.2	10.8	89.9	10.1
Yes	84.5	15.5	82.5	17.5	84.2	15.8	90.5	9.5	89.2	10.8
Immediate										
Type of toilette		*******		*******		*******		*******		*******
Flush/upgraded latrin	94.4	5.6	88.5	11.5	90.2	9.8	95.6	4.4	93.4	6.6
Traditional latrines	83.0	17.0	83.0	17.0	80.2	19.9	87.4	12.6	88.3	11.7
Lack of toilet	80.3	19.7	86.6	13.4	82.8	17.2	90.5	9.5	89.3	10.7
Other type	81.6	18.4	77.2	22.8	85.1	14.9	95.0	5.0	95.6	4.5
Quality of Main floor		*******		*******		*******		*******		*******
Poor	81.3	18.7	84.5	15.5	77.4	22.6	86.7	13.3	87.6	12.4
Middle	85.3	14.7	84.0	16.0	82.9	17.1	91.3	8.7	90.9	9.1
Rich	86.1	13.9	96.7	3.3	89.7	10.3	95.0	5.0	92.0	8.0
Sources of drinking		*******		**ns**		*******		*******		*******
Piped/Public tap/stan	88.0	12.0	86.2	13.8	84.7	15.3	90.1	9.9	88.6	11.4
Tube well or borehole	79.4	20.6	83.1	16.9	77.7	22.3	90.7	9.3	91.2	8.8

Well	82.7	17.3	84.4	15.6	87.5	12.5	87.6	12.4	88.5	11.5
Spring/river/lake/other	91.6	8.4	84.3	15.7	81.8	18.2	91.0	9.0	89.4	10.6
Child level variables										
Sex of the child		***		ns		*		**		ns
Female	84.8	15.2	84.2	15.8	83.1	16.9	90.1	9.9	89.7	10.4
Male	82.4	17.6	84.5	15.5	81.0	19.0	89.1	10.9	89.6	10.4
Age in months		***		***		***		**		***
0-6	87.0	13.0	90.6	9.4	84.6	15.4	92.0	8.0	92.8	7.2
07-12	72.4	27.6	80.1	19.9	74.0	26.0	83.4	16.6	82.6	17.4
13-18	71.8	28.2	81.0	19.1	71.3	28.7	82.8	17.2	83.3	16.7
19-24	77.1	23.0	82.0	18.0	71.8	28.3	86.4	13.6	85.1	14.9
25-30	80.8	19.2	86.2	13.8	78.9	21.1	88.5	11.5	89.0	11.0
31-36	84.3	15.7	86.8	13.3	83.0	17.0	91.8	8.2	90.0	10.0
37-42	90.9	9.1	-	-	86.1	13.9	91.4	8.6	92.6	7.4
42-48	91.3	8.7	-	-	90.2	9.8	93.8	6.2	93.5	6.5
48-59	92.1	8.0	-	-	92.9	7.1	94.4	5.6	94.8	5.2
Has Measles vaccine		***		ns		***		***		***
No	81.3	18.7	83.9	16.1	79.0	21.0	88.0	12.1	88.1	11.9
Yes	86.6	13.4	85.3	14.8	87.9	12.2	92.5	7.5	92.1	8.0
Size of child at birth		***		ns		***		***		***
Large	85.9	14.1	85.4	14.6	85.1	14.9	89.9	10.2	89.3	10.7
Average	83.4	16.6	83.9	16.1	80.9	19.1	90.5	9.5	91.1	8.9
Small	79.9	20.1	83.9	16.1	76.4	23.6	86.0	14.1	85.9	14.1
DK (Don't know)	75.6	24.4	79.1	20.9	69.7	30.3	94.3	5.7	95.6	4.4

**=p-value<0.05; **=p-value <0.01; ***=p-value <0.001, ns= no significant*

Appendix 1: Determinant Variables in Bivariate Analysis (Count…)

	Niger							
Variable	1992		1998		2006		2012	
	No	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**
n	***4,168***	***1,424***	***2,700***	***1,543***	***6,540***	***1,669***	***10,011***	***1,591***
Household size		**		ns		**		***
1-3	67.0	33.0	64.0	36.0	74.7	25.3	80.1	19.9
4-6	74.4	25.6	64.8	35.3	80.0	20.0	86.1	13.9
7&+	75.3	24.7	63.0	37.1	80.1	19.9	87.2	12.8
Sex of the head of		ns		ns		ns		ns
Male	74.6	25.4	63.4	36.7	80.0	20.0	86.3	13.7
Female	73.0	27.0	67.1	32.9	77.7	22.3	86.2	13.8
Age of the mother		**		ns		***		***
15-19	66.8	33.2	64.6	35.4	73.9	26.1	80.2	19.8
20-24	75.5	24.5	63.6	36.4	77.7	22.3	85.7	14.3
25-29	75.1	24.9	65.0	35.0	79.5	20.5	86.5	13.5
30-34	76.0	24.0	64.0	36.1	81.8	18.2	86.9	13.1
35-39	72.9	27.1	62.5	37.5	82.6	17.4	86.7	13.3
40-44	75.2	24.8	59.6	40.4	79.5	20.5	88.5	11.5
45-49	79.4	20.6	53.2	46.8	79.9	20.1	89.8	10.2
Place of residence		***		***		***		***
Urban	80.4	19.6	68.7	31.3	82.9	17.1	84.6	15.4
Rural	70.6	29.4	61.9	38.1	78.3	21.7	86.8	13.2
Mother Occupation		***		***		***		ns
Not working	75.8	24.2	66.2	33.8	80.9	19.1	86.6	13.4
Sale	76.8	23.2	59.7	40.3	79.9	20.2	86.3	13.7
Agriculter	67.5	32.5	60.6	39.4	74.9	25.2	82.5	17.5
Manual	71.2	28.8	68.2	31.8	80.2	19.8	84.5	15.5
Mother's education		***		***		***		***
No Education	73.5	26.5	62.7	37.3	78.7	21.3	86.8	13.2
1-6 years	77.8	22.2	65.9	34.1	82.6	17.4	84.1	15.9
7&+ years	85.9	14.1	75.3	24.7	87.8	12.2	83.1	16.9
Has Electricity		***		***		***		*
No	73.8	26.2	62.6	37.4	79.0	21.1	86.7	13.3
Yes	80.5	19.5	72.8	27.2	83.4	16.6	84.8	15.3
Has Television		***		***		***		***
No	73.6	26.5	63.0	37.0	79.0	21.1	86.6	13.4
Yes	82.4	17.6	72.3	27.7	84.8	15.2	84.6	15.4
Has Refrigerator		**		***		***		ns
No	74.2	25.9	63.2	36.8	79.2	20.8	86.3	13.7
Yes	81.0	19.1	75.0	25.0	88.2	11.8	86.2	13.9
Has Bicycle		ns		ns		***		ns
No	74.3	25.7	63.9	36.1	79.0	21.1	86.3	13.7
Yes	76.6	23.4	60.6	39.4	83.6	16.4	86.5	13.5
Has Motorcycle		**		***		ns		ns
No	74.1	25.9	63.1	36.9	79.4	20.6	86.4	13.6
Yes	80.2	19.8	73.1	26.9	82.0	18.1	85.5	14.5
Immediate environment								
Type of toilette		**		ns		***		*
Flush/upgraded latrin	83.3	16.7	71.2	28.9	87.7	12.3	86.5	13.5
Traditional latrines	80.7	19.3	69.0	31.0	82.5	17.5	84.9	15.1
Lack of toilet	71.4	28.6	62.0	38.0	78.4	21.6	86.9	13.1
Other type	72.1	27.9	35.3	64.7	78.5	21.5	82.0	18.0
Quality of Main floor		***		***		***		***
Poor	71.9	28.1	61.7	38.3	78.5	21.5	87.0	13.1
Middle	80.3	19.7	71.2	28.8	83.7	16.3	86.1	13.9
Rich	84.4	15.6	75.8	24.2	88.9	11.1	82.0	18.0
Sources of drinking		**		***		***		***
Piped/Public tap/stan	78.2	21.8	68.8	31.2	82.5	17.6	85.1	14.9
Tube well or borehole	70.8	29.2	61.9	38.1	-	-	85.8	14.2
Well	76.9	23.1	65.6	34.4	78.2	21.8	87.6	12.4

Spring/river/lake/other	83.2	16.8	63.6	36.4	82.4	17.6	79.9	20.1
Child level variables								
Sex of the child		**ns**		**ns**		**ns**		**ns**
Female	75.2	24.8	64.4	35.6	79.4	20.6	86.7	13.3
Male	73.9	26.1	62.9	37.1	79.9	20.1	85.8	14.2
Age in months		*******		*******		*******		*******
0-6	74.1	26.0	69.3	30.7	80.7	19.3	84.6	15.4
07-12	55.4	44.6	50.4	49.6	66.7	33.3	71.2	28.8
13-18	62.0	38.0	61.8	38.2	67.8	32.2	77.5	22.5
19-24	63.8	36.2	63.5	36.5	72.9	27.1	82.3	17.7
25-30	73.1	26.9	66.6	33.4	78.1	21.9	84.9	15.2
31-36	79.3	20.7	72.9	27.1	81.7	18.3	89.7	10.3
37-42	85.1	14.9			87.2	12.8	92.3	7.7
42-48	86.4	13.7			87.8	12.2	93.7	6.3
48-59	88.5	11.5			90.2	9.8	96.2	3.8
Has Measles vaccine		*******		**ns**		*******		*******
No	71.7	28.3	62.7	37.3	77.3	22.7	84.1	15.9
Yes	79.3	20.7	65.8	34.2	82.4	17.6	87.7	12.3
Size of child at birth		*******		**ns**		*******		*******
Large	78.2	21.8	63.1	36.9	79.6	20.4	85.5	14.5
Average	76.2	23.8	64.5	35.5	81.4	18.6	87.5	12.5
Small	69.5	30.5	62.5	37.5	75.5	24.5	83.5	16.5
DK (Don't know)	71.9	28.1	80.0	20.0	82.8	17.2	90.0	10.0

**=p-value<0.05; **=p-value <0.01; ***=p-value <0.001, ns= no significant*

Appendix 2: Multilevel Logistic Regression

	Burkina Faso			
	1992-93	**1998-99**	**2003**	**2010**
Variable	**AOR (95% CI)**	**AOR (95% CI)**	**AOR (95% CI)**	**AOR (95% CI)**
n				
Household size				
1-3	1	1	1	1
4-6	1.1 (0.8; 1.6)	0.9 (0.7; 1.3)	0.7** (0.6; 0.9)	0.8 (0.7;1.0)
7&+	1.1 (0.8; 1.5)	1.1 (0.8; 1.6)	0.8*(0.6; 0.9)	0.9 (0.7; 1.1)
Sex of the head of household				
Male	1	1	1	1
Female	0.8	0.9 (0.6; 1.3)	1.2 (0.9; 1.5)	0.9 (0.8; 1.2)
Age of the mother				
15-19	1	1	1	1
20-24	1.0 (0.7; 1.4)	1.1 (0.8; 1.5)	1.1 (0.8; 1.4)	0.9 (0.7; 1.2)
25-29	1.0 (0.7; 1.4)	1.0 (0.7; 1.4)	1.1 (0.8; 1.3)	0.9(0.7; 1.1)
30-34	1.0 (0.7; 1.4)	0.9 (0.6; 1.3)	1.1 (0.8; 1.4)	0.9 (0.7; 1.2)
35-39	1.0 (0.7; 1.4)	1.0 (0.7; 1.4)	1.1 (0.8; 1.4)	0.9 (0.7; 1.2)
40-44	1.1 (0.8; 1.7)	0.8 (0.5; 1.3)	1.0 (0.8; 1.4)	1.0(0.7; 1.3)
45-49	1.5 (0.9; 2.7)	1.4 (0.8; 2.4)	1.4 (0.9; 2.1)	0.8 (0.5; 1.3)
Place of residence				
Urban	1	1	1	1
Rural	0.9 (0.7; 1.3)	1.1 (0.7; 1.7)	1.1 (0.8;1.4)	1.0 (0.8; 1.3)
Mother Occupation				
Not working	1	1	1	1
Sale	1.2 (0.9; 1.4)	1.3*(1.03; 1.6)	0.9 (0.7; 1.1)	1.2*(1.02; 1.5)
Agriculter	1.2 (0.9; 1.6)	1.4** (1.1; 1.7)	0.8 (0.6; 1.0)	1.2*(1.02; 1.4)
Manual	1.1 (0.8; 1.4)	1.3 (0.9; 1.7)	1.0 (0.7; 1.5)	1.4**(1.1; 1.7)
Mother's education level				
No Education	1	1	1	1
1-6 years	1.2 (0.9; 1.6)	1.1 (0.8; 1.4)	1.1 (0.9; 1.3)	1.2(1.0; 1.4)
7&+ years	0.9 (0.6; 1.3)	0.9 (0.5; 1.4)	0.8 (0.5; 1.1)	1.0 (0.8; 1.3)
Has Electricity				
No	0.9 (0.6; 1.4)	0.5* (0.3; 0.8)	0.9 (0.7; 1.3)	0.9 (0.7; 1.3)
Yes	1	1	1	1
Has Television				
No	0.9 (0.6; 1.4)	0.9 (0.6; 1.4)	0.9 (0.6; 1.13)	0.9 (0.8; 1.1)
Yes	1	1	1	1
Has Refrigerator				
No	0.9 (0.5; 1.6)	1.6 (0.9; 3.1)	0.7 (0.5; 1.1)	0.8 (0.5; 1.2)
Yes	1	1	1	1
Has Bicycle				
No	0.9 (0.8; 1.2)	0.8* (0.6; 0.9)	0.9 (0.8; 1.1)	0.8 (0.7; 1.0)
Yes	1	1	1	1
Has Motorcycle				
No	0.9 (0.8; 1.13)	0.9 (0.8; 1.2)	0.9 (0.8; 1.1)	0.9 (0.8; 1.1)
Yes	1	1	1	1
Immediate environment and hygiene				
Type of toilette				
Flush/upgraded latrin	1	1	1	1
Traditional latrines	0.9 (0.4; 2.5)	0.8 (0.3; 2.3)	0.6 (0.3; 1.0)	0.6 (0.4; 1.0)
Lack of toilet	0.9 (0.4; 2.4)	0.6 (0.2; 1.9)	0.5(0.3; 0.9)	0.6*(0.3; 0.9)
Other type	0.9 (0.3; 3.4)	0.9 (0.3; 3.3)	0.4 (0.2; 9)	0.4*(0.2; 0.9)
Quality of Main floor material				
Poor	1	1	1	1
Middle	0.7** (0.6; 0.9)	1.0 (0.8; 1.2)	0.9 (0.8; 1.1)	1.1 (0.9; 1.2)
Rich	0.9 (0.4; 2.6)	1.9 (0.8; 4.8)	1.3 (0.7; 2.3)	0.9 (0.5; 1.8)
Sources of drinking water				
Piped/Public tap/stan	1	1	1	1
Tube well or borehole	0.8 (0.6; 1.1)	0.9 (0.6; 1.3)	0.9 (0.8; 1.1)	0.9 (0.8; 1.2)

Well	0.7 (0.4; 1.2)	0.8 (0.5; 1.4)	0.9 (0.7; 1.2)	1.0 (0.8; 1.2)
Spring/river/lake/other	1.1 (0.7; 1.8)	0.7 (0.3; 1.4)	0.9 (0.7; 1.2)	1.0 (0.8; 1.4)
Child level variables				
Sex of the child				
Female	1	1	1	1
Male	1.2**(1.1; 1.4)	1.1 (0.9; 1.2)	1.2** (1.1; 1.3)	1.0 (0.9; 1.1)
Age in months				
0-6	1	1	1	1
07-12	2.0***(1.5; 2.6)	2.8***(2.2; 3.8)	2.7***(2.2; 3.3)	2.7***(2.2; 3.3)
13-18	2.8***(2.1; 3.7)	2.8** (2.1; 3.8)	2.9***(2.3; 3.6)	3.2***(2.6; 4.1)
19-24	1.7***(1.2; 2.4)	2.5*** (1.8; 3.4)	2.5***(1.9; 3.1)	2.3***(1.8; 3.0)
25-30	1.6***(1.2; 2.2)	2.1*** (1.6; 2.9)	2.2***(1.7; 2.8)	2.0***(1.6; 2.6)
31-36	1.3 (0.9; 1.8)	1.7** (1.2; 2.3)	1.3* (1.0 ; 1.7)	1.4** (1.1; 1.9)
37-42	0.81 (0.6; 1.1)	1.1 (0.8; 1.6)	1.1 (0.8; 1.4)	0.9 (0.7; 1.2)
42-48	0.7 (0.5; 1.1)	0.8 (0.6; 1.2)	0.8 (0.9; 1.4)	0.7*(0.5; 0.9)
48-59	0.3***(0.2; 0.5)	0.5*** (0.3; 0.7)	0.5*** (0.4; 0.7)	0.5***(0.4; 0.6)
Has Measles vaccine				
No	0.9 (0.8; 1.1)	0.9 (0.8; 1.1)	0.9*(0.8; 0.9)	0.9(0.8; 1.1)
Yes	1	1	1	1
Size of child at birth				
Large	1	1		1
Average	0.9 (0.8; 1.1)	0.9 (0.7; 1.0)	0.8**(0.7; 0.9)	0.8***(0.7; 0.9)
Small	1.3**(1.1; 1.5)	1.0 (0.8; 1.2)	1.0 (0.8; 1.2)	1.0(0.9; 1.2)
DK (Don't know)	0.9 (0.6; 1.6)	0.3 (0.04; 2.4)	0.5*(0.3; 0.9)	0.5(0.2; 1.4)
Constant	0.2* (0.1; 0.6)	0.2* (0.1; 0.8)	0.6 (0.3; 1.1)	0.3**(.1; 0.5)
Community Level SD	0.39 (0.29; 0.54)	0.46 (0.36 ; 0.58)	0.50 (0.43; 0.59)	0.56 (0.49; 0.65)
ICC	0.04 (0.2; 0.08)	0.06 (0.04; 0.09)	0.07 (0.05; 0.10)	0.09 (0.07; 0.11)

Appendix 2: Multilevel Logistic Regression (Count…)

	Mali			
	1995	**2001**	**2006**	**2012**
Variable	**AOR (95%**	**AOR (95% CI)**	**AOR (95% CI)**	**AOR (95% CI)**
n				
Household size				
1-3	1	1	1	1
4-6	1.2 (0.9; 1.6)	0.8*(0.7; 0.9)	0.9 (0.7; 1.2)	1.0 (0.7; 1.4)
7&+	1.1 (0.9; 1.5)	0.8*(0.7; 0.9)	0.9 (0.7; 1.2)	0.9 (0.7; 1.3)
Sex of the head of household				
Male	1	1	1	1
Female	1.04 (0.8; 1.4)	0.9(0.7; 1.1)	1.2(0.9; 1.5)	1.0 (0.7; 1.4)
Age of the mother				
15-19	1	1	1	1
20-24	1.04 (0.8; 1.3)	0.9(0.8; 1.1)	1.0 (0.8; 1.3)	0.9 90.7; 1.2)
25-29	1.0 (0.8; 1.3)	0.9(0.7; 1.1)	1.1 (0.8; 1.4)	0.8 (0.6; 1.1)
30-34	1.1 (0.9; 1.5)	1.0(0.8; 1.3)	0.9 (0.8; 1.3)	0.8 (0.6; 1.1)
35-39	1.1 (0.8; 1.5)	0.9 (0.8; 1.2)	0.9 (0.7; 1.3)	0.9 (0.7; 1.4)
40-44	1.3(0.9; 1.8)	1.1(0.9; 1.5)	0.9 (0.7; 1.3)	0.9 (0.6; 1.3)
45-49	1.6 (0.9; 2.8)	0.8(0.5; 1.2)	1.1(0.7; 1.7)	0.6 (0.3; 1.2)
Place of residence				
Urban	1	1	1	1
Rural	0.9 (0.8; 1.2)	1.3*(1.1; 1.6)	1.5**(1.1; 1.9)	1.1 (0.8; 1.6)
Mother Occupation				
Not working	1		1	1
Sale	1.3**(1.1; 1.5)	1.1(0.9; 1.2)	1.3*(1.1; 1.5)	1.8***(1.5; 2.3)
Agriculter	1.2*(1.03; 1.5)	1.1(0.9; 1.3)	-	1.8***(1.4; 2.3)
Manual	1.1 (0.8; 1.4)	1.3**(1.1; 1.6)	1.4***(1.2;1.6)	1.8***(1.4; 2.3)
Mother's education level				
No Education	1	1	1	1
1-6 years	0.7 (0.6; 0.9)	0.9 (0.8; 1.2)	1.02 (0.8;1.3)	1.2 (0.9; 1.6)
7&+ years	0.6*(0.4; 0.9)	1.1(10.8; 1.5)	1.1 (0.8; 1.5)	1.3 (0.9; 1.7)
Has Electricity				
No	0.9 (0.6; 1.4)	1.0 (0.8; 1.3)	0.8 (0.6; 1.1)	1.1 (0.8; 1.4)
Yes	1	1	1	1
Has Television				
No	0.7 (0.5; 1.02)	0.9(0.7; 1.1)	0.9 90.7; 1.04)	0.9 (0.7; 1.1)
Yes	1	1	1	1
Has Refrigerator				
No	0.9(0.5; 1.5)	1.1 (0.8; 1.6)	1.3 (0.8; 1.9)	1.0 (0.7; 1.5)
Yes	1	1	1	1
Has Bicycle				
No	0.9(0.8; 1.05)	0.8**(0.7; 0.9)	1.0 (0.9; 1.2)	0.9 (0.8; 1.2)
Yes	1	1	1	1
Has Motorcycle				
No	1.2(0.9; 1.4)	1.0(0.9; 1.1)	0.9 (0.8; 1.1)	0.9 (0.8; 1.1)
Yes	1	1	1	1
Immediate environment and hygiene				
Type of toilette				
Flush/upgraded latrin	1	1	1	1
Traditional latrines	1.7 (0.5; 5.1)	1.4*(1.1; 1.9)	1.4 (0.8; 2.4)	1.2 (0.9; 1.7)
Lack of toilet	1.9 (0.6; 6.1)	1.7***(1.2; 2.3)	1.4 (0.8; 2.4)	1.5*(1.02; 2.3)
Other type	0.6 (0.1; 3.7)	1.2 (0.9; 1.1)	1.1 (0.5; 2.5)	1.3 (0.5; 3.1)
Quality of Main floor material				
Poor	1	1	1	1
Middle	0.6***(0.5;	0.8*(0.6; 0.9)	0.9 (0.8; 1.2)	1.1 (0.8; 1.3)
Rich	0.9 (0.4; 2.2)	1.1 (0.6; 1.7)	1.1 (0.6; 1.9)	1.3(0.8; 2.0)
Sources of drinking water				
Piped/Public tap/stan	1	1	1	1
Tube well or borehole	0.8 (0.7; 1.1)	1.3**(1.1; 1.5)	-	0.8 (0.6; 1.04)
Well	1.3 (0.8; 2.0)	1.2(0.9; 1.4)	1.0 (0.8; 1.2)	0.8 (0.6; 1.1)

Spring/river/lake/other	1.3(0.3; 5.8)	1.7***(1.3; 2.2)	0.9 (0.7; 1.3)	0.8(0.4; 1.3)
Child level variables				
Sex of the child				
Female	1	1	1	1
Male	1.1 (0.9; 1.2)	1.1 (0.9; 1.2)	1.1 (0.9; 1.2)	1.2(0.9; 1.3)
Age in months				
0-6	1	1	1	1
07-12	2.6*** (2.1;	2.4***(2.0; 2.9)	3.7***(2.9; 4.7)	2.0***(1.4; 2.7)
13-18	2.9***(2.3;	2.2***(1.8; 2.6)	3.6***(2.8; 4.7)	1.8***(1.4; 2.5)
19-24	2.4***(1.9;	2.0***(1.6; 2.5)	3.6***(2.7; 4.7)	1.3(0.9; 1.8)
25-30	1.9***(1.5;	1.6***(1.3; 19)	2.3***(1.7; 3.0)	1.1 (0.8; 1.6)
31-36	1.7***(1.3;	1.3*(0.1; 1.6)	1.7***(1.3; 2.3)	0.8 (0.6; 1.2)
37-42		0.9 (0.7; 1.1)	1.6**(1.2; 2.1)	0.8 (0.5; 1.1)
42-48		0.8(0.7; 1.0)	0.8 (0.5; 1.1)	0.6*(0.4; 0.8)
48-59		0.5***(0.4; 0.7)	0.7* (0.5; 0.9)	0.6**(0.4; 0.8)
Has Measles vaccine				
No	1.0 (0.8; 1.2)	0.9*(0.8; 0.9)	0.9 (0.8; 1.0)	1.2* (1.0; 1.5)
Yes	1	1	1	1
Size of child at birth				
Large	1	1	1	1
Average	0.9 (0.7; 1.0)	0.9 (0.8; 1.0)	1.0 (0.9; 1.1)	0.9 (0.8; 1.1)
Small	1.1 (0.8; 1.3)	1.0 (0.9; 1.2)	1.3***(1.1; 1.5)	0.8(0.6; 1.1)
DK (Don't know)	0.4*(0.2; 0.8)	0.7 (0.5; 1)	0.6 (0.4; 1.1)	0.8(0.5; 1.2)
Constant	0.10***(0.03;	0.12***(0.08;	0.03***(0.01; 0.05)	0.04***(0.02; 0.1)
Community Level SD	0.37 (0.28;	0.50(0.43; 0.59)	0.70 (0.60; 0.80)	0.80 (0.70; 0.93)
ICC	0.04 (0.02;	0.07 (0.05; 0.10)	0.13 (0.10; 0.16)	0.16 (0.12; 0.21)

Appendix 2: Multilevel Logistic Regression (Count…)

	Nigeria				
	1990	**1995**	**2001**	**2006**	**2012**
Variable	**AOR (95%**	**AOR (95% CI)**	**AOR (95% CI)**	**AOR (95%**	**AOR (95%**
n					
Household size					
1-3	1	1	1	1	1
4-6	0.9 (0.7;1.2)	1.0 (0.7; 1.5)	1.1 (0.8; 1.4)	0.8 (0.7;1.0)	0.9 (0.8; 1.1)
7&+	0.9 (0.7; 1.2)	1.2 (0.8; 1.7)	1.0 (0.7; 1.3)	0.9 (0.8; 1.1)	1.1 (0.9; 1.3)
Sex of the head of					
Male	1	1	1	1	1
Female	1.1 (0.8; 1.5)	0.7 (0.4; 1.1)	1.1 (0.8; 1.6)	0.9 (0.7; 1.1)	0.9 (0.8; 1.1)
Age of the mother					
15-19	1	1	1	1	1
20-24	0.8 (0.6: 1.2)	1.1 (0.7; 1.6)	1.0 (0.7; 1.4)	0.9 (0.8; 1.1)	0.9 (0.8; 1.2)
25-29	0.9 (0.7;1.2)	0.8 (0.6; 1.3)	0.9 (0.7; 1.4)	0.9 (0.8; 1.1)	0.9 (0.8; 1.1)
30-34	0.8 (0.6: 1.1)	0.9 (0.6; 1.5)	0.9 (0.7; 1.4)	0.9 (0.7; 1.1)	0.9 (0.7; 1.1)
35-39	0.8 (0.5; 1.1)	0.9 (0.6; 1.5)	0.8 (0.6; 1.3)	0.9 (0.7; 1.1)	0.9 (0.7; 1.1)
40-44	0.6* (0.4; 0.9)	0.7 (0.4: 1.4)	0.9 (0.5; 1.4)	0.9 (0.7; 1.2)	0.7*(0.5; 0.9)
45-49	1.1 (0.7; 1.8)	0.5 (0.2; 1.5)	1.4 (0.7; 2.7)	0.8 (0.6; 1.1)	0.9 (0.7; 1.3)
Place of residence					
Urban	1	1	1	1	1
Rural	1.6**(1.2; 2.3)	0.9 (0.7; 1.3)	1.2 (0.9; 1.6)	1.1 (0.9; 1.3)	0.9 (0.8; 1.1)
Mother Occupation					
Not working	1	1	1	1	1
Sale	1.3**(1.1; 1.6)	1.1 (0.9; 1.5)	1.2* (1.0; 1.5)	1.2 (1.1; 1.4)	1.1 (0.9; 1.2)
Agriculter	0.8* (0.6; 0.9)	1.6* (1.1; 2.4)	0.9 (0.7; 1.3)	1.03 (0.9; 1.2)	1.1 (0.9; 1.3)
Manual	1.0 (0.7; 1.4)	0.9 (0.6; 1.3)	1.2 (0.9; 1.6)	1.1 (0.9; 1.3)	1.2* (1.1; 1.3)
Mother's education level					
No Education	1	1	1	1	1
1-6 years	1.0 (0.8; 1.2)	0.7 (0.5; 1.0)	0.8* (0.6; 0.9)	0.9 (0.9; 1.1)	1.0 (0.9; 1.2)
7&+ years	0.7* (0.5; 0.9)	0.7* (0.5; 0.9)	0.7**(0.5; 0.9)	0.8* (0.7; 0.9)	0.9 (0.8; 1.01)
Has Electricity					
No	0.7* (0.5; 0.9)	0.8(0.6; 1.1)	1.0 (0.8; 1.3)	0.8* (0.7; 0.9)	0.9 (0.8; 1.1)
Yes	1	1	1	1	1
Has Television					
No	0.8 (0.6; 1.2)	1.1 (0.7; 1.5)	1.0 (0.8; 1.3)	0.9* (0.7; 1.0)	0.9 (0.8; 1.0)
Yes	1	1	1	1	1
Has Refrigerator					
No	1.4* (1.0; 1.9)	0.9 (0.6; 1.4)	1.0 (0.8; 1.4)	0.9 (0.8; 1.2)	1.0 (0.8; 1.2)
Yes	1	1	1	1	1
Has Bicycle					
No	1.1 (0.9; 1.3)	0.9 (0.7; 1.2)	1.2 (0.9; 1.4)	1.0 (0.9; 1.1)	0.9 (0.9; 1.1)
Yes	1	1	1	1	1
Has Motorcycle					
No	0.9 (0.7; 1.1)	1.2 (0.9; 1.7)	0.9 (0.8; 1.2)	0.9 (0.9; 1.1)	1.1 (1.01; 1.2)
Yes	1	1	1	1	1
Immediate environment and					
Type of toilette					
Flush/upgraded latrine	1	1	1	1	1
Traditional latrines	1.8**(1.2; 2.8)	1.1 (0.7; 1.8)	1.3 (0.9; 1.9)	1.6*** (1.2;	1.3**(1.1; 1.5)
Lack of toilet	2.1**(1.3; 3.3)	0.8 (0.5; 1.4)	1.0 (0.7; 1.6)	1.2 (0.9; 1.6)	1.2 (0.9; 1.5)
Other type	2.9* (1.2; 7.3)	1.7 (0.7; 3.9)	1.2 (0.5; 2.6)	0.7 (0.5; 1.1)	0.7* (0.4; 1.0)
Quality of Main floor					
Poor	1	1	1	1	1
Middle	1.1 (0.9; 1.3)	1.2 (0.9; 1.5)	0.9 (0.7; 1.1)	0.8*(0.7; 0.9)	0.9 (0.8; 1.1)
Rich	1.6 (0.9; 2.8)	0.3 (0.03;2.2)	0.6** (0.5; 0.9)	0.7**(0.6;	0.9 (0.7; 1.1)
Sources of drinking water					
Piped/Public tap/stan	1	1	1	1	1
Tube well or borehole	0.9 (0.7; 1.2)	1.0 (0.7; 1.5)	1.2 (0.9; 1.6)	0.8 (0.7; 1.0)	0.8 (0.7; 1.0)
Well	0.9 (0.6; 1.2)	0.9 (0.6; 1.4)	0.9 (0.7; 1.3)	0.8* (0.6; 0.9)	0.9 (0.8; 1.1)

Spring/river/lake/other	0.8 (0.5; 1.3)	1.1 (0.8; 1.7)	1.0 (0.7; 1.4)	0.7**(0.6;0.9)	1.0 (0.8; 1.2)
Child level variables					
Sex of the child					
Female	1	1	1	1	1
Male	1.2**(1.1; 1.4)	0.9 (0.8; 1.2)	1.2* (1.04; 1.4)	1.2***(1.1;	1.0 (0.9; 1.1)
Age in months					
0-6	1	1	1	1	1
07-12	2.9***(2.3;	2.7***(1.9; 3.8)	2.2***(1.7; 3.01)	2.6***(2.2;	3.2***(2.7;
13-18	3.1***(2.4;	2.4***(1.7; 3.4)	2.7***(1.9; 3.6)	2.7***(2.3;	3.0 (2.6; 3.6)
19-24	2.4***(1.8;	2.5*** (1.7; 3.7)	2.9***(2.1; 4.0)	2.1***(1.7;	2.6***(2.2;
25-30	1.8***(1.3;	1.6*(1.1: 2.4)	1.6**(1.2;2.2)	1.6***(1.4;	1.8*** (1.5;
31-36	1.5* (1.1; 2.1)	1.8* (1.1; 2.8)	1.4 (0.9; 1.9)	1.1 (0.9; 1.4)	1.6*** (1.3;
37-42	0.8 (0.6; 1.1)	-	0.9 (0.7; 1.4)	1.1 (0.9; 1.4)	1.1 (0.9; 1.4)
42-48	0.7 (0.5; 1.1)	-	0.6* (0.4; 0.9)	0.9 (0.7; 1.1)	0.9 (0.8; 1.2)
48-59	0.6**(0.5; 0.9)	-	0.4***(0.3;	0.7**(0.6;	0.7 (0.6; 0.9)
Has Measles vaccine					
No	0.8(0.7; 1.0)	0.9 (0.8; 1.3)	0.7 (0.6; 0.9)	0.9 (0.8; 1.0)	0.8 (0.8; 0.9)
Yes	1	1	1	1	1
Size of child at birth					
Large	1	1	1	1	1
Average	1.2 (0.9; 1.4)	1.2 (0.9; 1.6)	1.2 (0.9; 1.4)	0.8* (0.8; 0.9)	0.8***(0.7;
Small	1.4**(1.1; 1.7)	1.2 (0.8; 1.7)	1.4**(1.1; 1.8)	1.2**(1.1;	1.1 (0.9; 1.2)
DK (Don't know)	1.8 (0.8; 4.2)	1.5(0.6; 3.5)	1.8 (0.7; 4.5)	0.6 (0.4; 0.1)	0.4 (0.3; 1.0)
Constant	0.5*** (0.03;	0.08***(0.04;0.2)	0.09***(0.05;	0.07***	0.06*** (0.04;
Community Level SD	0.71 (0.60;	0.63 (0.47; 0.84)	0.77 (0.6; 0.9)	0.82 (0.75;	0.87 (0.80;
ICC	0.13 (0.10;	0.11 (0.06; 0.18)	0.15 (0.11; 0.21)	0.17 (0.14;	0.19 (0.16;

Appendix 2: Multilevel Logistic Regression (Count…)

	Niger			
	1992	**1998**	**2006**	**2012**
Variable	**AOR (95% CI)**	**AOR (95% CI)**	**AOR (95% CI)**	**AOR (95% CI)**
n				
Household size				
1-3	1	1	1	1
4-6	0.8 (0.62; 1.1)	0.9 (0.7; 1.2)	0.9 (0.7; 1.2)	08 * (0.6; 0.9)
7&+	0.8 (0.6; 1.1)	0.9 (0.8: 1.3)	0.9 (0.7; 1.2)	0.7(0.6; 0.9)
Sex of the head of household				
Male	1	1	1	1
Female	1.4*(1.03; 1.8)	0.9(0.7; 1.2)	1.0 (0.9; 1.2)	0.9 (0.7; 1.1)
Age of the mother				
15-19	1	1	1	1
20-24	0.9 (0.7; 1.2)	1.1 (0.9; 1.4)	1.0 (0.8; 1.3)	0.9 (0.7; 1.1)
25-29	0.9 (0.8; 1.3)	1.1(0.8;1.4)	1.0(0.8; 1.2)	0.9 (0.7; 1.1)
30-34	1.0 (0.7; 1.3)	1.1(0.9; 1.4)	0.9 (0.7; 1.1)	0.9 (0.7; 1.2)
35-39	1.1 (0.8; 1.5)	1.1 (0.9; 1.5)	0.8 (0.6; 1.1)	1.0 (0.8; 1.3)
40-44	1.1 (0.8; 1.6)	1.3 (0.9; 1.8)	0.1(0.8; 1.5)	0.9 (0.7; 1.3)
45-49	1.0 (0.6; 1.8)	1.6 (0.9; 2.9)	1.1 (0.7; 1.7)	0.9 (0.6; 1.5)
Place of residence				
Urban	1	1	1	1
Rural	1.4*(1.0; 1.9)	1.1 (0.8; 1.5)	1.0 (0.7; 1.4)	0.9 (0.7; 1.3)
Mother Occupation				
Not working	1	1	1	1
Sale	1.1(0.9; 1.3)	1.3**(1.1; 1.5)	1.3**(1.1; 1.5)	1.1 (0.9; 1.3)
Agriculture	1.4**(1.1; 1.7)	1.1 (0.9; 1.4)	1.4***(1.2; 1.7)	1.5**(1.1; 2.1)
Manual	1.4**(1.1; 1.8)	1.0 (0.8; 1.2)	1.2 (0.9; 1.5)	1.0 (0.8; 1.3)
Mother's education level				
No Education	1	1	1	1
1-6 years	0.9 (0.7; 1.2)	1.1 (0.8; 1.3)	0.9 (0.7; 1.1)	1.1 (0.9; 1.3)
7&+ years	0.5** (0.4; 0.8)	0.8 (0.5; 1.2)	0.6* (0.4; 1.5)	1.0 (0.8; 1.3)
Has Electricity				
No	1.2 (0.8; 1.7)	1.0 (0.7; 1.5)	1.2 (0.9; 1.6)	1.1 (0.9; 1.5)
Yes	1	1	1	1
Has Television				
No	0.9 (0.6; 1.3)	1.2 (0.8; 1.9)	1.0 (0.7; 1.4)	0.9 (0.7; 1.3)
Yes	1	1	1	1
Has Refrigerator				
No	1.1 (0.7; 1.8)	0.8 (0.5; 1.4)	0.8 (0.5; 1.2)	0.8(0.6; 1.1)
Yes	1	1	1	1
Has Bicycle				
No	0.9 (0.7; 1.3)	1.2 (0.9; 1.5)	0.8 (0.7; 1.0)	0.9 (0.8; 1.2)
Yes	1	1	1	1
Has Motorcycle				
No	1.03 (0.7; 1.4)	0.8 (0.5; 1.1)	0.9 (0.8; 1.2)	1.0 (0.9; 1.2)
Yes	1	1	1	1
Immediate environment and				
Type of toilette				
Flush/upgraded latrine	1	1	1	1
Traditional latrines	1.3 (0.7; 2.4)	0.8 (0.4; 1.8)	1.2 (0.7; 2.0)	1.3 (0.9; 1.8)
Lack of toilet	1.5(0.8; 2.8)	0.9 (0.4; 1.9)	1.2 (0.7; 2.2)	1.3(0.9; 1.9)
Other type	2.2 (0.9; 5.9)	2.5 (0.7; 9.4)	2.0 (0.8; 4.9)	1.7 (0.8; 3.4)
Quality of Main floor material				
Poor	1	1	1	1
Middle	1.0 (0.8; 1.3)	0.7* (0.5; 0.9)	0.8 (0.7; 2.0)	0.9 (0.7; 1.2)
Rich	1.1 (0.5; 2.6)	0.6 (0.2; 1.5)	0.7 (0.3; 1.4)	1.4**(1.1; 3.4)
Sources of drinking water				
Piped/Public tap/stan	1	1	1	1
Tube well or borehole	1.0 (0.8; 1.4)	0.9 (0.7; 1.3)	-	0.9 (0.8; 1.2)
Well	0.9 (0.5; 1.4)	0.8 (0.5; 1.4)	1.1 (0.8; 1.4)	0.8 (0.7; 1.0)

Spring/river/lake/other	0.7 (0.6; 1.0)	1.1 (0.8; 1.5)	0.7 (0.4;1.2)	1.3 (0.9; 1.9)
Child level variables				
Sex of the child				
Female	1	1	1	1
Male	1.1 (0.9; 1.2)	1.1(0.9; 1.2)	1.0 (0.9; 1.1)	1.1(0.9; 1.2)
Age in months				
0-6	1	1	1	1
07-12	2.6***(2.1; 3.3)	2.3***(1.9; 2.8)	2.4*** (1.9; 2.9)	2.4***(1.8; 2.9)
13-18	1.9***(1.5; 2.5)	1.4**(1.1; 1.8)	2.4***(1.9;2.9)	1.7***(1.3; 2.1)
19-24	1.9***(1.4; 2.4)	1.3* (1.1; 1.7)	1.9***(1.5; 2.4)	1.2(0.9; 1.5)
25-30	1.1 (0.9; 1.4)	1.1 (0.9; 1.4)	1.4**(1.1; 1.8)	1.1(0.8; 1.3)
31-36	0.8 (0.6; 1.02)	0.8 (0.6; 1.1)	1.1(0.9; 1.4)	0.6 (0.5; 0.8)
37-42	0.5***(0.4; 0.7)	-	0.7 (0.5; 0.9)	0.5***(0.3; 0.6)
42-48	0.5***(0.3; 0.6)	-	0.7 **(0.5; 0.9)	0.4***(0.3; 0.5)
48-59	0.4***(0.3; 0.5)	-	0.5***(0.4; 0.6)	0.2***(0.2; 0.3)
Has Measles vaccine				
No	1.0 (0.9; 1.2)	1.0 (0.8: 1.2)	0.8 (0.7; 0.9)	1.0 (0.9; 1.2)
Yes	1	1	1	1
Size of child at birth				
Large	1	1	1	1
Average	1.0 (0.9; 1.2)	0.9 (0.8; 1.1)	0.8* (0.7; 0.9)	0.9 (0.8; 1.1)
Small	1.4***(1.2; 1.7)	1.02 (0.8; 1.2)	1.1 (0.9; 1.3)	1.2*(0.1; 1.5)
DK (Don't know)	1.3 (0.6; 3.2)	0.4 (0.1; 2.2)	0.9 (0.5; 1.7)	0.6 (0.4; 1.0)
Constant	0.16***(0.07;	0.4***(0.2; 1.1)	0.2***(0.1; 0.4)	0.16***(0.10; 0.27)
Community Level SD	0.50(0.40; 0.60)	0.43 (0.35; 0.56)	0.60 (0.51; 0.70)	0.65 (0.56; 0.75)
ICC	0.07 (0.05; 0.10)	0.06 (0.04; 0.09)	0.10 (0.07; 0.13)	0.11(0.09; 0.15)

Chapter 8: Summary/Discussion

Understanding child survival in developing countries requires looking at the inequalities in children's mortality and analysing the factors that contribute to these disparities. In sub-Saharan countries, under-five mortality has declined over the last decades but this decline seems to hide huge inequalities among social strata within countries. Results also show that progress towards the fourth Millennium Development Goal (MDG-4) in many countries has been accompanied by rising inequality in mortality rates (M. Garde & N. Sabina (Save the Children UK), 2010).

This research was undertaken to analyse health inequalities (mortality) of children under five in sub-Saharan Africa, and it was based on the assumption that the under-five mortality rate has declined in recent decades, particularly in developing countries. However, all the social strata across the countries do not seem to benefit from this reduction of mortality and mortality remains abnormally high among children from underprivileged social strata. This research is, therefore, a holistic approach to analysing and quantifying the inequalities of health among children under five in sub-Saharan Africa over the last two decades (1990-2010). This research sought to investigate the trends and determinants of health inequalities of under-five years (mortality and morbidity) in sub-Saharan Africa (SSA) from 1990 to 2010. An essential focus is devoted to the decomposition of effects and analysis of the contribution of the factors explaining these inequalities. The data used in the study was drawn from Demographic and Heath Surveys (DHS) done between 1990 and 2015 in sub-Saharan Africa countries. In order to analyse the inequalities in trends of mortality and morbidity of children, we selected countries based on the availability of DHS data over the period 1990-2010. Several statistical methods were used for data analysis.

For the first paper titled "Decomposing Inequalities in Under-Five Mortality in Selected African Countries", concentration index (CI) and Generalized Linear Model (GLM) were used to analyse and measure under 5 mortality inequalities and the associated factors.

For the second paper titled "Determinants of Under-Five Mortality in Burkina Faso: A Concentration Dimension », a logistics regression and Oaxaca-Blinder decomposition method for the binary outcome to analyse data.

For data analysis of the third paper of my thesis "Women Education, Health Inequalities in Under-Five Mortality in sub-Saharan Africa, 1990–2013", logistic regression and Bius's decomposition method were used to examine the effect of mother's education level on childhood mortality. Lastly, in the fourth paper titled "Trends and Risk Factors for Childhood Diarrheal in sub-Saharan Countries (1990-2010): Assessing the Neighbourhood Inequalities", Multilevel logistic regression modelling was used to determine the fixed and random effects of the risk factors associated with the diarrheal morbidity.

The main findings of this research were threefold: First, we identified the magnitude and the contributing factors of socio-economic inequalities in under-five mortality in sub-Saharan Africa. Second, we analysed the trends and determinants of inequality in under-five mortality related to the maternal education level in sub-Saharan Africa. And third, we identified the geographical/neighbourhood inequalities of diarrhoeal disease in sub-Saharan Africa.

8.1. Socio-economic inequalities in under-five mortality

The results presented in chapters four and five demonstrate that there are large inequalities in mortality of children under five years: children in poor households have considerably higher mortality rate than children from better-off households. The results were similar in the seven sub-Saharan countries studied but with slight differences: the poorest Q1 have the highest proportions of deaths: Nigeria (31.4%), Cote d'Ivoire (30.4%) and Ghana (36.4%), over 30% of deaths of children under 5 years are among the children of the poorest (Q1) and the absolute differences of proportions Q1-Q5 are more than 20 points (25.8 in Ghana, 23.6 in Nigeria and Cote d'Ivoire has 19.3). For Burkina Faso (14.5), Benin (15.7) and Mali (12), the absolute differences in the proportions of deaths of children under-five years between the poorest and the richest is more than 10 points. Niger appears to have low gaps between the poorest and richest with an absolute difference of less than 1 (0.7). The overall concentration index was -0.12 for Burkina Faso in 2010, -0.07 for both Benin in 2006 and for Cote d'Ivoire in 2011. The concentration index was -0.03 for Ghana in 2008 and -0.10 for Mali in 2006. It was -0.12 and -0.07 respectively for Nigeria in 2008 and Niger in 2012. The contributing factors of inequalities of child mortality were birth order, maternal age, parity and household size. Our findings also showed that the intensity of inequality varies from one country to another.

The results of chapter five showed in Burkina Faso that concentration index (CI) increased in absolute terms between 1993 and 2010 from -0.03 to -0.11 (1993 DHS (CI = -0023, standard error (se) = 0.0417) in 1998 DHS (CI = 0.0447, se = 0.0448) in 2003 DHS (CI = -0.0688, se = 0.0236) and 2010 DHS (CI = -0.1149, se = 0.0402)). This result shows that inequalities between the rich and the poor in under-five mortality has increased between 1993 and 2010. However, mortality rates of children under five have declined over period 1993 2010.

8.2 Maternal education inequalities in under-five mortality

Chapter six documented the gradient between mothers' education and the under-five mortality of their children in eight Sub-Saharan African countries. The results showed that children of mothers who did not attend school have a higher rate of death compared to those of mothers who have been to school. However, mortality rate differentials are reduced from the older birth cohort of children (1986-1989) to the younger birth cohort of children in each country. The results also show a variation between countries: Cameroon, Namibia, Burkina Faso, Niger and Guinea are countries where large inequalities in mortality by education level of the mother. Indeed, in these countries, the concentration index is less than -0.10 (-0.19 for the birth cohort of 1986-1989, -0.10 for the birth cohort of 1990-1999 and -0.11 to -0.20 for birth-cohort of 2000-2009 and birth-cohort of 2010-2013). This showed that the high concentration of deaths is among children of mothers who did not attend school.

Furthermore, the results of this study show that inequalities in mortality of children under five years of age by the level of education of the mother are significantly reduced during the last two decades. Reducing child mortality differences by level of education is certainly the results of several improved policies on the one hand, and the education of women, on another. This reduction is due to improved supply of health care programs and health policies in reducing economic inequalities in access to health care.

Drop in the mortality rate of children under-five during the period 1990-2010 show that the decline was much greater among children in poor households compared to children from households in high quintiles. The drop recorded over the past two decades is attributable to the combined effects of several policy actions at a regional and local level to combat illnesses and diseases that kill children under-five years.

Including efforts geared to fighting malaria, malnutrition and diarrhea diseases. The decline is also the action of expanded programmes of immunization against measles and other diseases, the integrated management of disease programmes in early childhood and PCMIE / PMTCT.

Similarly, the multiple programmes to improve the population's access to primary health care undertaken since the Alma Ata conference in 1978 had positive effects on the use of health services in countries of Africa south of Sahara where effort morbidity and mortality in children under five is among the highest in the world.

8.3 Neighbourhood inequalities in child health

The intra-correlation coefficient (ICC) value allows us to analyse the neighbourhood disparities in diarrheal morbidity. Results of the study showed that Nigeria (0.19) and Mali (0.16) are the countries where we observe large neighbourhood disparities in diarrheal morbidity in children under five. Low diarrheal morbidity inequalities are recorded in Burkina Faso (0.09). The analysis shows an increasing trend of diarrheal inequalities according to DHS rounds. In Burkina Faso, the value of the ICC was 0.04 for the 1993 DHS, while it was 0.09 in 2010 DHS; in Mali. The ICC increased from 0.04 in 1995 to 0.16 in 2012; in Nigeria, increased from 0.13 in 1990 to 0.19 in 2013; and in Niger, and from 0.07 in 1992 to 0.11 in 2012. These results show that the neighbourhood disparities of diarrheal morbidity among children under five years have increased in all four countries.

The results of our study revealed, on the one hand, a strong variation in inequality across countries as showing a contextual effect at the country level, and secondly, major changes in the level and trends in inequalities in mortality and morbidity diarrheal between countries.

Changes in the levels of mortality and morbidity of children between countries would be related to differences in policies and health systems (% of the budget to health) (Doherty et al., 2015), the level of efficiency and performance of the health system of each country fight against diseases of children and to provide accessible health care to all children especially those from disadvantaged backgrounds.

Furthermore, habits and behaviour of the health population may vary from one country to another and may induce different habits between countries. These habits are strongly

associated with the level of education and awareness of the population on the aspects (knowledge, attitudes and practices) related to health in general and children in particular.

Chapter 9: Conclusion

This study extends the literature on the trends and magnitude of inequalities in under-five mortality in sub-Saharan Africa. This thesis has several strengths. One of the key strengths is its ability to address an existing problem in line with the international agenda on children's health. Indeed, this research is part of the evaluation of MDG 4 which is aimed at reducing by two-thirds, between 1990 and 2015, the under-five mortality rate. The problem statement of the study on child health inequalities in the context of the MDGs has been the subject of many debates which bring together both researchers and political actors. The results of this research will, therefore, provide answers to the question of health inequalities amongst children under five in sub-Saharan Africa.

Another of the strengths of this research was the analyses of large-scale data of several rounds of DHS conducted in the countries studied. Using several rounds of DHS allowed the analyses of trends in mortality and morbidity of children under five years. The use of standardised questionnaires and the same sampling methodology in all countries for data collection made the DHS as a single source of nationally representative data that lends to easy comparative analyses between countries and over time within the same country, for a wide range of health indicators (Boco, 2011).

The main limitation of the thesis is related to the cross-sectional nature of DHS data and the retrospective nature of the DHS data collection which may induce possible omissions of deaths of children under-five years old and leads to inaccuracy of date of death. As we have already mentioned in the third chapter, the cross-sectional nature of the DHS data is one of the limitations of analysing the chains of causality between child survival and varying backgrounds. However, the use of several rounds of DHS allows to some extent to overcome this limitation.

Another limitation is related to recall bias from self-report in the survey. Recall bias stems from the fact that the survey used to generate the data rely on the woman’s recall of her birth event to construct the birth history. It is possible that the women may have forgotten some events or had imperfect recall of the details.

9.1 Policy Implications

This study clearly indicated that there are inequities in under-five mortality and morbidity in sub-Saharan countries over the last two decades. These findings have major policy implications which require the adoption of well-designed and transparent equity-oriented strategies, and policies for monitoring and reducing inequalities in children's health and mortality. Efforts have been made to identify interventions that are safe, affordable, and acceptable and can be scaled up in order to effectively reduce early child morbidity and mortality.

Previous research in some countries in sub-Saharan Africa has shown the positive effect of policies on cash transfers (CTs) (Zembe-Mkabile, Doherty, Sanders, & Jackson, 2014) and user fees exemptions on reducing inequalities in access and utilisation of healthcare for children under five. These policies deserve to be disseminated in sub-Saharan Africa, targeting children of the poorest and most vulnerable social groups to have access to healthcare services and to reduce their exposure to disease and death.

Increases in access and coverage of care for mothers and children have averted a considerable number of childhood deaths (Besada et al., 2016). Therefore, access to universal health insurance, especially for children and their mothers in low-income countries especially in sub-Saharan Africa, could significantly reduce health inequalities (mortality and morbidity) among children under five years.

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Appendices

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Original Article

Decomposing Wealth-Based Inequalities in Under-Five Mortality in West Africa

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Abstract

Background: This study aimed to analysis the inequalities of mortality of children under 5 years in West Africa by examining the determinants and contributing factors to the overall inequality concentration in these countries.

Method: Data used came from the DHS surveys conducted in the six countries in West Africa: Burkina Faso (2010), Benin (2006), Cote d'Ivoire 2011), Ghana (2008), Mali (2006), Nigeria (2008) and Niger (2012). The concentration index (CI) and Generalized Linear Model (GLM) with logit link were used to access inequality.

Results: The results show that in all countries, the poorest Q1 have the highest proportions of deaths: Nigeria (31.4%), Cote d'Ivoire (30.4%) and Ghana (36.4%), over 30% of deaths of children under 5 years are among the children of the poorest (Q1) and the absolute differences of proportions Q1-Q5 are more than 20 points (25.8 in Ghana and 23.6 in Nigeria). The contributing factors of inequalities of child mortality were birth order, maternal age, parity and household size. Our findings also showed that the intensity of inequality varies from one country to another.

Conclusion: The most important conclusion of this study is to reduce mortality in children under 5 years, it is needed to reduce economic and social inequalities and improve the country's economic and social condition. There is a need for monitoring and assessment inequalities by leading causes of death and morbidity among children in the region in order to advance in understanding the gaps and finding a way to reduce them in West Africa countries.

Keywords: Concentration index Infant mortality, Child mortality, Under five mortality, Family planning

Introduction

The Millennium Development Goals (MDGs) are the world's biggest promise; that is a global agreement to reduce poverty and human deprivation at historically unprecedented rates through collaborative action (1). Of its many goals, the fourth goal (MDG 4) specifically calls on the international community to reduce mortality in children under 5 (U5) by two thirds between 1990 and 2015 (1). Therefore, the health of children under-five years in general and mortality in particular are a major priority for developing countries. Recent studies indicate that under-five mortality has decreased much during these last decades both in developed and developing countries (2–5). But the fourth MDG goal will not be met by 2015 in many sub-Saharan countries in Africa in the light of progress made (6). Despite the fall in the regional and global child mortality rate, deaths remain alarmingly concentrated in the poorest regions of the world and most notably, sub-Saharan Africa has the highest regional rate of child mortality amongst under-fives. One child out of nine dies before their fifth birthday(5). Similarly, inequalities exist and remain between countries, within each country, between different sub-groups and socio-economic groups (7–12), between place of residence (13,14), between ethnicity (12,15,16), between parental characteristics (8) and children (11). Socio-economic inequalities in childhood mortality are a major public health problem in develop-

ing countries. Childhood mortality is systematically and considerably higher among lower socioeconomic groups within countries (2). Reducing these inequalities by improving child survival up to the level of more advantaged groups within countries would substantially improve population health (2). Specific attention is being devoted into the research on child health inequalities in developing countries (2,13,15,17–28). Some of these researches focused on sub-Saharan Africa by conducting regional and multi-country studies on this topic. But in the case of West Africa to be specific, the literature consulted indicates that research remains low even where this part of Africa has the highest rates of under-five mortality in the world and these countries are among the world's poorest countries(29). What are the determinants of inequalities in mortality among under-five in West Africa? Are there some variations between and within countries?

The objective of this study is to analyze the inequalities of mortality of children under 5 years in West Africa by examining the determinants and contributing factors to the overall inequality concentration in these countries.

Study Design

Previous research' results found several factors that explain child health inequalities in developing countries. These factors are related to: 1) individual's characteristics of parents and children; 2) the living conditions of households; 3) the geographical factors and; 4) national policies and reforms especially in the health sector.

Prior research found that a mother's characteristics such as her education, age during child delivery, parity, food habits and health status could influence the survival of the child(3,15,30–32). Mother's education level was found in the literature to be strongly associated with child survival and was a determinant factor of inequalities in child health in sub-Saharan Africa(8,33).

Houweling and Kunst (2) argued that maternal education is thought to exert its influence through increased status and decision making power of mothers within the household, increased willingness and ability to travel outside the community, more timely use of health care, greater negotiating power with health care providers, increased knowledge, skills and identification with modern health systems and responsiveness to new ideas. Maternal education is estimated to be accounted for by its association with household wealth, and probably the associated better living conditions and ability to pay for health services.

Socioeconomic environment of households was also found as an important factor of child health inequalities. In fact, the living conditions of households have a direct influence on children's health through the quality of drinking water and hygiene in the household, the use of health services, food and health practices, fashion life (2,34,35). The poverty level of the household(25,35–37), size and household composition (31), the gender of the head of the households(34) have an impact on child mortality.

With regard to community factors, research results show that the contextual effects have an influence on children's health. Indeed, the availability and access to health centers, the availability of qualified staff are often lacking in rural and poor areas thus creating favorable factors to population health inequalities (2,9,35,38). Good hygiene practices are relatively difficult to be met under local conditions where water supply and sanitation are poor. Communities often have common values and norms, like peer pressure, contribute significantly to shaping the health behaviors. At the community level as well as at the household level, the poor may be disadvantaged. Thus they are more likely to live in remote places, far from health centers thus making accessibility very low in case of health problem(36). Several studies examine the effect of the type of residence (urban/rural) on childhood mortality inequalities(13,14,16,30,34). These studies showed that the location of residence (urban vs rural) had a significant influence on the child survival and so residing in rural areas increased the probability of a child dying before the fifth birthday. Houweling and Kunst (2) study showed that at the country level, several factors can impact on the magnitude of mortality inequalities through multiple pathways. Indeed, these authors showed that policies

at the country level can increase or decrease the inequalities between social groups and influence health policy for the poor. West Africa is one of the poorest parts of the world where health indicators are still poorly reported. Under-five mortality remains high in the region and MDG's fifth (5^{th}) goal will not be met in many West African countries. Common causes of child mortality and morbidity include diarrhea, acute respiratory infections, measles, and malaria. Studies have shown that many children in Nigeria mainly die from malaria, diarrhea, neonatal tetanus, tuberculosis, whooping cough and broncho-pneumonia (39).

Materials and Methods

We used data from Demographic and Health Surveys (DHS) run in six countries in West Africa including Burkina Faso (DHS, 2010), Benin (DHS, 2006), Cote d'Ivoire (DHS, 2011), Ghana (DHS, 2008), Mali (DHS, 2006), Nigeria (DHS, 2008) and Niger (DHS, 2012).
Data sharing statement Data available for public through internet http://www.measuredhs.com

The outcome variable used was the risk of under-five death (0–59 months), which is defined as the probability of dying between birth and the fifth birthday. Variable socioeconomic status built from household assets is used as the main variable for measuring inequalities in mortality.

Selected variables

Child' sex: Male and Female
Birth order: 1st birth, 2nd-6th birth and 7th & +
Mother's age: 15-19, 20-24, 25-29, 30-34, 35-39, 40-44 and 45-49
Mother's Occupation: Not working, skilled manual and other occupation
Mother's education: No education, Primary, Secondary
Parity: 1-3, 4-6, 7 & +
Father's occupation: Agriculture, Sales, Skilled Manual and Other Occupation
Father's education: No education, Primary, Secondary, Higher and DK
Household's size: 1-3, 4-6, 7 &+
Household head's sex: Male and Female
Location of residence: Urban and Rural
Wealth index: Q1 (Poorest), Q2 Poorer, Q3 Middle Q4 Rich and Q5 Richest

The socio-economic variable was categorized into 5 categories: Q1 being the Poorest, Q2, Q3, Q4 and Q5 as the Richest. The independent variables included: sex of the child, birth order (1st, 2-6th, 7th and above), the mother's age at delivery (15-19), parity (1-3, 4-6, 7 and above), educational level (no education, primary, secondary and high) and occupation (not working, agriculture, sale, manual, other occupation) of the mother, educational level (no education, primary, secondary, highest and do not know (DK) and the occupation of the father (agriculture, skilled manual, other occupation), household size (1-3, 4-6, 7 and above), sex of household head and the middle of residence (urban vs. rural).

Statistical analysis

The concentration index (CI) is employed in this paper to measure under 5 mortality inequalities.
CI quantifies the degree of income-related inequality in a health variable, and is becoming a standard tool for the measurement of income-related health inequality (Liu, Gao & Yan, 2014).
Detailed information about the methodological tools used is presented in some publications (37,41–44).

$$C = \frac{2}{n\mu}\left(\sum_{1}^{n} h_i R_i\right) - 1$$

Where h_i is the variable of interest for the ith person; μ is the mean or proportion of h:n is the number of persons; and if the n individuals are ranked according to their socioeconomic status, beginning with the most disadvantaged, then R_i is their relative rank, i-0.5/n. When there is no inequality (or when inequality is balanced and opposite for equal fractions of the income- ranked population), the concentration index equals 0. If the variable of interest is concentrated at a lower (or higher) socioeconomic level, the concentration index becomes negative (or positive).

Generalized Linear Model (GLM) specifying binomial distribution and identity link was used to perform multivariate analysis. The coefficients from GLM were used subsequently to decomposing and computing the contribution of independent variable to the concentration index. The method used is detailed somewhere (41).

Results

Table 1 presents the proportions of deaths by poverty status and country. The results show that in all countries, the poorest Q1 have the highest proportions of deaths: Nigeria (31.4%), Cote d'Ivoire (30.4%) and Ghana (36.4%), over 30% of deaths of children under 5 years are among the children of the poorest (Q1) and the absolute differences of proportions Q1-Q5 are more than 20 points (25.8 in Ghana, 23.6 in Nigeria and Cote d'Ivoire has 19.3). For Burkina Faso (14.5), Benin (15.7) and Mali (12), the absolute differences of the proportions of deaths of children under-five years between the poorest and the richest is more than 10 points. Niger appears to have the low gaps between poorest and richest with an absolute difference of less than 1 (0.7). The overall concentration index was -0.12 for Burkina Faso in 2010, -0.07 for both Benin in 2006 and for Cote d'Ivoire in 2011. The concentration index was -0.03 for Ghana in 2008 and -0.10 for Mali in 2006. It was -0.12 and -0.07 respectively for Nigeria in 2008 and Niger in 2012.

Table 1: Proportion of deaths in children under 5 years by socioeconomic quintile and country

Country	Q1(Poorest)	Q2	Q3	Q4	Q5(Richest)	|Q5-Q1|	(Q5-Q1)/Q1	C(95%CI)	N1	N2
Benin	25.56	22.47	23.91	18.23	9.83	15.72	-0.62	-0.07(-0.10;-0.04)	16075	1393
Cote d'Ivoire	30.39	25.41	19.61	13.54	11.05	19.34	-0.64	-0.07(-0.14;-0.01)	3644	362
Ghana	36.36	17.68	19.19	16.16	10.61	25.76	-0.71	-0.03(-0.11;0.05)	2992	198
Mali	22.77	24.43	21.82	20.21	10.77	11.99	-0.53	-010(-0.13; -0.08)	14238	1801
Nigeria	31.38	27.39	19.84	13.66	7.74	23.64	-0.75	-0.12(-0.14; -0.10)	28653	3206
Niger	17.36	22.7	20.5	22.8	16.63	0.73	-0.04	-0.07(-0.10; -0.03)	12558	956

N1=Number of births; N2=Number of deaths: Source: data from Demographic and Health Surveys (DHS) run in six countries in West Africa including Burkina Faso (DHS, 2010), Benin (DHS, 2006), Cote d'Ivoire (DHS, 2011), Ghana (DHS, 2008), Mali (DHS, 2006), Nigeria (DHS, 2008) and Niger (DHS, 2012). Q1Poorest; Q2 Poorer; Q3 Middle; Q4 Richer Q5 Richest

In all the countries concerned by this study, the value of the concentration index is negative and thus shows that mortality is concentrated among children from poor households (Q1=Poorest) than among children of wealthy households (Q5=Richest). Inequalities in mortality are higher in Burkina Faso, Nigeria and Mali whose concentration index was lower than -0.10. Inequalities in child mortality are less pronounced in Ghana, Niger and Cote d'Ivoire than elsewhere.

Figure 1 presents the proportions of deaths of children under-five years by quintile of socioeconomic and by country. The results of the graph show that the poorest are those with the highest death proportions.

Factors associated with child mortality

Table 2 shows the proportions of deaths for each determinant factor associated with child mortality. The results on factors associated with the mortality of children under the age of 5 years for each country are presented in Table 3. Birth order was significant in all countries in the study. Children with 7th and above were more likely to die before their fifth year than the first child. The variable sex of the child is significant for Nigeria and Cote d'Ivoire and the results showed that girls had less probability to die before their fifth birthday than boys.

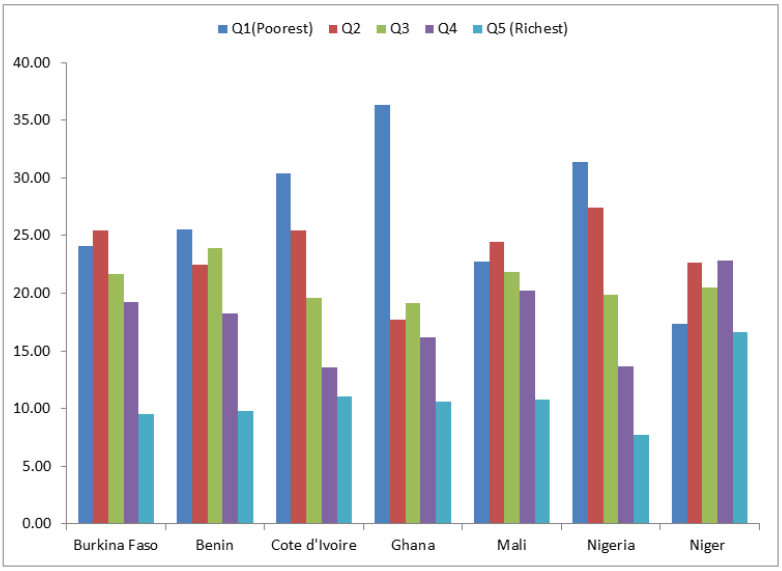

Fig. 1: Proportion of deaths in children under 5 years by socioeconomic quintile and country

The demographic characteristics of the mother such as age and parity have proved significant in the countries in the study and it appeared that the children of elderly mothers and mothers with high parity are more likely to die before their fifth birthday than those of the young mothers (15 and 19 years) who have low parity. The mother's occupation is only significant in Mali and Cote d'Ivoire. Contrary to our expectations, the mother's education level was not significant in some countries concerned as observed in the analysis. In Mali and Nigeria, the mother's education was significantly associated with child mortality of under 5 years.

According to the father's characteristics, results showed that the father's occupation is significantly associated with under-five mortality in Benin and Nigeria, while father's educational level is significant in Ghana, Mali and Niger. Thus, children whose fathers are educated had lower probability of dying than those whose fathers were not going to school.

Household size seemed to be a determinant of under-five year's mortality in the countries concerned in our analysis. In all countries, the results showed that the probability of dying before the age of five year increased with household size. Thus, children living in large households are more likely to die before their fifth birthday. The results were similar in all countries. Exceptions are in Ghana and Cote d'Ivoire, where the variable sex of the household head was significantly associated to under-five mortality and the results showed that children in households headed by women had a higher probability of dying before their fifth birthday than those belonging to households headed by a man.

Table 4 presents the concentration index for each health outcome by country. The proportions (presented in Table 2 above) are used to calculate the concentration index related to each factor (Table 4). A negative C_k means that the determining factor is more prevalent among the poorest households. To the values of the concentrations of variables, we see that the birth order, maternal age, parity, and household size are potential contributing factors to inequalities in mortality among children under five years.

The mortality of children under five years appears to be higher among children of high birth rank (Ck = -0.36 for Ghana, -0.20 for Burkina and Benin and -0.21 for Cote d'Ivoire), among children whose mothers had high parity among children whose mothers are older and among children belonging to in large households.

Table 2: Repartition of death by Explanatory variables and countries

Variables	Burkina		Benin		Ghana		Mali		Nigeria		Niger		Cote d'Ivoire	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Child' sex														
Male	715	53.84	725	52.05	106	53.54	945	52.47	1,735	54.12	513	53.66	198	54.70
Female	613	46.16	668	47.95	92	46.46	856	47.53	1,471	45.88	443	46.34	164	45.30
Birth order														
1st	250	18.83	281	20.17	44	22.22	371	20.60	584	18.22	154	16.11	101	27.90
2nd-6th	834	62.80	884	63.46	121	61.11	1,031	57.25	1,895	59.11	537	56.17	201	55.52
7th & +	244	18.37	228	16.37	33	16.67	399	22.15	727	22.68	265	27.72	60	16.57
Mother's age														
15-19	74	5.57	62	4.45	4	2.02	148	8.22	188	5.86	43	4.50	49	13.54
20-24	283	21.31	266	19.10	39	19.70	440	24.43	675	21.05	203	21.23	91	25.14
25-29	365	27.48	440	31.59	41	20.71	421	23.38	818	25.51	250	26.15	83	22.93
30-34	261	19.65	282	20.24	41	20.71	361	20.04	612	19.09	204	21.34	49	13.54
35-39	203	15.29	219	15.72	46	23.23	255	14.16	508	15.85	158	16.53	59	16.30
40-44	95	7.15	96	6.89	19	9.60	131	7.27	257	8.02	69	7.22	23	6.35
45-49	47	3.54	28	2.01	8	4.04	45	2.50	148	4.62	29	3.03	8	2.21
Mother's Occupation														
Not working	246	18.52	152	10.91	23	11.62	608	33.76	1,020	31.82	695	72.70	90	24.86
Sales	211	15.89	562	40.34	68	34.34	334	18.55	1,017	31.72	176	18.41	117	32.32
Agriculture	706	53.16	577	41.42	80	40.40	-		635	19.81	27	2.82	121	33.43
Manual	132	9.94	84	6.03	12	6.06	126	7.00	355	11.07	35	3.66	4	1.10
Other occupation	33	2.48	18	1.29	15	7.58	733	40.70	179	5.58	23	2.41	30	8.29
Mother's education														
No education	1184	89.39	1110	79.68	86	43.43	1,598	88.73	1,871	58.36	824	86.19	249	68.78
Primary	107	8.06	232	16.65	53	26.77	161	8.94	721	22.49	92	9.62	94	25.97
Secondary &+	37	2.79	51	3.66	59	29.80	42	2.33	614	19.15	40	4.18	19	5.25
Parity														
1-3	497	37.42	530	38.05	84	42.42	693	38.48	1,170	36.49	286	29.92	171	47.24
4-6	494	37.20	552	39.63	70	35.35	580	32.20	1,074	33.50	321	33.58	113	31.22
7 &+	337	25.38	311	22.33	44	22.22	528	29.32	962	30.01	349	36.51	78	21.55
Father's occupation														
Agriculture	1039	78.24	877	62.96	111	56.06	1,275	70.79	1,535	47.88	567	59.22		
Sales	108	8.13	231	16.58	17	8.59	186	10.33	550	17.16	-	-		
Skilled Manual	111	8.36	130	9.33	32	16.16	152	8.44	398	12.41	255	26.67		
Other Occupation	70	5.27	155	11.13	38	19.19	188	10.44	723	22.55	134	14.02		
Father's education														
No education	1145	87.14	804	58.30	83	42.56	1,495	83.15	1,500	47.41	815	85.25		
Primary	113	8.60	308	22.34	21	10.77	183	10.18	672	21.24	83	8.68		
Secondary	48	3.65	175	12.69	71	36.41	78	4.34	714	22.57	35	3.66		
Higher	3	0.23	16	1.16	9	4.62	11	0.61	223	7.05	6	0.63		
DK	5	0.38	76	5.51	11	5.64	31	1.72	55	1.74	17	1.78		
Household's size														
1-3	217	16.34	250	17.95	57	28.79	339	18.82	597	18.62	148	15.48	42	11.60
4-6	441	33.21	562	40.34	83	41.92	677	37.59	1,246	38.86	349	36.51	123	33.98
7 &+	670	50.45	581	41.71	58	29.29	785	43.59	1,363	42.51	459	48.01	197	54.42
Household head's sex														
Male	1249	94.05	1237	88.80	147	74.24	1,690	93.84	2,920	91.08	858	89.75	72	19.89
Female	79	5.95	156	11.20	51	25.76	111	6.16	286	8.92	98	10.25	290	80.11
Location of residence														
Urban	198	14.91	424	30.44	67	33.84	403	22.38	634	19.78	122	12.76	123	33.98
Rural	1130	85.09	969	69.56	131	66.16	1,398	77.62	2,572	80.22	834	87.24	239	66.02
Socio-economic status														
Q1 (Poorest)	320	24.10	356	25.56	72	36.36	410	22.77	1,006	31.38	166	17.36	110	30.39
Q2	338	25.45	313	22.47	35	17.68	440	24.43	878	27.39	217	22.70	92	25.41
Q3	288	21.69	333	23.91	38	19.19	393	21.82	636	19.84	196	20.50	71	19.61
Q4	255	19.20	254	18.23	32	16.16	364	20.21	438	13.66	218	2.80	49	13.54
Q5 (richest)	127	9.56	137	9.83	21	10.61	194	10.77	248	7.74	159	16.63	40	11.05
N	1,328	8.83	1,393	8.67	198	6.62	1,801	12.7	3,206	11.19	956	7.61	362	9.93

Source: Demographic and Health Surveys (DHS) different countries in West Africa including Burkina Faso (DHS, 2010), Benin (DHS, 2006), Cote d'Ivoire (DHS, 2011), Ghana (DHS, 2008), Mali (DHS, 2006), Nigeria (DHS, 2008) and Niger (DHS, 2012). Q1Poorest; Q2 Poorer; Q3 Middle; Q4 Richer Q5 Richest

Table 3: Adjusted associations between infant mortality and its dominants

Variables	Burkina		Benin		Ghana		Mali		Nigeria		Niger		Cote d'Ivoire	
	Coef.	Pvalue	Coef.	Pvalue	Coef.	Pvalue	Coef.	Pvalue	Coef.	Pvalue	Coef.	Pvalue	Coef.	*P*value
Child' sex (Male)	-0.138	0.019	-0.098	0.086	-0.106	0.491	-0.082	0.110	-0.150	0.000	-0.134	0.051	-0.230	0.042
Birth order (1st)														
2nd-6th	-0.064	0.565	-0.292	0.004	-0.453	0.076	-0.378	0.000	-0.022	0.748	-0.404	0.003	-0.259	0.150
7th & +	-0.893	0.000	-0.980	0.000	-1.180	0.014	-1.014	0.000	-0.665	0.000	-0.892	0.000	-0.816	0.026
Mother's age (15-19)														
20-24	-0.040	0.794	-0.105	0.507	1.057	0.094	0.250	0.024	0.185	0.055	0.645	0.001	-0.402	0.046
25-29	-0.005	0.976	-0.178	0.279	0.866	0.178	0.075	0.553	-0.051	0.616	0.520	0.011	-0.666	0.005
30-34	-0.472	0.011	-0.537	0.003	0.993	0.137	0.127	0.356	-0.216	0.051	0.366	0.095	-1.102	0.000
35-39	-0.499	0.012	-0.426	0.024	1.073	0.113	0.007	0.961	-0.211	0.073	0.429	0.064	-0.846	0.004
40-44	-0.709	0.001	-0.560	0.008	0.831	0.244	0.001	0.996	-0.265	0.042	0.308	0.226	-1.128	0.001
45-49	-0.066	0.795	-0.833	0.002	0.478	0.540	0.031	0.887	-0.129	0.373	0.449	0.135	-1.249	0.009
Mother's Occupation (Not working)														
Sales	-0.244	0.016	0.174	0.080	0.001	0.998	0.195	0.010	0.046	0.357	-0.062	0.500	0.317	0.039
Agriculture	-0.216	0.009	0.055	0.592	-0.267	0.346			-0.021	0.721	-0.308	0.135	0.063	0.684
Manual	0.111	0.353	0.059	0.688	-0.350	0.364	0.208	0.052	0.079	0.248	0.201	0.279	0.289	0.609
Other occupation	0.206	0.333	0.200	0.475	-0.116	0.752	0.213	0.001	0.080	0.393	0.081	0.733	0.373	0.111
Mother's education (No education)														
Primary	-0.179	0.117	0.057	0.498	0.205	0.327	0.000	0.998	-0.085	0.133	0.119	0.321	0.133	0.325
Secondary &+	-0.266	0.209	-0.302	0.080	0.089	0.710	-0.351	0.051	-0.195	0.005	0.209	0.288	-0.240	0.370
Parity (1-3)														
4-6	0.741	0.000	0.805	0.000	0.772	0.001	0.483	0.000	0.607	0.000	0.701	0.000	0.828	0.000
7 &+	1.945	0.000	1.776	0.000	2.176	0.000	1.530	0.000	1.745	0.000	1.673	0.000	2.054	0.000
Father's occupation (agriculture)														
Sales	-0.267	0.020	-0.133	0.166	0.175	0.603	-0.278	0.003	0.119	0.042	-0.437	0.677		
Skilled Manual	0.122	0.279	-0.206	0.069	-0.070	0.790	-0.116	0.260	0.090	0.177	-0.073	0.396		
Other Occupation	-0.197	0.238	-0.297	0.008	-0.273	0.312	-0.076	0.430	0.125	0.031	-0.013	0.906		
Father's education (No education)														
Primary	-0.201	0.064	-0.133	0.083	-0.254	0.348	-0.046	0.601	-0.024	0.674	-0.280	0.023		
Secondary	-0.092	0.617	-0.045	0.661	-0.863	0.000	-0.363	0.007	-0.027	0.671	-0.531	0.006		
Higher	0.124	0.845	-0.278	0.336	-0.968	0.028	-0.635	0.056	-0.150	0.105	-1.059	0.022		
DK	-0.157	0.738	-0.097	0.459	-0.018	0.959	0.053	0.791	0.072	0.631	0.232	0.378		
Household's size (1-3)														
4-6	-1.037	0.000	-0.849	0.000	-1.102	0.000	-0.940	0.000	-1.009	0.000	-1.135	0.000	-0.648	0.002
7 &+	-1.215	0.000	-1.128	0.000	-1.409	0.000	-1.320	0.000	-1.332	0.000	-1.534	0.000	-0.895	0.000
Household head's sex (Male)	0.312	0.019	0.270	0.005	0.140	0.472	0.359	0.001	0.241	0.001	0.295	0.015	-0.156	0.282
Location of residence(Urban)	0.122	0.247	0.085	0.217	-0.121	0.597	-0.009	0.909	0.210	0.000	0.522	0.000	0.082	0.581
Socio-economic status (Q1 (Poorest))														
Q2	0.036	0.674	0.008	0.920	-0.102	0.667	-0.022	0.776	-0.005	0.920	0.337	0.002	-0.122	0.429
Q3	-0.101	0.255	0.129	0.128	0.259	0.356	-0.207	0.008	-0.064	0.293	0.241	0.032	-0.167	0.342
Q4	-0.143	0.127	0.058	0.560	0.157	0.642	-0.172	0.042	-0.184	0.017	0.321	0.004	-0.277	0.195
Q5 (richest)	-0.329	0.025	-0.089	0.513	0.251	0.540	-0.290	0.021	-0.385	0.000	0.183	0.224	0.024	0.922
Intercept	-1.608	0.000	-1.743	0.000	-2.276	0.001	-1.351	0.000	-1.700	0.000	-2.822	0.000	-1.038	0.001

Source: Demographic and Health Surveys (DHS) different countries in West Africa including Burkina Faso (DHS, 2010), Benin (DHS, 2006), Cote d'Ivoire (DHS, 2011), Ghana (DHS, 2008), Mali (DHS, 2006), Nigeria (DHS, 2008) and Niger (DHS, 2012). Q1Poorest; Q2 Poorer; Q3 Middle; Q4 Richer Q5 Richest

Table 4: Decomposition analysis of concentration index of infant mortality by socioeconomic status

Variables	Burkina		Benin		Ghana		Mali		Nigeria		Niger		Cote d'Ivoire	
	C_k	Contr C	C_k	Contr C	Ck	Contr C	C_k	Contri C	C_k	Contr C	C_k	Contri C	C_k	Contri C
Child' sex (Female)	-0.006	0.004	-0.022	0.011	-0.006	0.005	0.005	-0.002	0.006	-0.004	0.002	-0.001	-0.002	0.002
Birth order (1st)														
2nd-6th	0.009	-0.004	0.000	0.001	-0.007	0.029	0.017	-0.030	0.021	-0.002	0.001	-0.004	0.005	-0.007
7th & +	-0.209	0.389	-0.203	0.343	-0.357	1.131	-0.149	0.264	-0.182	0.246	-0.076	0.246	-0.215	0.292
Mother's age (15-19)														
20-24	0.056	-0.005	0.018	-0.004	-0.032	-0.108	0.039	0.019	-0.058	-0.020	0.043	0.078	0.031	-0.031
25-29	0.034	-0.001	0.025	-0.015	0.029	0.084	0.038	0.005	0.052	-0.006	0.007	0.013	0.029	-0.045
30-34	-0.003	0.004	0.020	-0.023	0.106	0.353	-0.035	-0.007	0.068	-0.025	-0.026	-0.026	0.028	-0.042
35-39	-0.063	0.054	-0.032	0.022	-0.025	-0.101	-0.063	0.000	0.018	-0.005	0.000	0.000	0.001	-0.002
40-44	-0.118	0.068	-0.060	0.024	-0.124	-0.159	-0.105	0.000	-0.044	0.008	-0.015	-0.004	-0.153	0.111
45-49	-0.105	0.003	-0.185	0.033	-0.261	-0.081	-0.155	-0.001	-0.184	0.010	-0.104	-0.019	-0.025	0.007
Mother's Occupation (Not working)														
Sales	0.239	-0.105	0.200	0.148	0.271	0.002	0.193	0.055	0.103	0.013	0.146	-0.022	0.214	0.221
Agriculture	-0.111	0.144	-0.319	-0.077	-0.459	0.799		0.000	-0.307	0.011	-0.143	0.016	-0.373	-0.079
Manual	-0.142	-0.018	0.248	0.009	0.115	-0.039	0.109	0.013	0.082	0.006	0.029	0.003	0.025	0.001
Other occupation	0.466	0.027	0.590	0.016	0.391	-0.055	-0.188	-0.129	0.480	0.019	0.504	0.013	0.405	0.126
Mother's education (No education)														
Primary	0.335	-0.055	0.296	0.030	0.000	0.000	0.253	0.000	0.062	-0.011	0.288	0.043	0.069	0.024
Secondary &+	0.742	-0.062	0.656	-0.076	0.330	0.141	0.632	-0.041	0.458	-0.153	0.698	0.080	0.490	-0.062
Parity (1-3)														
4-6	-0.050	-0.155	-0.062	-0.207	-0.083	-0.364	-0.020	-0.024	-0.009	-0.016	-0.029	-0.090	-0.015	-0.040
7 &+	-0.205	-1.147	-0.208	-0.868	-0.366	-2.852	-0.146	-0.516	-0.177	-0.828	-0.078	-0.623	-0.232	-1.036
Father's occupation (agriculture)														
Sales	0.416	-0.102	0.371	-0.086	0.439	0.106	0.386	-0.088	0.188	0.034	0.986	0.000		
Skilled Manual	0.263	0.030	0.341	-0.069	0.273	-0.050	0.381	-0.029	0.249	0.025	0.178	-0.045		
Other Occupation	0.579	-0.068	0.388	-0.135	0.344	-0.290	0.378	-0.024	0.306	0.077	0.345	-0.008		
Father's education (No education)														
Primary	0.304	-0.060	0.116	-0.036	-0.185	0.082	0.111	-0.004	0.013	-0.001	0.221	-0.071		
Secondary	0.681	-0.026	0.430	-0.026	0.201	-1.018	0.523	-0.065	0.279	-0.015	0.530	-0.135		
Higher	1.000	0.003	0.798	-0.027	0.540	-0.390	0.762	-0.023	0.529	-0.050	0.962	-0.084		
DK	0.295	-0.002	0.212	-0.012	0.019	0.000	0.263	0.002	0.002	0.000	0.300	0.016		
Household's size (1-3)														
4-6	0.029	-0.115	0.026	-0.094	0.061	-0.457	0.046	-0.130	0.059	-0.208	-0.015	0.082	-0.025	0.056
7 &+	-0.036	0.249	-0.052	0.255	-0.205	1.366	-0.047	0.214	-0.072	0.362	0.007	-0.068	0.005	-0.023
Household head's sex (Female)	0.099	0.021	0.042	0.001	0.123	0.071	-0.216	-0.038	-0.200	-0.038	-0.176	-0.070	-0.282	0.355
Location of residence (Rural)	-0.155	-0.183	-0.178	-0.111	-0.298	0.385	-0.014	0.001	-0.011	-0.016	0.019	0.112	-0.003	-0.002

Source: Demographic and Health Surveys (DHS) different countries in West Africa including Burkina Faso (DHS, 2010), Benin (DHS, 2006), Cote d'Ivoire (DHS, 2011), Ghana (DHS, 2008), Mali (DHS, 2006), Nigeria (DHS, 2008) and Niger (DHS, 2012)

Discussion

Results of this study show that the inequalities of the mortality of children under-five remain in West African countries and gaps of under-five mortality between children from wealthy households and those living in poorest household are still important, thus supporting findings of earlier studies (16,37). Findings of the study show that the intensity of inequality varies from one country to another i.e. it is more concentrated in Burkina Faso, Nigeria and Mali and weakly concentrated in Ghana, showing that community or country level conditions can be potential sources of inequalities in mortality and health of children under five years (2,30,31,45). Indeed, Countries involved in this study are all West African countries, where political context, economic development and social policies underway are not the same. These differences could explain differences in inequality of child mortality as observed. Ssewanyana & Kasirye (32) argued that with regard to contextual factors driving health inequalities, political factors are highlighted as major drivers of both income and health inequalities. Findings also showed that socio-economic inequalities of under-five mortality are related to child's characteristics (birth, gender), to mother's characteristics (age, the main occupation, parity), the characteristics of the father (education) and to household's characteristics (size, gender of household head, the standard of living of the household). These variables are been listed in the conceptual frameworks developed for explaining inequality of child mortalities in developing countries (27, 38, 46). Our findings also showed that the birth's order, mother's age, parity, mother's occupation and household's size are major contributors of inequalities of child mortalities by decomposition analysis of concentration index in the countries concerned by the study. Surprisingly, our results do not confirm a strong relationship between the mother's educational level and location of residence and inequalities in under-five mortality in the countries concerned. Such result was also found in recent research (32,47,48).

Conclusion

The most important conclusion of this study is to reduce mortality in children under 5 years, it is needed to reduce economic and social inequalities and improve the country's economic and social condition. Tackling under-five inequalities of child mortality could therefore be through specific actions in country level and by stressing family planning programs aimed at promoting the reduction of number of births per women and by increasing women empowerment in economic activities.

Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors

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Global Health Action

ORIGINAL ARTICLE

Trends and risk factors for childhood diarrhea in sub-Saharan countries (1990–2013): assessing the neighborhood inequalities

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Background: Diarrheal diseases are a major cause of child mortality and one of the main causes of medical consultation for children in sub-Saharan countries. This paper attempts to determine the risk factors and neighborhood inequalities of diarrheal morbidity among under-5 children in selected countries in sub-Saharan Africa over the period 1990–2013.

Design: Data used come from the Demographic and Health Survey (DHS) waves conducted in Burkina Faso (1992–93, 1998–99, 2003, and 2010), Mali (1995, 2001, 2016, and 2012), Nigeria (1990, 1999, 2003, 2008, and 2013), and Niger (1992, 1998, 2006, and 2012). Bivariate analysis was performed to assess the association between the dependent variable and each of the independent variables. Multilevel logistic regression modelling was used to determine the fixed and random effects of the risk factors associated with diarrheal morbidity.

Results: The findings showed that the proportion of diarrheal morbidity among under-5 children varied considerably across the cohorts of birth from 10 to 35%. There were large variations in the proportion of diarrheal morbidity across countries. The proportions of diarrheal morbidity were higher in Niger compared with Burkina Faso, Mali, and Nigeria. The risk factors of diarrheal morbidity varied from one country to another, but the main factors included the child's age, size of the child at birth, the quality of the main floor material, mother's education and her occupation, type of toilet, and place of residence. The analysis shows an increasing trend of diarrheal inequalities according to DHS rounds. In Burkina Faso, the value of the intraclass correlation coefficient (ICC) was 0.04 for 1993 DHS and 0.09 in 2010 DHS; in Mali, the ICC increased from 0.04 in 1995 to 0.16 in 2012; in Nigeria, the ICC increased from 0.13 in 1990 to 0.19 in 2013; and in Niger, the ICC increased from 0.07 in 1992 to 0.11 in 2012.

Conclusions: This suggests the need to fight against diarrheal diseases on both the local and community levels across villages.

Keywords: *diarrheal morbidity*; *neighborhood inequalities*; *under-5 mortality*; *sub-Saharan Africa*; *Demographic and Health Survey*

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Introduction

The morbidity and mortality related to diarrheal diseases in under-5 children are still sizeable and persistent in low-income countries, especially in sub-Saharan Africa, and pose a significant, long-standing public health concern. Diarrheal disease is one of the leading causes of morbidity and mortality in less-developed countries, especially among under-5 children (1). Fischer Walker et al. (2) estimated that in 2010, about 1,731 billion episodes of diarrhea in children younger than 5 years were recorded worldwide. Every year, nearly 760,000 under-5 children continue to die from diarrheal disease, and the majority of these deaths have been identified as being avoidable (2, 3) The burden of diarrheal morbidity lies largely in the developing world, where water and living conditions remain poor (4). In 2011, Fischer Walker et al. (2) showed that nearly three-quarters of diarrheal mortality and pneumonia mortality are concentrated in 15 high-burden countries, and among these 15 countries, 10 were from sub-Saharan Africa; namely Angola, Burkina Faso,

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Democratic Republic of the Congo, Ethiopia, Kenya, Mali, Niger, Nigeria, Tanzania, and Uganda. Therefore, aggressive efforts to reduce child mortality must be through the reduction or elimination of diarrheal morbidity and mortality among under-5 children, especially in low- and middle-incomes countries (5). The United Nations' Millennium Development Goal 4, which aims to decrease the child mortality rate by two-thirds between 1990 and 2015, will not be achievable if morbidity and mortality caused through diarrhea are not curbed (6, 7).

The fight against diarrheal diseases in under-5 children was the subject of several international interventions as well as regional and national interventions in low- and middle-income countries (8, 9). In the late 1970s and early 1980s, international initiatives were implemented to reduce diarrheal mortality in under-5 children in developing countries (6). These actions included the promotion of the use of oral rehydration therapy, coupled with programs to educate caregivers on its appropriate use (10); supplementation with zinc, which has been shown to reduce the duration, severity, and complications associated with diarrhea; the promotion of hygiene; and access to drinking water in households.

Indeed, diarrheal diseases remain linked largely to living conditions, poverty, lack of hygiene, and lack of drinking water in households and in the neighborhood. The differences among cities, villages, neighborhoods, and countries with purified water supply, sanitation, drainage, and waste removal are the factors of inequalities in morbidity and mortality from diarrheal disease (11). The neighborhoods with inadequate provisions of water or sanitation and with unsanitary living conditions are often more likely to suffer the burden of diarrheal disease and record higher rates of mortality of under-5 children (11–13). The results of earlier studies have shown that lack of sanitation, availability and supply of drinking water, and lack of proper septic tanks and toilets, especially in urban suburbs, are generally expected to increase the risk of diarrheal morbidity and mortality and the infant mortality rate (14–17). Similarly, poor economic status, food scarcity, hand washing without soap, and kind of water storage were identified as risk factors for diarrheal morbidity and mortality (18–20).

Earlier studies on risk factors of morbidity and mortality caused by diarrhea have highlighted a large group of factors related to socio-economic status, living conditions for children, and factors related to etiology. Among the socio-economic variables, household poverty level; a high number of people living in the household (19) or a high number of under-5 children in the household; and maternal age, education, and working status (21) were the risk factors for morbidity and mortality from diarrheal diseases as reported in previous studies. The child's characteristics that were found to be significantly associated with the risk of diarrheal morbidity and mortality included age, gender, type of breast-feeding used, underweight, and acute malnutrition. Malnutrition and low socio-economic status are the factors that lead to the risk of mortality due to morbidity and diarrheal morbidity.

Aim

This paper attempts to determine the risk factors and neighborhood inequalities of diarrheal morbidity among under-5 children in selected countries in sub-Saharan Africa from 1990 to 2013. Measurements of trends in diarrheal morbidity among under-5 children are important to assess the progress toward Millennium Development Goal 4, which targets the reduction of child mortality by two-thirds over the period 1990–2013.

Methods

Study design

This study is a comparative cross sectional. Four countries have been selected to be in this study: Burkina Faso, Mali, Nigeria, and Niger. These countries are all located in West Africa, one of the poorest parts of the world, where the indicators of morbidity and mortality of children are the most disturbing in the world. According to Fischer Walker et al. (2), these four countries were among the top 10 countries of the world that accounted for more than 52% of childhood deaths from diarrhea and pneumonia. One of the reasons that motivated the choice of these countries is that, during 1990–2013, each country has made at least the fourth rounds of Demographic and Health Survey (DHS). The availability of data on diarrheal morbidity in under-5 children, as well as information on household hygiene, type of drinking water sources used in the household, and type of sanitation used in each database from the different rounds of DHS offers an opportunity to analyze the trend of the morbidity of diarrhea in under-5 children in these countries. The data allow the research to make a comparative analysis among countries selected for this study.

Data source

Data used come from the DHS waves conducted in Burkina Faso (1992–93, 1998–99, 2003, and 2010), Mali (1995, 2001, 2016, and 2012), Nigeria (1990, 1999, 2003, 2008, and 2013), and Niger (1992, 1998, 2006, and 2012) (Table 1). The data were obtained from the MEASURE DHS. Each of these surveys collected information from a representative sample at the national level. The DHS is based on a stratified, two-stage cluster sample. A cluster usually consists of one or a few villages in the rural area or a neighborhood in the urban environment. This type of sampling allows us to take into account the contextual effect for studying the determinants of diarrheal morbidity in the countries selected for the study.

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Three types of questionnaires were administered in each survey, namely the Household, Man, and Woman questionnaires. In this paper, we used the data for birth history information of all women aged 15 to 49 interviewed for the different surveys. The birth history data set contains information on the date of birth of all the children a woman has had in her life, starting from her first child until the time of the survey. Information on child survival (dead or alive) was also collected.

Variable specification

Diarrhea is a syndrome that can be caused by different bacterial, viral, and parasitic pathogens. In West African countries, studies show that diarrheal morbidity is caused mainly by *Escherichia coli*, *Shigella* spp., and rotavirus (22, 23).

The variables used in this study for the explanation of diarrheal morbidity in under-5 children have been selected according to the conceptual framework of risk factors for diarrhea incidence in developing countries as proposed by Genser et al. (24). This conceptual framework proposes five groups of variables considered as determinants of diarrheal morbidity. The socio-economic status of households (the standard of living in the household, the number of people in the household, age of mother, occupation, and level of education) comprises the first group of variables. The second group of variables is related to the hygiene of the immediate environment of the household. This group of variables includes the drinking water source and type of toilet used in the household. Weight at birth, breast-feeding duration, anthropometric measurements, and age and sex of the child represent the third group of potential determinants of diarrheal morbidity.

Dependent variable

The main variable of our study is under-5 children having had diarrhea in the past 2 weeks preceding the survey. This variable was collected during each round of DHS. During the interview, to assess the prevalence of diarrheal diseases in under-5 children, mothers were asked whether their children had had diarrhea in the 2 weeks preceding the survey and if there was blood in the stool. The dependent variable then is dichotomous: yes, if the child had an episode of diarrhea in the past 2 weeks, and no, otherwise.

Independent variables

Four groups of variables are taken into account in the analysis models. The first includes variables related to socio-economic status of the household (the number of people in household; presence of electricity; ownership of radio, television, refrigerator, bicycle, and motorcycle in the household; and the level of the mother's education and her age). The source of drinking water, type of toilet, and floor material quality are the variables related to hygiene and quality of the immediate environment of the household. Demographic information for the child includes age, weight at birth, sex, and status regarding measles vaccine.

Data analysis

Data analysis was carried out using STATA software Version 13.1 (StataCorp. 2013. *Stata Statistical Software: Release 13*. College Station, TX: StataCorp LP). Two types of analysis were used: a bivariate analysis and a multilevel logistic regression modelling. Bivariate analysis for each independent variable was performed against the dependent variable to elicit the impact of each factor on diarrheal morbidity. The dependent variable was dichotomous, and to reflect the hierarchical structure of the data, a two-level multilevel logistic regression model, with individuals at level-1 and the local area Primary Sampling Unit (PSU) at level-2, was used to assess the effect of each variable independently on the dependent variable while controlling for the cofounders.

Specification of the model

In $(\frac{p_{ij}}{1-p_{ij}}) = \beta_0 + \beta_1 x_{1ij} + \beta_2 x_{2ij} + \ldots + \beta_n x_{nij} + \omega_j$, the random effects vector ω_j is distributed as $N(0,\sigma^2_\omega)$,

where x_1 to x_n represents the explanatory variables for the probability that a child aged less than 5 years i from a PSUj has suffered from diarrheal disease. β_0 is the intercept and $\beta(_1$ to $_n)$ are the fixed effect (coefficients) for the explanatory variables included in the model. ω_j is the PSU-level random effect.

Intraclass correlation and neighborhood inequalities measurement

The random effect (ω_j) measures the variation between neighborhoods in the proportion of diarrheal morbidity among under-5 children. To quantify the neighborhood inequalities in diarrheal morbidity, we calculated the intraclass correlation (ICC), which is the percentage of the total variance among the neighborhoods. The ICC is the proportion of the total variance of diarrheal morbidity among under-5 children at the neighborhood level (PSU). The ICC quantified the inequalities or the contextual effect of diarrheal morbidity (25, 26).

Results

Figure 1 presents the prevalence of diarrheal morbidity by cohort across countries. There are variations by country and by cohort. The highest prevalence of diarrheal morbidity is among children in Niger whereas the lowest proportions were recorded among children in Nigeria.

The proportions of under-5 children who suffered from diarrheal diseases were higher in Niger (36.4%, 95% confidence interval [CI] = [34.9; 37.8]) among children of the 1995–1999 birth cohort compared with other countries. In Nigeria, the proportions of diarrheal morbidity were (14.7% [12.5; 16.9] for the 1990–1994 birth cohort; 13.6% [12.6; 14.6] for the 1995–1999 birth cohort) compared with the prevalence of other countries for the same

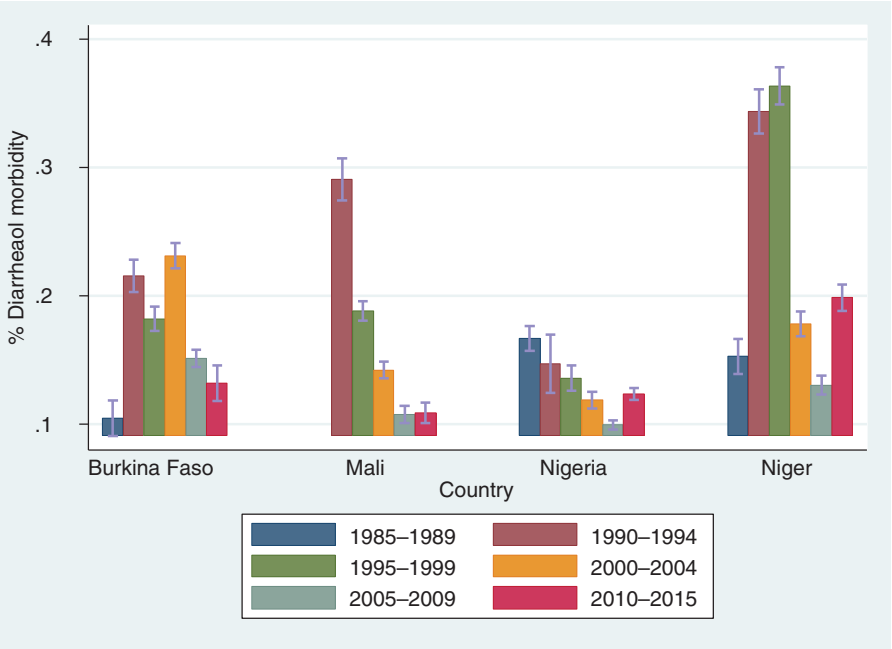

Fig. 1. Diarrheal morbidity prevalence by cohort and country.

birth cohort of children. For all countries, the results showed that diarrheal morbidity proportions among under-5 children are declining from 1995 to 2009. In Niger, although the results show an overall decrease of diarrheal morbidity, there is an increase in the last birth cohort (2010–2015) compared with the previous birth cohorts (2005–2009 and 2000–2004).

Table 2 presents the results of the descriptive analysis of diarrheal morbidity. The results by countries show that the child-level variables (sex, age, size of the child at birth, and had a measles vaccine) are significantly associated with diarrheal morbidity as variables. However, there are differences among countries. For Burkina Faso, only the child-level variables are significant. For Mali, Nigeria, and Niger, the variables related to the immediate environment and hygiene (type of toilet, quality of main floor material, and source of drinking water) are associated significantly with diarrheal morbidity in under-5 children. Children from households using a traditional latrine or who do not have a toilet and those from the households with poor quality of main floor material, and using a tube well or borehole, are more likely to suffer from diarrheal disease compared with the children from households using improved toilets, having a good quality of main floor material, and who are using piped water as their main source of drinking water.

Table 3 shows that among the economic variables, presence of electricity in the household and ownership of a television and refrigerator are associated with diarrheal morbidity in under-5 children in Mali, Niger, and Nigeria. The children living in rural areas and those of mothers who have not been to school are more at risk for diarrheal disease in Mali, Nigeria, and Niger compared with children living in urban areas and whose mothers are educated. The occupation of the mother also is associated significantly with diarrheal disease in under-5 children in Mali, Nigeria, and Niger.

In all four countries, age of the child is associated significantly with diarrheal disease among under-5 children. The risk of diarrheal morbidity among under-5 children has a U shape according to the child's age (Supplementary file). Compared with children of 0 to 6 months, the odds ratio is between 1.5 and 3.7 for children whose age is between 7 and 36 months, whereas after 37 months, the risk of diarrheal disease is reduced (OR <1) (Supplementary file).

Table 1. Years of survey and population of under-five children by country

Country	Year of survey	1990–1995	1996–2001	2002–2008	2009–2012	2013
Burkina Faso	1992, 1998, 2003, 2010	5,096	5,071	9,361	13,716	
Mali	1995, 2001, 2006, 2012	5,231	11,055	12,388	9,582	
Nigeria	1990, 1999, 2003, 2008, 2013	6,823	3,139	5,163	25,446	28,596
Niger	1992, 1998, 2006, 2012	5,592	4,243	8,209	11,602	

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Table 2. Determinant variables in bivariate analysis

Country	1990–1995	1996–2001	2002–2008	2009–2012	2013
	1993	1999	2003	2010	
Burkina Faso	- Quality of the main floor*** - Sex of the child** - Child's age (months)*** - Has measles vaccine***	- Child's age (months)*** - Has measles vaccine*** - Type of toilet	- Household size*** - Has a refrigerator* - Has bicycle in the HH* - Child's age (months)*** - Has measles vaccine*** - Size of the child at birth*** - Sex of the child**	- Household size*** - Age of the mother** - Mother's educational level** - Has a refrigerator* - Has bicycle in the HH* - Child's age (months)*** - Size of the child at birth***	
Mali	1995 - Age of the mother* - Place of residence*** - Mother's occupation** - Mother's education level*** - Has electricity*** - Has television*** - Type of toilet*** - Quality of main floor material*** - Sources of drinking water** - Child's age (months)*** - Size of the child at birth***	2001 - Household size*** - Age of the mother*** - Place of residence*** - Mother's occupation*** - Has electricity*** - Has a television*** - Has a refrigerator*** - Has a bicycle*** - Has a motorcycle*** - Type of toilet*** - Quality of main floor material*** - Sources of drinking water*** - Child's age (months)*** - Has measles vaccine*** - Size of the child at birth***	2006 - Household size** - Place of residence*** - Mother's occupation*** - Has electricity*** - Has television*** - Has a bicycle** - Has a motorcycle** - Quality of main floor material*** - Sources of drinking water*** - Child's age (months)*** - Size of the child at birth***	2012 - Mother occupation*** - Mother's education level*** - Quality of main floor material** - Sources of drinking water*** - Sex of the child* - Child's age (months)*** - Has measles vaccine** - Size of the child at birth*	
Nigeria	1990 - Age of the mother*** - Place of residence*** - Mother's occupation*** - Mother's education*** - Has electricity*** - Has a television*** - Has a refrigerator*** - Has a bicycle*** - Type of toilet*** - Quality of the main floor material***	1999 - Sex of the head of the HH*** - Mother's occupation*** - Mother's education*** - Has electricity*** - Has a television*** - Has a refrigerator*** - Type of toilet*** - Quality of the main floor material*** - Child's age (months)***	2003 - Age of the mother* - Place of residence*** - Mother's education*** - Has electricity*** - Has a television*** - Has a refrigerator*** - Has a bicycle*** - Has a motorcycle* - Type of toilet*** - Quality of the main floor material***	2008 - Household size*** - Sex of the head of the HH*** - Age of the mother*** - Place of residence*** - Mother's education*** - Mother's education*** - Has electricity*** - Has a television*** - Has a refrigerator*** - Has a bicycle*** - Has a motorcycle***	2013 - Household size*** - Sex of the head of the HH*** - Age of the mother*** - Place of residence*** - Mother's education*** - Mother's education*** - Has electricity*** - Has a television*** - Has a refrigerator*** - Has a bicycle*** - Type of toilet***

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Table 2 (*Continued*)

Country	1990–1995	1996–2001	2002–2008	2009–2012	2013
	- Sources of drinking water*** - Sex of the child*** - Child's age (months)*** - Has measles vaccine*** - Size of the child at birth***		- Sources of drinking water*** - Sex of the child* - Child's age (months)*** - Has measles vaccine*** - Size of the child at birth***	- Type of toilet*** - Quality of the main floor material*** - Sources of drinking water*** - Sex of the child** - Child's age (months)** - Has measles vaccine*** - Size of the child at birth***	- Quality of the main floor material*** - Sources of drinking water*** - Child's age (months)*** - Has measles vaccine*** - Size of the child at birth***
Niger	1992	1998	2006	2012	
	- Household size** - Age of the mother* - Place of residence*** - Mother's occupation*** - Mother's education level*** - Has electricity*** - Has a television*** - Has a refrigerator** - Has a motorcycle** - Type of toilet** - Quality of the main floor material*** - Sources of drinking water** - Child's age (months)*** - Has a measles vaccine*** - Size of the child at birth***	- Place of residence*** - Mother's occupation*** - Mother's education level*** - Has electricity*** - Has a television*** - Has a refrigerator*** - Has a motorcycle*** - Quality of the main floor material*** - Sources of drinking water*** - Child's age (months)***	- Household size** - Age of the mother* - Place of residence*** - Mother's occupation*** - Mother's education level*** - Has electricity*** - Has a television*** - Has a refrigerator** - Has bicycle*** - Type of toilet*** - Quality of the main floor material*** - Sources of drinking water*** - Child's age (months)*** - Has a measles vaccine*** - Size of the child at birth***	- Household size*** - Age of the mother* - Place of residence*** - Mother's education level*** - Has electricity* - Has a television* - Type of toilet* - Quality of the main floor material** - Sources of drinking water*** - Child's age (months)*** - Has a measles vaccine*** - Size of the child at birth***	

*$p < 0.05$;**$p < 0.01$;***$p < 0.001$.

Table 3. Significant Variables from the Multilevel Logistic Regression of with diarrheal morbidity among children under-five years old in Burkina, Mali, Nigeria and Niger (cf. Supplementary file for full table)

Country	1990–1995	1996–2001	2002–2008	2009–2012	2013
Burkina Faso	1993	1999	2003	2010	
	- Quality of the main floor material**	- Mother's occupation**	- Household size**	- Mother's occupation**	
	- Sex of the child**	- Child's age (months)***	- Has a bicycle*	- Type of toilet*	
	- Child's age (months)***		- Sex of the child**	- Child's age (months)***	
	- Size of the child at birth**		- Child's age (months)***	- Size of the child at birth***	
			- Has a measles vaccine*		
			- Size of the child at birth**		
Mali	1995	2001	2006	2012	
	- Mother's occupation**	- Household size*	- Place of residence**	- Mother's occupation***	
	- Mother's education level*	- Place of residence*	- Mother's occupation*	- Type of toilet*	
	- Quality of the main floor material***	- Mother's occupation**	- Child's age (months)***	- Child's age (months)***	
	- Child's age (months)***	- Has a bicycle**	- Has a measles vaccine*		
	- Size of the child at birth*	- Type of toilet**	- Size of the child at birth**		
		- Sources of drinking water**			
		- Child's age (months)***			
Nigeria	1990	1999	2003	2008	2013
	- Place of residence**	- Mother's occupation*	- Mother's occupation*	- Mother's education level*	- Type of toilet**
	- Mother's occupation**	- Mother's education level*	- Mother's education level*	- Has electricity*	- Child's age (months)***
	- Mother's education level*	- Child's age (months)***	- Quality of the main floor material**	- Has a television*	- Size of the child at birth**
	- Has electricity*		- Sex of the child*	- Type of toilet**	
	- Has a refrigerator*		- Child's age (months)***	- Quality of the main floor material**	
	- Type of toilet**		- Size of the child at birth**	- Sources of drinking water**	
	- Sex of the child**			- Sex of the child***	
	- Child's age (months)***			- Child's age (months)***	
	- Size of the child at birth*			- Size of the child at birth**	
Niger	1992	1998	2006	2012	
	- Sex of the head of the HH*	- Mother's occupation**	- Mother's occupation**	- Household size*	
	- Place of residence*	- Quality of the main floor material*	- Mother's education level*	- Mother's occupation**	
	- Mother's occupation**	- Child's age (months)***	- Child's age (months)***	- Quality of the main floor material**	
	- Mother's education level**		- Size of the child at birth*	- Child's age (months)***	
	- Child's age (months)***			- Size of the child at birth*	
	- Size of the child at birth**				

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

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Table 4. Random Effects of the Multilevel Logistic Regression of diarrheal morbidity among children under-five years old in Burkina, Mali, Nigeria and Niger

Country	Random Effects	1990–1995	1996–2001	2002–2008	2009–2012	2013
Burkina Faso	Community Level SD	0.39 (0.29; 0.54)	0.46 (0.36; 0.58)	0.50 (0.43; 0.59)	0.56 (0.49; 0.65)	
	ICC	0.04 (0.2; 0.08)	0.06 (0.04; 0.09)	0.07 (0.05; 0.10)	0.09 (0.07; 0.11)	
Mali	Community Level SD	0.37 (0.28; 0.50)	0.50 (0.43; 0.59)	0.70 (0.60; 0.80)	0.80 (0.70; 0.93)	
	ICC	0.04 (0.02; 0.07)	0.07 (0.05; 0.10)	0.13 (0.10; 0.16)	0.16 (0.12; 0.21)	
Nigeria	Community Level SD	0.71 (0.60; 0.84)	0.63 (0.47; 0.84)	0.77 (0.6; 0.9)	0.82 (0.75; 0.91)	0.87 (0.80; 0.95)
	ICC	0.13 (0.10; 0.17)	0.11 (0.06; 0.18)	0.15 (0.11; 0.21)	0.17 (0.14; 0.20)	0.19 (0.16; 0.21)
Niger	Community Level SD	0.50 (0.40; 0.60)	0.43 (0.35; 0.56)	0.60 (0.51; 0.70)	0.65 (0.56; 0.75)	
	ICC	0.07 (0.05; 0.10)	0.06 (0.04; 0.09)	0.10 (0.07; 0.13)	0.11 (0.09; 0.15)	

ICC = intraclass correlation coefficient.

The results of the four DHSs conducted in Burkina Faso (Table 3) show that variables related to the child level are those most significantly associated with diarrheal morbidity in under-5 children. Male children, those who had a low birth weight, and those aged 7 to 36 months are more likely to have a diarrheal morbidity compared with female children and those who had a normal birth weight. The quality of main floor material, the type of toilet, the mother's occupation, had measles vaccine, and household sizes were associated significantly with diarrheal morbidity for the Burkina DHS. The child's age and occupation of the mother are the two significant variables for the four rounds of DHS in Mali. Children of mothers who trade or have agriculture as their main activity are more likely to suffer from diarrheal morbidity compared with children of mothers without a primary occupation. Low weight at birth and rural residence are likely to increase the likelihood of a diarrheal disease in under-5 children in Mali. Children living in rural areas were 1.3 (2001 DHS) and 1.5 (2006 DHS) more likely to have a diarrheal disease compared with children living in urban areas (Supplementary file).

The effect (Table 3) of variables, namely quality of the main floor material, the types of toilet, and the source of drinking water in Mali is significant for the explanation of diarrheal morbidity in under-5 children. Children in households using traditional toilets and those of households without toilets are at higher risk for diarrheal disease compared with children from households using a flush toilet or upgraded latrine. Regarding Nigeria, the variables related to the child (age, sex, and weight at birth) are factors associated with diarrheal morbidity in under-5 children. The results also find that variables related to the mother (occupation and education level) and socio-economic variables (electricity in the household and the possession of goods such as refrigerators and televisions) are associated with diarrheal morbidity.

Age of the child and birth weight are significantly associated with diarrheal disease in under-5 children in Niger. Children who had a low birth weight are between 1.2 and 1.4 times more likely to have a diarrheal disease compared with children who had a normal birth weight (Supplementary file).

Table 4 and Fig. 2 present the random effect estimates of the multilevel regression analysis of diarrheal morbidity of each country. The ICC value allows us to analyze the neighborhood disparities in diarrheal morbidity. As shown in Fig. 2, Nigeria (0.19) and Mali (0.16) are the countries where we observe large neighborhood disparities in diarrheal morbidity in under-5 children. Low diarrheal morbidity inequalities are recorded in Burkina Faso (0.09). The analysis shows an increasing trend of diarrheal inequalities according to DHS rounds. In Burkina Faso, the value of the ICC was 0.04 for the 1993 DHS, while it was 0.09 in 2010 DHS; in Mali, the ICC increased from 0.04 in 1995 to 0.16 in 2012; in Nigeria, the ICC increased from 0.13 in 1990 to 0.19 in 2013; and in Niger, the ICC increased from 0.07 in 1992 to 0.11 in 2012 (Supplementary file). These results show that the neighborhood disparities of diarrheal morbidity among under-5 children have increased in all four countries.

Discussion

Main findings

The findings showed that the proportion of diarrheal morbidity among under-5 children varied considerably across the cohorts of birth from 10 to 35%, and we also observed large variations in the proportions of diarrheal morbidity across countries. The proportions of diarrheal morbidity are higher in Niger compared with Burkina, Mali, and Nigeria, where lower proportions were reported. Studies showed that mortality caused by diarrheal diseases among under-5 children in low- and middle-income countries has declined about 30% over the past two decades (2).

Our results showed that risk factors of diarrheal morbidity varied from one country to another, but the main factors included child's age, size of the child at birth,

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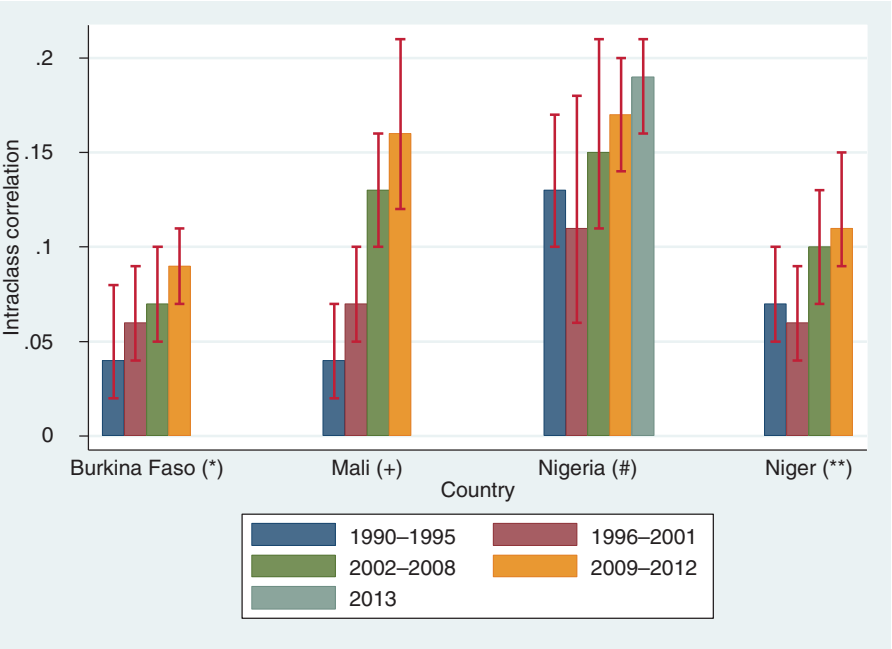

Fig. 2. Trend of intra-class correlation by country.
* = Burkina DHS 1993, 1999, 2003, 2010; + = Mali DHS 1995, 2001, 2006, 2012; # = Nigeria DHS 1990, 1999, 2003, 2008, 2013; ** = Niger DHS 1992, 1998, 2006, 2012.

the quality of the main floor material, mother's education and her occupation, type of toilet, and place of residence. We observed high neighborhood disparities in diarrheal morbidity in Nigeria and Mali and low neighborhood disparities in Niger and Burkina Faso.

Strengths and limitations

Previous studies on risk factors for diarrheal morbidity and mortality in low- and middle-income countries often were interested in individual factors. This study used data from all DHS rounds conducted in Burkina Faso, Mali, Nigeria, and Niger during the 1990–2013 period, corresponding to cohorts of children born between 1986 and 2013. The use of these rounds of DHS data allowed the researchers first to study the trend of the prevalence of diarrheal morbidity among under-5 children and, second, to make a comparative analysis across countries. One of the strengths of this study is to have investigated and quantified the magnitude of neighborhood inequalities in diarrheal morbidity in the selected countries of our study. Diarrheal morbidity in the DHS was captured by asking mothers if their children had had diarrhea in the 2 weeks preceding the survey and, if so, whether there was blood in the stool. This methodology, based on the mother's statement, contained deficiencies related to problems of recall (2 weeks) on the one hand and, on the other, the problems associated with the uncertainty of the mother's statement on the state of her child's health.

Interpretation of the results

Previous studies have shown that during the past three decades, thanks to the introduction of oral rehydration solutions and zinc supplementation in the treatment of diarrhea, the prevalence of diarrheal diseases has been reduced drastically in low-income countries (6, 27). Santosham et al. (6) showed that with the distribution of oral solutions, the number of child deaths caused by diarrhea dropped from 4.6 million in 1980 to 3.3 million in 1990 and to 1.3 million in 2008. These significant declines recorded in the different countries would be the result of action undertaken since the late 1970s to fight against diarrheal diseases through the introduction of drugs and, especially, through awareness and promotion of hygiene. Important activities have been undertaken including training of health workers, participation of religious leaders, educational campaigns in schools, and modifications to the use of oral rehydration formulations to fit local traditions and beliefs. Mass media campaigns have been set up around the world, and many political leaders and celebrities have endorsed the use of oral rehydration solution (6). In the Niger, we found an increased proportion of diarrheal morbidity among the children born after 2010. This result was not expected given the politic against diarrheal diseases through the distribution of oral rehydration salts, with low-osmolarity salts introduced in 2006 in Niger (28).

We found that child's age is a risk factor of diarrheal morbidity, and its effect is significant for all countries and

for each of the rounds of DHS. The results showed that children aged 7 to 36 months are more likely to experience diarrheal disease than children aged to 6 months, and after 36 months, the risk of suffering from a diarrheal disease becomes low. Similar results were found in Ethiopia (29), Iraq (30), Egypt (31), Turkey (32), and India (16, 33). It seems that children aged 6 to 36 months have an immune system not yet sufficiently developed to protect against the diseases compared with children aged less than 6 months who benefit directly from their mother's immune system (30). We also found that children with a small size (low weight) at birth are more likely to have been reported as having been associated with diarrheal morbidity than children who had a large size at birth. Results of earlier studies have shown that malnutrition and underweight in children are risk factors in diarrheal morbidity (34–37).

According to the results of the present study, in Burkina Faso (1993 and 2003 DHS) and in Nigeria (1990, 2003, and 2003 DHS), male children are more likely to have been reported as being associated with diarrheal morbidity than female children. Similar results were found in previous studies (20, 30, 32, 33, 38, 39). This result is not surprising as the results of both morbidity and mortality studies of under-5 children in sub-Saharan countries often have found an excess mortality in male children in early life (40–42). Studies carried out in developing countries reveal that mother's education level is an important factor of diarrheal morbidity and death among under-5 children, and children from less-educated mothers are more likely to experience diarrheal diseases than children of more-educated mothers (30, 43, 44).

Maternal education and her occupation are factors that provide information about the level of autonomy of the woman who could empower herself to take care of her child. The effect of the quality of the immediate environment as a risk factor in diarrheal morbidity in under-5 children was revealed as significant in previous studies (29, 38, 39, 45, 46). We found that the poor quality of main floor material (in Burkina, Mali, Niger, and Nigeria), the type of latrine used (in Mali and Nigeria), and the source of drinking water (in Mali and Nigeria) are associated significantly with the risk of diarrheal morbidity.

Our study found high neighborhood inequalities in diarrheal morbidity in the selected countries, while the results showed a decline in the overall prevalence of diarrhea morbidity among under-5 children. These neighborhood inequalities show that the decline in prevalence of diarrheal morbidity hides huge disparities among neighborhoods and villages in the countries under study. These results inform us that in some villages or neighborhoods in big cities, the prevalence of diarrheal diseases has lowered greatly, while for some neighborhoods or villages, the proportions of diarrheal morbidity are still high. Neighborhood inequalities observed may be explained in part by the quality of the immediate environment and the poor quality of the drinking water experienced in some villages and suburbs around large cities.

Conclusion

In this study, we identified a decrease in the proportions of diarrheal morbidity among under-5 children in Burkina Faso, Mali, Nigeria, and Niger during the period between 1990 and 2013. However we have observed a growing trend of inequalities among neighborhoods and villages of countries selected for the study. This result shows that the decline in the prevalence of diarrheal morbidity is not uniform in the different villages and neighborhoods, and in some places, under-5 children still suffer from the burden of diarrheal disease. This suggests the need to fight against diarrheal diseases on both the local and community level across villages and countries. Successful implementation of an integrated plan requires the commitment of families, health care providers, and key actors in water and sanitation.

Authors' contributions

AB made substantial contributions to conception, acquisition, and interpretation of data. AB contributed in drafting the article and AS extensively reviewed and revised the article. EN provided substantial contributions and help in manuscript drafting. All authors read and approved the final document.

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Conflict of interest and funding

The authors declare that they have no financial or non-financial competing interests in relation to this manuscript.

Paper context

Health inequalities of children in Sub-Saharan Africa

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Appendix 1: Determinant Variables in Bivariate Analysis

	Burkina Faso							
Variable	**1993**		**1998**		**2003**		**2010**	
	No	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**
n	***4089***	***1010***	***4,056***	***1,015***	***7,485***	***1,876***	***11,685***	***2,031***
Household size		**ns**	**ns**			*******		*******
1-3	78.7	21.3	78.7	21.3	72.6	27.4	81.3	18.7
4-6	79.3	20.7	81.6	18.4	80.8	19.2	85.6	14.4
7&+	80.7	19.3	79.4	20.6	80.3	19.7	85.5	14.5
Sex of the head of		**ns**		**ns**		**ns**		**ns**
Male	80.0	20.0	80.0	20.0	80.11	19.89	85.3	14.8
Female	83.8	16.3	80.5	19.5	76.82	23.18	84.4	15.6
Age of the mother		**ns**		**ns**		**ns**		******
15-19	76.2	23.8	76.9	23.1	76.5	23.5	80.0	20.0
20-24	79.5	20.6	78.0	22.1	78.6	21.4	84.2	15.8
25-29	80.4	19.6	80.6	19.4	81.0	19.0	85.6	14.4
30-34	81.1	18.9	81.1	18.9	80.5	19.5	85.9	14.1
35-39	81.8	18.2	80.6	19.4	80.3	19.7	86.0	14.0
40-44	79.6	20.4	82.8	17.2	81.2	18.8	85.6	14.4
45-49	78.2	21.8	78.1	22.0	78.9	21.1	88.5	11.5
Place of residence		**ns**		**ns**		**ns**		**ns**
Urban	81.4	18.6	80.3	19.7	80.2	19.8	84.7	15.3
Rural	79.6	20.5	79.9	20.1	79.9	20.1	85.3	14.7
Mother Occupation		**ns**		**ns**		**ns**		**ns**
Not working	81.5	18.5	82.6	17.4	77.8	22.2	86.4	13.6
Sale	78.9	21.1	79.7	20.3	79.7	20.3	84.9	15.1
Agriculter	78.5	21.5	78.8	21.2	80.4	19.6	85.3	14.8
Manual	81.4	18.6	80.6	19.4	77.9	22.1	83.4	16.6
Mother's education level		**ns**		**ns**		**ns**		******
No Education	80.0	20.0	80.1	19.9	80.0	20.0	85.6	14.4
1-6 years	79.3	20.7	78.5	21.5	78.1	22.0	82.6	17.4
7&+ years	85.2	14.8	80.9	19.1	83.1	16.9	84.4	15.6
Has Electricity		**ns**		**ns**		**ns**		**ns**
No	79.8	20.2	79.8	20.3	79.8	20.2	85.2	14.8
Yes	83.4	16.6	83.5	16.5	82.4	17.6	84.8	15.2
Has Television		**ns**		**ns**		**ns**		**ns**
No	79.9	20.1	79.9	20.1	79.7	20.3	85.2	14.8
Yes	83.4	16.6	81.6	18.4	82.3	17.7	85.3	14.7
Has Refrigerator		**ns**		**ns**		*****		*****
No	80.0	20.0	80.0	20.0	79.8	20.2	85.1	14.9
Yes	85.1	15.0	79.0	21.1	85.2	14.8	87.6	12.4
Has Bicycle		**ns**		**ns**		*****		*****
No	80.1	19.9	77.9	22.1	77.6	22.4	83.0	17.0
Yes	80.2	19.8	80.4	19.6	80.4	19.6	85.5	14.6
Has Motorcycle		**ns**		**ns**		**ns**		**ns**
No	79.3	20.7	79.9	20.1	79.5	20.5	84.9	15.1
Yes	81.6	18.5	80.1	19.9	81.2	18.8	85.7	14.3
Immediat environment and								
Type of toilette		**ns**		**ns**		**ns**		**ns**
Flush/upgraded latrin	85.7	14.3	72.4	27.6	72.4	27.6	78.9	21.1
Traditional latrines	80.7	19.3	78.8	21.2	79.4	20.6	84.9	15.1
Lack of toilet	79.8	20.2	80.7	19.4	80.2	19.8	85.5	14.6
Other type	78.3	21.7	74.7	25.3	81.4	18.6	85.1	14.9
Quality of Main floor		*******		**ns**		**ns**		**ns**
Poor	78.6	21.5	79.9	20.2	79.5	20.5	85.8	14.2
Middle	82.6	17.4	80.5	19.5	80.8	19.2	84.5	15.5
Rich	82.6	17.4	75.0	25.0	79.4	20.6	83.2	16.8
Sources of drinking water		**ns**		**ns**		**ns**		**ns**
Piped/Public tap/stan	80.5	19.5	79.1	20.9	79.7	20.3	84.4	15.6
Tube well or borehole	80.0	20.0	80.3	19.7	80.5	19.5	85.6	14.4
Well	83.5	16.5	79.6	20.4	79.7	20.3	85.1	14.9

Spring/river/lake/other	78.7	21.3	77.2	22.8	80.0	20.0	85.0	15.1
Child level variables								
Sex of the child		**		ns		***		ns
Female	81.75	18.25	80.3	19.7	81.3	18.7	85.4	14.6
Male	78.65	21.35	79.7	20.3	78.7	21.3	85.0	15.0
Age in months		***		***		***		***
0-6	82.07	17.93	85.1	14.9	84.3	15.8	89.1	10.9
07-12	71.22	28.78	67.8	32.2	68.8	31.2	76.4	23.6
13-18	64.49	35.51	68.4	31.6	68.2	31.8	73.4	26.7
19-24	74.64	25.36	71.4	28.6	71.2	28.8	78.7	21.3
25-30	74.79	25.21	75.0	25.1	73.4	26.6	80.7	19.3
31-36	78.91	21.09	77.5	22.5	81.6	18.4	85.5	14.6
37-42	85.79	14.21	83.6	16.4	84.4	15.6	90.1	9.9
42-48	86.78	13.22	87.4	12.7	87.4	12.6	92.4	7.6
48-59	93.62	6.38	92.4	7.6	91.4	8.7	94.6	5.4
Has Measles vaccine		***		***		***		ns
No	77.42	22.58	78.4	21.6	78.1	21.9	85.4	14.7
Yes	82.12	17.88	81.7	18.3	81.7	18.4	85.1	14.9
Size of child at birth		ns		ns		***		***
Large	80.52	19.48	78.7	21.3	78.3	21.8	83.2	16.8
Average	81.2	18.8	81.5	18.5	81.3	18.7	86.7	13.3
Small	77.19	22.81	78.6	21.4	77.8	22.2	83.1	16.9
DK (Don't know)	81.75	18.25	92.9	7.1	89.3	10.7	93.8	6.3

**=p-value<0.05; **=p-value <0.01; ***=p-value <0.001, ns= no significant*

Appendix 1: Determinant Variables in Bivariate Analysis (Count…)

	Mali							
Variable	**1995**		**2001**		**2006**		**2012**	
	No	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**
n	***3,857***	***1,374***	***8,872***		***10,938***	***1,450***	***8,738***	***844***
Household size		**ns**		***		**		**ns**
1-3	76.0	24.1	75.3	24.7	85.6	14.4	90.1	9.9
4-6	72.7	27.3	80.3	19.7	88.9	11.1	91.2	8.8
7&+	74.1	26.0	81.2	18.8	88.3	11.7	91.3	8.7
Sex of the head of household		**ns**		**ns**		**ns**		**ns**
Male	73.8	26.2	80.2	19.8	88.5	11.5	91.1	8.9
Female	73.1	26.9	81.3	18.7	86.3	13.7	92.3	7.7
Age of the mother		*		***		**ns**		**ns**
15-19	76.7	23.3	76.7	23.3	86.4	13.6	89.1	10.9
20-24	75.0	25.0	79.9	20.1	87.9	12.1	90.9	9.1
25-29	75.4	24.7	81.6	18.4	88.3	11.7	91.6	8.4
30-34	71.9	28.2	79.5	20.5	88.7	11.3	91.9	8.1
35-39	72.2	27.8	81.2	18.8	88.8	11.2	90.4	9.6
40-44	68.9	31.1	79.4	20.6	89.7	10.3	91.4	8.6
45-49	64.7	35.3	84.7	15.4	88.8	11.2	94.4	5.6
Place of residence		**		***		***		**ns**
Urban	76.3	23.7	85.3	14.8	91.5	8.5	90.3	9.7
Rural	72.6	27.4	78.9	21.1	86.9	13.1	91.5	8.5
Mother Occupation		**		***		***		***
Not working	76.1	23.9	80.6	19.4	90.8	9.24	94.0	6.0
Sale	72.2	27.8	82.5	17.5	88.3	11.66	87.8	12.2
Agriculter	70.4	29.6	79.4	20.6	-	-	87.6	12.4
Manual	74.4	25.6	76.8	23.3	86.0	14.04	89.2	10.9
Mother's education level		***		**ns**		**ns**		***
No Education	72.4	27.6	79.9	20.1	88.1	12.0	91.7	8.3
1-6 years	79.5	20.5	81.6	18.4	88.9	11.1	89.2	10.8
7&+ years	85.0	15.0	83.7	16.3	90.9	9.1	88.4	11.6
Has Electricity		***		***		***		**ns**
No	73.1	26.9	79.6	20.4	87.5	12.5	91.5	8.5
Yes	82.6	17.4	86.1	14.0	92.5	7.5	90.4	9.6
Has Television		***		***		***		**ns**
No	72.7	27.3	79.3	20.7	87.3	12.7	91.4	8.6
Yes	83.8	16.2	85.8	14.2	91.4	8.7	90.7	9.3
Has Refrigerator		***		***		*		**ns**
No	73.4	26.7	79.9	20.1	88.2	11.8	91.3	8.7
Yes	85.2	14.8	86.5	13.5	91.8	8.2	89.5	10.5
Has Bicycle		**ns**		***		**		**ns**
No	73.3	26.7	78.0	22.0	89.1	10.9	91.2	8.8
Yes	74.3	25.7	82.3	17.7	87.5	12.5	91.2	8.8
Has Motorcycle		**ns**		***		**		**ns**
No	73.2	26.8	79.5	20.5	87.7	12.3	91.2	8.8
Yes	75.7	24.3	82.7	17.3	89.3	10.7	91.2	8.8
Immediat environment and hygiene								
Type of toilette		***		***		**ns**		**ns**
Flush/upgraded latrin	88.6	11.4	86.6	13.4	92.1	7.9	92.5	7.6
Traditional latrines	75.2	24.8	81.3	18.7	88.3	11.7	91.2	8.8
Lack of toilet	69.2	30.8	75.3	24.7	88.0	12.0	90.2	9.8
Other type	84.9	15.2	81.5	18.5	89.2	10.8	90.1	9.9
Quality of Main floor material		***		***		***		**
Poor	71.6	28.4	79.2	20.9	87.7	12.3	91.7	8.3
Middle	81.9	18.1	85.6	14.4	90.1	9.9	90.0	10.0
Rich	82.0	18.0	82.5	17.5	91.6	8.4	88.8	11.2
Sources of drinking water		**		***		***		***
Piped/Public tap/stan	75.1	25.0	84.6	15.4	91.1	8.9	89.4	10.6
Tube well or borehole	73.8	26.2	79.2	20.8	-	-	92.3	7.7
Well	63.1	36.9	80.4	19.6	87.5	12.6	91.6	8.4

Spring/river/lake/other	81.8	18.2	73.6	26.4	87.5	12.5	93.9	6.2
Child level variables								
Sex of the child		**ns**		**ns**		**ns**		*****
Female	74.6	25.4	81.0	19.1	88.7	11.3	91.8	8.2
Male	72.9	27.1	79.6	20.4	87.9	12.1	90.6	9.4
Age in months		*******		*******		*******		*******
0-6	84.5	15.6	82.8	17.2	93.2	6.8	92.5	7.5
07-12	68.5	31.5	69.0	31.0	79.9	20.1	85.8	14.2
13-18	65.9	34.1	71.5	28.5	80.4	19.6	84.7	15.3
19-24	69.7	30.3	73.4	26.6	81.0	19.1	88.8	11.2
25-30	74.0	26.0	77.5	22.6	86.8	13.2	90.1	9.9
31-36	75.0	25.0	80.0	20.0	89.4	10.6	92.5	7.5
37-42	-	-	85.6	14.4	90.3	9.8	93.3	6.7
42-48	-	-	86.1	13.9	94.7	5.3	94.4	5.6
48-59	-	-	90.1	10.0	95.3	4.7	94.8	5.2
Has Measles vaccine		**ns**		*******		**ns**		******
No	74.5	25.5	78.1	21.9	87.7	12.3	92.3	7.8
Yes	72.5	27.5	83.3	16.7	88.8	11.2	90.5	9.5
Size of child at birth		*******		*******		*******		*****
Large	73.2	26.8	80.9	19.1	88.8	11.2	90.7	9.3
Average	75.2	24.8	81.5	18.5	88.9	11.1	91.0	9.1
Small	69.9	30.1	76.8	23.2	85.4	14.6	92.5	7.6
DK (Don't know)	87.7	12.3	82.3	17.7	93.3	6.7	94.4	5.6

**=p-value<0.05; **=p-value <0.01; ***=p-value <0.001, ns= no significant*

Appendix 1: Determinant Variables in Bivariate Analysis (Count…)

	Nigeria									
Variable	**1990**		**1999**		**2003**		**2008**		**2013**	
	No	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**
n	***5,704***	***1,119***	***2,648***	***491***	***4,234***	***929***	***22,801***	***2,645***	***25,628***	***2,968***
Household size		**ns**		**ns**		**ns**		*******		*******
1-3	80.8	19.3	85.3	14.7	81.9	18.1	89.1	10.9	89.1	11.0
4-6	84.2	15.8	85.6	14.4	82.5	17.5	90.9	9.1	91.0	9.0
7&+	83.6	16.4	83.0	17.1	81.6	18.4	88.5	11.5	88.5	11.5
Sex of the head of		**ns**		*******		**ns**		*******		*******
Male	83.5	16.6	83.9	16.1	81.7	18.3	89.3	10.7	89.4	10.6
Female	85.5	14.5	89.2	10.8	85.2	14.8	92.7	7.3	91.6	8.4
Age of the mother		*******		**ns**		*****		*******		*******
15-19	76.1	23.9	83.6	16.4	77.3	22.7	85.0	15.0	85.8	14.2
20-24	82.5	17.5	82.7	17.3	80.1	19.9	88.9	11.1	88.2	11.8
25-29	83.3	16.7	86.1	13.9	82.3	17.7	90.1	9.9	89.7	10.3
30-34	85.5	14.5	84.4	15.6	82.3	17.7	90.5	9.5	90.6	9.5
35-39	85.4	14.6	83.3	16.7	84.6	15.4	90.1	9.9	90.0	10.0
40-44	86.9	13.1	85.3	14.7	85.2	14.8	89.6	10.4	92.0	8.0
45-49	78.1	21.9	87.5	12.5	80.4	19.6	89.1	11.0	89.2	10.8
Place of residence		*******		**ns**		*******		*******		*******
Urban	90.1	9.9	85.5	14.5	85.2	14.8	91.1	8.9	91.0	9.0
Rural	79.9	20.1	83.9	16.1	80.2	19.8	89.0	11.0	88.9	11.1
Mother Occupation		*******		*******		**ns**		*******		*******
Not working	81.4	18.6	83.5	16.5	81.3	18.8	89.4	10.7	88.3	11.7
Sale	83.0	17.1	85.2	14.8	81.2	18.8	88.9	11.1	90.4	9.6
Agriculter	85.5	14.5	81.2	18.8	84.5	15.6	91.0	9.0	90.6	9.4
Manual	89.7	10.3	88.1	11.9	83.5	16.6	89.7	10.3	89.4	10.6
Mother's education		*******		*******		*******		*******		*******
No Education	80.6	19.4	81.5	18.5	77.2	22.8	86.6	13.4	87.5	12.5
1-6 years	85.4	14.6	86.0	14.0	84.7	15.4	90.9	9.2	89.9	10.1
7&+ years	91.6	8.4	87.9	12.1	88.2	11.8	93.9	6.1	92.3	7.7
Has Electricity		*******		*******		*******		*******		*******
No	79.8	20.2	83.0	17.0	79.4	20.6	88.0	12.0	88.0	12.0
Yes	90.4	9.6	86.3	13.8	85.0	15.1	92.1	8.0	91.4	8.6
Has Television		*******		*******		*******		*******		*******
No	81.1	18.9	83.6	16.4	80.1	19.9	88.0	12.0	87.9	12.1
Yes	90.5	9.5	86.6	13.4	86.5	13.5	93.1	7.0	91.9	8.1
Has Refrigerator		*******		*******		*******		*******		*******
No	82.4	17.6	83.8	16.2	81.0	19.0	89.0	11.0	89.0	11.0
Yes	90.3	9.8	87.6	12.4	87.2	12.8	94.0	6.0	92.7	7.4
Has Bicycle		*******		**ns**		*******		*******		*******
No	84.6	15.4	84.6	15.4	84.0	16.0	90.3	9.7	89.9	10.1
Yes	81.3	18.7	83.7	16.3	79.1	20.9	87.9	12.1	88.7	11.3
Has Motorcycle		**0.324**		**0.2**		**0.043**		**0.001**		**0.066**
No	83.4	16.6	84.7	15.3	81.5	18.5	89.2	10.8	89.9	10.1
Yes	84.5	15.5	82.5	17.5	84.2	15.8	90.5	9.5	89.2	10.8
Immediat										
Type of toilette		*******		*******		*******		*******		*******
Flush/upgraded latrin	94.4	5.6	88.5	11.5	90.2	9.8	95.6	4.4	93.4	6.6
Traditional latrines	83.0	17.0	83.0	17.0	80.2	19.9	87.4	12.6	88.3	11.7
Lack of toilet	80.3	19.7	86.6	13.4	82.8	17.2	90.5	9.5	89.3	10.7
Other type	81.6	18.4	77.2	22.8	85.1	14.9	95.0	5.0	95.6	4.5
Quality of Main floor		*******		*******		*******		*******		*******
Poor	81.3	18.7	84.5	15.5	77.4	22.6	86.7	13.3	87.6	12.4
Middle	85.3	14.7	84.0	16.0	82.9	17.1	91.3	8.7	90.9	9.1
Rich	86.1	13.9	96.7	3.3	89.7	10.3	95.0	5.0	92.0	8.0
Sources of drinking		*******		**ns**		*******		*******		*******
Piped/Public tap/stan	88.0	12.0	86.2	13.8	84.7	15.3	90.1	9.9	88.6	11.4

Tube well or borehole	79.4	20.6	83.1	16.9	77.7	22.3	90.7	9.3	91.2	8.8
Well	82.7	17.3	84.4	15.6	87.5	12.5	87.6	12.4	88.5	11.5
Spring/river/lake/other	91.6	8.4	84.3	15.7	81.8	18.2	91.0	9.0	89.4	10.6
Child level variables										
Sex of the child		***		ns		*		**		ns
Female	84.8	15.2	84.2	15.8	83.1	16.9	90.1	9.9	89.7	10.4
Male	82.4	17.6	84.5	15.5	81.0	19.0	89.1	10.9	89.6	10.4
Age in months		***		***		***		**		***
0-6	87.0	13.0	90.6	9.4	84.6	15.4	92.0	8.0	92.8	7.2
07-12	72.4	27.6	80.1	19.9	74.0	26.0	83.4	16.6	82.6	17.4
13-18	71.8	28.2	81.0	19.1	71.3	28.7	82.8	17.2	83.3	16.7
19-24	77.1	23.0	82.0	18.0	71.8	28.3	86.4	13.6	85.1	14.9
25-30	80.8	19.2	86.2	13.8	78.9	21.1	88.5	11.5	89.0	11.0
31-36	84.3	15.7	86.8	13.3	83.0	17.0	91.8	8.2	90.0	10.0
37-42	90.9	9.1	-	-	86.1	13.9	91.4	8.6	92.6	7.4
42-48	91.3	8.7	-	-	90.2	9.8	93.8	6.2	93.5	6.5
48-59	92.1	8.0	-	-	92.9	7.1	94.4	5.6	94.8	5.2
Has Measles vaccine		***		ns		***		***		***
No	81.3	18.7	83.9	16.1	79.0	21.0	88.0	12.1	88.1	11.9
Yes	86.6	13.4	85.3	14.8	87.9	12.2	92.5	7.5	92.1	8.0
Size of child at birth		***		ns		***		***		***
Large	85.9	14.1	85.4	14.6	85.1	14.9	89.9	10.2	89.3	10.7
Average	83.4	16.6	83.9	16.1	80.9	19.1	90.5	9.5	91.1	8.9
Small	79.9	20.1	83.9	16.1	76.4	23.6	86.0	14.1	85.9	14.1
DK (Don't know)	75.6	24.4	79.1	20.9	69.7	30.3	94.3	5.7	95.6	4.4

**=p-value<0.05; **=p-value <0.01; ***=p-value <0.001, ns= no significant*

Appendix 1: Determinant Variables in Bivariate Analysis (Count…)

	Niger							
Variable	1992		1998		2006		2012	
	No	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**
n	***4,168***	***1,424***	***2,700***	***1,543***	***6,540***	***1,669***	***10,011***	***1,591***
Household size		**		ns		**		***
1-3	67.0	33.0	64.0	36.0	74.7	25.3	80.1	19.9
4-6	74.4	25.6	64.8	35.3	80.0	20.0	86.1	13.9
7&+	75.3	24.7	63.0	37.1	80.1	19.9	87.2	12.8
Sex of the head of		ns		ns		ns		ns
Male	74.6	25.4	63.4	36.7	80.0	20.0	86.3	13.7
Female	73.0	27.0	67.1	32.9	77.7	22.3	86.2	13.8
Age of the mother		**		ns		***		***
15-19	66.8	33.2	64.6	35.4	73.9	26.1	80.2	19.8
20-24	75.5	24.5	63.6	36.4	77.7	22.3	85.7	14.3
25-29	75.1	24.9	65.0	35.0	79.5	20.5	86.5	13.5
30-34	76.0	24.0	64.0	36.1	81.8	18.2	86.9	13.1
35-39	72.9	27.1	62.5	37.5	82.6	17.4	86.7	13.3
40-44	75.2	24.8	59.6	40.4	79.5	20.5	88.5	11.5
45-49	79.4	20.6	53.2	46.8	79.9	20.1	89.8	10.2
Place of residence		***		***		***		***
Urban	80.4	19.6	68.7	31.3	82.9	17.1	84.6	15.4
Rural	70.6	29.4	61.9	38.1	78.3	21.7	86.8	13.2
Mother Occupation		***		***		***		ns
Not working	75.8	24.2	66.2	33.8	80.9	19.1	86.6	13.4
Sale	76.8	23.2	59.7	40.3	79.9	20.2	86.3	13.7
Agriculter	67.5	32.5	60.6	39.4	74.9	25.2	82.5	17.5
Manual	71.2	28.8	68.2	31.8	80.2	19.8	84.5	15.5
Mother's education		***		***		***		***
No Education	73.5	26.5	62.7	37.3	78.7	21.3	86.8	13.2
1-6 years	77.8	22.2	65.9	34.1	82.6	17.4	84.1	15.9
7&+ years	85.9	14.1	75.3	24.7	87.8	12.2	83.1	16.9
Has Electricity		***		***		***		*
No	73.8	26.2	62.6	37.4	79.0	21.1	86.7	13.3
Yes	80.5	19.5	72.8	27.2	83.4	16.6	84.8	15.3
Has Television		***		***		***		***
No	73.6	26.5	63.0	37.0	79.0	21.1	86.6	13.4
Yes	82.4	17.6	72.3	27.7	84.8	15.2	84.6	15.4
Has Refrigerator		**		***		***		ns
No	74.2	25.9	63.2	36.8	79.2	20.8	86.3	13.7
Yes	81.0	19.1	75.0	25.0	88.2	11.8	86.2	13.9
Has Bicycle		ns		ns		***		ns
No	74.3	25.7	63.9	36.1	79.0	21.1	86.3	13.7
Yes	76.6	23.4	60.6	39.4	83.6	16.4	86.5	13.5
Has Motorcycle		**		***		ns		ns
No	74.1	25.9	63.1	36.9	79.4	20.6	86.4	13.6
Yes	80.2	19.8	73.1	26.9	82.0	18.1	85.5	14.5
Immediat environment								
Type of toilette		**		ns		***		*
Flush/upgraded latrin	83.3	16.7	71.2	28.9	87.7	12.3	86.5	13.5
Traditional latrines	80.7	19.3	69.0	31.0	82.5	17.5	84.9	15.1
Lack of toilet	71.4	28.6	62.0	38.0	78.4	21.6	86.9	13.1
Other type	72.1	27.9	35.3	64.7	78.5	21.5	82.0	18.0
Quality of Main floor		***		***		***		***
Poor	71.9	28.1	61.7	38.3	78.5	21.5	87.0	13.1
Middle	80.3	19.7	71.2	28.8	83.7	16.3	86.1	13.9
Rich	84.4	15.6	75.8	24.2	88.9	11.1	82.0	18.0
Sources of drinking		**		***		***		***
Piped/Public tap/stan	78.2	21.8	68.8	31.2	82.5	17.6	85.1	14.9

Tube well or borehole	70.8	29.2	61.9	38.1	-	-	85.8	14.2
Well	76.9	23.1	65.6	34.4	78.2	21.8	87.6	12.4
Spring/river/lake/other	83.2	16.8	63.6	36.4	82.4	17.6	79.9	20.1
Child level variables								
Sex of the child		**ns**		**ns**		**ns**		**ns**
Female	75.2	24.8	64.4	35.6	79.4	20.6	86.7	13.3
Male	73.9	26.1	62.9	37.1	79.9	20.1	85.8	14.2
Age in months		***		***		***		***
0-6	74.1	26.0	69.3	30.7	80.7	19.3	84.6	15.4
07-12	55.4	44.6	50.4	49.6	66.7	33.3	71.2	28.8
13-18	62.0	38.0	61.8	38.2	67.8	32.2	77.5	22.5
19-24	63.8	36.2	63.5	36.5	72.9	27.1	82.3	17.7
25-30	73.1	26.9	66.6	33.4	78.1	21.9	84.9	15.2
31-36	79.3	20.7	72.9	27.1	81.7	18.3	89.7	10.3
37-42	85.1	14.9			87.2	12.8	92.3	7.7
42-48	86.4	13.7			87.8	12.2	93.7	6.3
48-59	88.5	11.5			90.2	9.8	96.2	3.8
Has Measles vaccine		***		**ns**		***		***
No	71.7	28.3	62.7	37.3	77.3	22.7	84.1	15.9
Yes	79.3	20.7	65.8	34.2	82.4	17.6	87.7	12.3
Size of child at birth		***		**ns**		***		***
Large	78.2	21.8	63.1	36.9	79.6	20.4	85.5	14.5
Average	76.2	23.8	64.5	35.5	81.4	18.6	87.5	12.5
Small	69.5	30.5	62.5	37.5	75.5	24.5	83.5	16.5
DK (Don't know)	71.9	28.1	80.0	20.0	82.8	17.2	90.0	10.0

**=p-value<0.05; **=p-value <0.01; ***=p-value <0.001, ns= no significant*

Appendix 2: Multilevel Logistic Regression

	Burkina Faso			
	1992-93	1998-99	2003	2010
Variable	**AOR (95% CI)**	**AOR (95% CI)**	**AOR (95% CI)**	**AOR (95% CI)**
n				
Household size				
1-3	1	1	1	1
4-6	1.1 (0.8; 1.6)	0.9 (0.7; 1.3)	0.7** (0.6; 0.9)	0.8 (0.7;1.0)
7&+	1.1 (0.8; 1.5)	1.1 (0.8; 1.6)	0.8*(0.6; 0.9)	0.9 (0.7; 1.1)
Sex of the head of household				
Male	1	1	1	1
Female	0.8	0.9 (0.6; 1.3)	1.2 (0.9; 1.5)	0.9 (0.8; 1.2)
Age of the mother				
15-19	1	1	1	1
20-24	1.0 (0.7; 1.4)	1.1 (0.8; 1.5)	1.1 (0.8; 1.4)	0.9 (0.7; 1.2)
25-29	1.0 (0.7; 1.4)	1.0 (0.7; 1.4)	1.1 (0.8; 1.3)	0.9(0.7; 1.1)
30-34	1.0 (0.7; 1.4)	0.9 (0.6; 1.3)	1.1 (0.8; 1.4)	0.9 (0.7; 1.2)
35-39	1.0 (0.7; 1.4)	1.0 (0.7; 1.4)	1.1 (0.8; 1.4)	0.9 (0.7; 1.2)
40-44	1.1 (0.8; 1.7)	0.8 (0.5; 1.3)	1.0 (0.8; 1.4)	1.0(0.7; 1.3)
45-49	1.5 (0.9; 2.7)	1.4 (0.8; 2.4)	1.4 (0.9; 2.1)	0.8 (0.5; 1.3)
Place of residence				
Urban	1	1	1	1
Rural	0.9 (0.7; 1.3)	1.1 (0.7; 1.7)	1.1 (0.8;1.4)	1.0 (0.8; 1.3)
Mother Occupation				
Not working	1	1	1	1
Sale	1.2 (0.9; 1.4)	1.3*(1.03; 1.6)	0.9 (0.7; 1.1)	1.2*(1.02; 1.5)
Agriculter	1.2 (0.9; 1.6)	1.4** (1.1; 1.7)	0.8 (0.6; 1.0)	1.2*(1.02; 1.4)
Manual	1.1 (0.8; 1.4)	1.3 (0.9; 1.7)	1.0 (0.7; 1.5)	1.4**(1.1; 1.7)
Mother's education level				
No Education	1	1	1	1
1-6 years	1.2 (0.9; 1.6)	1.1 (0.8; 1.4)	1.1 (0.9; 1.3)	1.2(1.0; 1.4)
7&+ years	0.9 (0.6; 1.3)	0.9 (0.5; 1.4)	0.8 (0.5; 1.1)	1.0 (0.8; 1.3)
Has Electricity				
No	0.9 (0.6; 1.4)	0.5* (0.3; 0.8)	0.9 (0.7; 1.3)	0.9 (0.7; 1.3)
Yes	1	1	1	1
Has Television				
No	0.9 (0.6; 1.4)	0.9 (0.6; 1.4)	0.9 (0.6; 1.13)	0.9 (0.8; 1.1)
Yes	1	1	1	1
Has Refrigerator				
No	0.9 (0.5; 1.6)	1.6 (0.9; 3.1)	0.7 (0.5; 1.1)	0.8 (0.5; 1.2)
Yes	1	1	1	1
Has Bicycle				
No	0.9 (0.8; 1.2)	0.8* (0.6; 0.9)	0.9 (0.8; 1.1)	0.8 (0.7; 1.0)
Yes	1	1	1	1
Has Motorcycle				
No	0.9 (0.8; 1.13)	0.9 (0.8; 1.2)	0.9 (0.8; 1.1)	0.9 (0.8; 1.1)
Yes	1	1	1	1
Immediat environment and hygiene				
Type of toilette				
Flush/upgraded latrin	1	1	1	1
Traditional latrines	0.9 (0.4; 2.5)	0.8 (0.3; 2.3)	0.6 (0.3; 1.0)	0.6 (0.4; 1.0)
Lack of toilet	0.9 (0.4; 2.4)	0.6 (0.2; 1.9)	0.5(0.3; 0.9)	0.6*(0.3; 0.9)
Other type	0.9 (0.3; 3.4)	0.9 (0.3; 3.3)	0.4 (0.2; 9)	0.4*(0.2; 0.9)
Quality of Main floor material				
Poor	1	1	1	1
Middle	0.7** (0.6; 0.9)	1.0 (0.8; 1.2)	0.9 (0.8; 1.1)	1.1 (0.9; 1.2)
Rich	0.9 (0.4; 2.6)	1.9 (0.8; 4.8)	1.3 (0.7; 2.3)	0.9 (0.5; 1.8)
Sources of drinking water				
Piped/Public tap/stan	1	1	1	1
Tube well or borehole	0.8 (0.6; 1.1)	0.9 (0.6; 1.3)	0.9 (0.8; 1.1)	0.9 (0.8; 1.2)

Well	0.7 (0.4; 1.2)	0.8 (0.5; 1.4)	0.9 (0.7; 1.2)	1.0 (0.8; 1.2)
Spring/river/lake/other	1.1 (0.7; 1.8)	0.7 (0.3; 1.4)	0.9 (0.7; 1.2)	1.0 (0.8; 1.4)
Child level variables				
Sex of the child				
Female	1	1	1	1
Male	1.2**(1.1; 1.4)	1.1 (0.9; 1.2)	1.2** (1.1; 1.3)	1.0 (0.9; 1.1)
Age in months				
0-6	1	1	1	1
07-12	2.0***(1.5; 2.6)	2.8***(2.2; 3.8)	2.7***(2.2; 3.3)	2.7***(2.2; 3.3)
13-18	2.8***(2.1; 3.7)	2.8** (2.1; 3.8)	2.9***(2.3; 3.6)	3.2***(2.6; 4.1)
19-24	1.7***(1.2; 2.4)	2.5*** (1.8; 3.4)	2.5***(1.9; 3.1)	2.3***(1.8; 3.0)
25-30	1.6***(1.2; 2.2)	2.1*** (1.6; 2.9)	2.2***(1.7; 2.8)	2.0***(1.6; 2.6)
31-36	1.3 (0.9; 1.8)	1.7** (1.2; 2.3)	1.3* (1.0 ; 1.7)	1.4** (1.1; 1.9)
37-42	0.81 (0.6; 1.1)	1.1 (0.8; 1.6)	1.1 (0.8; 1.4)	0.9 (0.7; 1.2)
42-48	0.7 (0.5; 1.1)	0.8 (0.6; 1.2)	0.8 (0.9; 1.4)	0.7*(0.5; 0.9)
48-59	0.3***(0.2; 0.5)	0.5*** (0.3; 0.7)	0.5*** (0.4; 0.7)	0.5***(0.4; 0.6)
Has Measles vaccine				
No	0.9 (0.8; 1.1)	0.9 (0.8; 1.1)	0.9*(0.8; 0.9)	0.9(0.8; 1.1)
Yes	1	1	1	1
Size of child at birth				
Large	1	1		1
Average	0.9 (0.8; 1.1)	0.9 (0.7; 1.0)	0.8**(0.7; 0.9)	0.8***(0.7; 0.9)
Small	1.3**(1.1; 1.5)	1.0 (0.8; 1.2)	1.0 (0.8; 1.2)	1.0(0.9; 1.2)
DK (Don't know)	0.9 (0.6; 1.6)	0.3 (0.04; 2.4)	0.5*(0.3; 0.9)	0.5(0.2; 1.4)
Constant	0.2* (0.1; 0.6)	0.2* (0.1; 0.8)	0.6 (0.3; 1.1)	0.3**(.1; 0.5)
Community Level SD	0.39 (0.29; 0.54)	0.46 (0.36 ; 0.58)	0.50 (0.43; 0.59)	0.56 (0.49; 0.65)
ICC	0.04 (0.2; 0.08)	0.06 (0.04; 0.09)	0.07 (0.05; 0.10)	0.09 (0.07; 0.11)
Wald chi2 (Prob>chi2)	272.3(0.0001)	266.1(0.0001)	459.3(0.0001)	588.6(0.0001)

*=p-value<0.05; **=p-value <0.01; ***=p-value <0.001

Appendix 2: Multilevel Logistic Regression (Count…)

			Mali	
	1995	**2001**	**2006**	**2012**
Variable	**AOR (95% CI)**	**AOR (95% CI)**	**AOR (95% CI)**	**AOR (95% CI)**
n				
Household size				
1-3	1	1	1	1
4-6	1.2 (0.9; 1.6)	0.8*(0.7; 0.9)	0.9 (0.7; 1.2)	1.0 (0.7; 1.4)
7&+	1.1 (0.9; 1.5)	0.8*(0.7; 0.9)	0.9 (0.7; 1.2)	0.9 (0.7; 1.3)
Sex of the head of household				
Male	1	1	1	1
Female	1.04 (0.8; 1.4)	0.9(0.7; 1.1)	1.2(0.9; 1.5)	1.0 (0.7; 1.4)
Age of the mother				
15-19	1	1	1	1
20-24	1.04 (0.8; 1.3)	0.9(0.8; 1.1)	1.0 (0.8; 1.3)	0.9 90.7; 1.2)
25-29	1.0 (0.8; 1.3)	0.9(0.7; 1.1)	1.1 (0.8; 1.4)	0.8 (0.6; 1.1)
30-34	1.1 (0.9; 1.5)	1.0(0.8; 1.3)	0.9 (0.8; 1.3)	0.8 (0.6; 1.1)
35-39	1.1 (0.8; 1.5)	0.9 (0.8; 1.2)	0.9 (0.7; 1.3)	0.9 (0.7; 1.4)
40-44	1.3(0.9; 1.8)	1.1(0.9; 1.5)	0.9 (0.7; 1.3)	0.9 (0.6; 1.3)
45-49	1.6 (0.9; 2.8)	0.8(0.5; 1.2)	1.1(0.7; 1.7)	0.6 (0.3; 1.2)
Place of residence				
Urban	1	1	1	1
Rural	0.9 (0.8; 1.2)	1.3*(1.1; 1.6)	1.5**(1.1; 1.9)	1.1 (0.8; 1.6)
Mother Occupation				
Not working	1		1	1
Sale	1.3**(1.1; 1.5)	1.1(0.9; 1.2)	1.3*(1.1; 1.5)	1.8***(1.5; 2.3)

Agriculter	1.2*(1.03; 1.5)	1.1(0.9; 1.3)	-	1.8***(1.4; 2.3)
Manual	1.1 (0.8; 1.4)	1.3**(1.1; 1.6)	1.4***(1.2;1.6)	1.8***(1.4; 2.3)
Mother's education level				
No Education	1	1	1	1
1-6 years	0.7 (0.6; 0.9)	0.9 (0.8; 1.2)	1.02 (0.8;1.3)	1.2 (0.9; 1.6)
7&+ years	0.6*(0.4; 0.9)	1.1(10.8; 1.5)	1.1 (0.8; 1.5)	1.3 (0.9; 1.7)
Has Electricity				
No	0.9 (0.6; 1.4)	1.0 (0.8; 1.3)	0.8 (0.6; 1.1)	1.1 (0.8; 1.4)
Yes	1	1	1	1
Has Television				
No	0.7 (0.5; 1.02)	0.9(0.7; 1.1)	0.9 90.7; 1.04)	0.9 (0.7; 1.1)
Yes	1	1	1	1
Has Refrigerator				
No	0.9(0.5; 1.5)	1.1 (0.8; 1.6)	1.3 (0.8; 1.9)	1.0 (0.7; 1.5)
Yes	1	1	1	1
Has Bicycle				
No	0.9(0.8; 1.05)	0.8**(0.7; 0.9)	1.0 (0.9; 1.2)	0.9 (0.8; 1.2)
Yes	1	1	1	1
Has Motorcycle				
No	1.2(0.9; 1.4)	1.0(0.9; 1.1)	0.9 (0.8; 1.1)	0.9 (0.8; 1.1)
Yes	1	1	1	1
Immediat environment and hygiene				
Type of toilette				
Flush/upgraded latrin	1	1	1	1
Traditional latrines	1.7 (0.5; 5.1)	1.4*(1.1; 1.9)	1.4 (0.8; 2.4)	1.2 (0.9; 1.7)
Lack of toilet	1.9 (0.6; 6.1)	1.7***(1.2; 2.3)	1.4 (0.8; 2.4)	1.5*(1.02; 2.3)
Other type	0.6 (0.1; 3.7)	1.2 (0.9; 1.1)	1.1 (0.5; 2.5)	1.3 (0.5; 3.1)
Quality of Main floor material				
Poor	1	1	1	1
Middle	0.6***(0.5; 0.8)	0.8*(0.6; 0.9)	0.9 (0.8; 1.2)	1.1 (0.8; 1.3)
Rich	0.9 (0.4; 2.2)	1.1 (0.6; 1.7)	1.1 (0.6; 1.9)	1.3(0.8; 2.0)
Sources of drinking water				
Piped/Public tap/stan	1	1	1	1
Tube well or borehole	0.8 (0.7; 1.1)	1.3**(1.1; 1.5)	-	0.8 (0.6; 1.04)
Well	1.3 (0.8; 2.0)	1.2(0.9; 1.4)	1.0 (0.8; 1.2)	0.8 (0.6; 1.1)
Spring/river/lake/other	1.3(0.3; 5.8)	1.7***(1.3; 2.2)	0.9 (0.7; 1.3)	0.8(0.4; 1.3)
Child level variables				
Sex of the child				
Female	1	1	1	1
Male	1.1 (0.9; 1.2)	1.1 (0.9; 1.2)	1.1 (0.9; 1.2)	1.2(0.9; 1.3)
Age in months				
0-6	1	1	1	1
07-12	2.6*** (2.1; 3.2)	2.4***(2.0; 2.9)	3.7***(2.9; 4.7)	2.0***(1.4; 2.7)
13-18	2.9***(2.3; 3.7)	2.2***(1.8; 2.6)	3.6***(2.8; 4.7)	1.8***(1.4; 2.5)
19-24	2.4***(1.9; 3.1)	2.0***(1.6; 2.5)	3.6***(2.7; 4.7)	1.3(0.9; 1.8)
25-30	1.9***(1.5; 2.5)	1.6***(1.3; 19)	2.3***(1.7; 3.0)	1.1 (0.8; 1.6)
31-36	1.7***(1.3; 2.2)	1.3*(0.1; 1.6)	1.7***(1.3; 2.3)	0.8 (0.6; 1.2)
37-42		0.9 (0.7; 1.1)	1.6**(1.2; 2.1)	0.8 (0.5; 1.1)
42-48		0.8(0.7; 1.0)	0.8 (0.5; 1.1)	0.6*(0.4; 0.8)
48-59		0.5***(0.4; 0.7)	0.7* (0.5; 0.9)	0.6**(0.4; 0.8)
Has Measles vaccine				
No	1.0 (0.8; 1.2)	0.9*(0.8; 0.9)	0.9 (0.8; 1.0)	1.2* (1.0; 1.5)
Yes	1	1	1	1
Size of child at birth				
Large	1	1	1	1
Average	0.9 (0.7; 1.0)	0.9 (0.8; 1.0)	1.0 (0.9; 1.1)	0.9 (0.8; 1.1)
Small	1.1 (0.8; 1.3)	1.0 (0.9; 1.2)	1.3***(1.1; 1.5)	0.8(0.6; 1.1)
DK (Don't know)	0.4*(0.2; 0.8)	0.7 (0.5; 1)	0.6 (0.4; 1.1)	0.8(0.5; 1.2)
Constant	0.10***(0.03;	0.12***(0.08; 0.2)	0.03***(0.01; 0.05)	0.04***(0.02; 0.1)
Community Level SD	0.37 (0.28; 0.50)	0.50(0.43; 0.59)	0.70 (0.60; 0.80)	0.80 (0.70; 0.93)

ICC	0.04 (0.02; 0.07)	0.07 (0.05; 0.10)	0.13 (0.10; 0.16)	0.16 (0.12; 0.21)
Wald chi2 (Prob>chi2)	212.1 (0.0001)	484.9(0.0001)	454.1(0.0001)	211.1(0.0001)

*=p-value<0.05; **=p-value <0.01; ***=p-value <0.001

Appendix 2: Multilevel Logistic Regression (Count…)

	Nigeria				
	1990	**1995**	**2001**	**2006**	**2012**
Variable	**AOR (95% CI)**	**AOR (95% CI)**	**AOR (95% CI)**	**AOR (95%**	**AOR (95% CI)**
n					
Household size					
1-3	1	1	1	1	1
4-6	0.9 (0.7;1.2)	1.0 (0.7; 1.5)	1.1 (0.8; 1.4)	0.8 (0.7;1.0)	0.9 (0.8; 1.1)
7&+	0.9 (0.7; 1.2)	1.2 (0.8; 1.7)	1.0 (0.7; 1.3)	0.9 (0.8; 1.1)	1.1 (0.9; 1.3)
Sex of the head of					
Male	1	1	1	1	1
Female	1.1 (0.8; 1.5)	0.7 (0.4; 1.1)	1.1 (0.8; 1.6)	0.9 (0.7; 1.1)	0.9 (0.8; 1.1)
Age of the mother					
15-19	1	1	1	1	1
20-24	0.8 (0.6: 1.2)	1.1 (0.7; 1.6)	1.0 (0.7; 1.4)	0.9 (0.8; 1.1)	0.9 (0.8; 1.2)
25-29	0.9 (0.7;1.2)	0.8 (0.6; 1.3)	0.9 (0.7; 1.4)	0.9 (0.8; 1.1)	0.9 (0.8; 1.1)
30-34	0.8 (0.6: 1.1)	0.9 (0.6; 1.5)	0.9 (0.7; 1.4)	0.9 (0.7; 1.1)	0.9 (0.7; 1.1)
35-39	0.8 (0.5; 1.1)	0.9 (0.6; 1.5)	0.8 (0.6; 1.3)	0.9 (0.7; 1.1)	0.9 (0.7; 1.1)
40-44	0.6* (0.4; 0.9)	0.7 (0.4: 1.4)	0.9 (0.5; 1.4)	0.9 (0.7; 1.2)	0.7*(0.5; 0.9)
45-49	1.1 (0.7; 1.8)	0.5 (0.2; 1.5)	1.4 (0.7; 2.7)	0.8 (0.6; 1.1)	0.9 (0.7; 1.3)
Place of residence					
Urban	1	1	1	1	1
Rural	1.6**(1.2; 2.3)	0.9 (0.7; 1.3)	1.2 (0.9; 1.6)	1.1 (0.9; 1.3)	0.9 (0.8; 1.1)
Mother Occupation					
Not working	1	1	1	1	1
Sale	1.3**(1.1; 1.6)	1.1 (0.9; 1.5)	1.2* (1.0; 1.5)	1.2 (1.1; 1.4)	1.1 (0.9; 1.2)
Agriculter	0.8* (0.6; 0.9)	1.6* (1.1; 2.4)	0.9 (0.7; 1.3)	1.03 (0.9; 1.2)	1.1 (0.9; 1.3)
Manual	1.0 (0.7; 1.4)	0.9 (0.6; 1.3)	1.2 (0.9; 1.6)	1.1 (0.9; 1.3)	1.2* (1.1; 1.3)
Mother's education level					
No Education	1	1	1	1	1
1-6 years	1.0 (0.8; 1.2)	0.7 (0.5; 1.0)	0.8* (0.6; 0.9)	0.9 (0.9; 1.1)	1.0 (0.9; 1.2)
7&+ years	0.7* (0.5; 0.9)	0.7* (0.5; 0.9)	0.7**(0.5; 0.9)	0.8* (0.7; 0.9)	0.9 (0.8; 1.01)
Has Electricity					
No	0.7* (0.5; 0.9)	0.8(0.6; 1.1)	1.0 (0.8; 1.3)	0.8* (0.7; 0.9)	0.9 (0.8; 1.1)
Yes	1	1	1	1	1
Has Television					
No	0.8 (0.6; 1.2)	1.1 (0.7; 1.5)	1.0 (0.8; 1.3)	0.9* (0.7; 1.0)	0.9 (0.8; 1.0)
Yes	1	1	1	1	1
Has Refrigerator					
No	1.4* (1.0; 1.9)	0.9 (0.6; 1.4)	1.0 (0.8; 1.4)	0.9 (0.8; 1.2)	1.0 (0.8; 1.2)
Yes	1	1	1	1	1
Has Bicycle					
No	1.1 (0.9; 1.3)	0.9 (0.7; 1.2)	1.2 (0.9; 1.4)	1.0 (0.9; 1.1)	0.9 (0.9; 1.1)
Yes	1	1	1	1	1
Has Motorcycle					
No	0.9 (0.7; 1.1)	1.2 (0.9; 1.7)	0.9 (0.8; 1.2)	0.9 (0.9; 1.1)	1.1 (1.01; 1.2)
Yes	1	1	1	1	1
Immediat environment and					
Type of toilette					
Flush/upgraded latrin	1	1	1	1	1
Traditional latrines	1.8**(1.2; 2.8)	1.1 (0.7; 1.8)	1.3 (0.9; 1.9)	1.6*** (1.2;	1.3**(1.1; 1.5)
Lack of toilet	2.1**(1.3; 3.3)	0.8 (0.5; 1.4)	1.0 (0.7; 1.6)	1.2 (0.9; 1.6)	1.2 (0.9; 1.5)
Other type	2.9* (1.2; 7.3)	1.7 (0.7; 3.9)	1.2 (0.5; 2.6)	0.7 (0.5; 1.1)	0.7* (0.4; 1.0)
Quality of Main floor					
Poor	1	1	1	1	1
Middle	1.1 (0.9; 1.3)	1.2 (0.9; 1.5)	0.9 (0.7; 1.1)	0.8*(0.7; 0.9)	0.9 (0.8; 1.1)
Rich	1.6 (0.9; 2.8)	0.3 (0.03;2.2)	0.6** (0.5; 0.9)	0.7**(0.6; 0.9)	0.9 (0.7; 1.1)
Sources of drinking water					
Piped/Public tap/stan	1	1	1	1	1

Tube well or borehole	0.9 (0.7; 1.2)	1.0 (0.7; 1.5)	1.2 (0.9; 1.6)	0.8 (0.7; 1.0)	0.8 (0.7; 1.0)
Well	0.9 (0.6; 1.2)	0.9 (0.6; 1.4)	0.9 (0.7; 1.3)	0.8* (0.6; 0.9)	0.9 (0.8; 1.1)
Spring/river/lake/other	0.8 (0.5; 1.3)	1.1 (0.8; 1.7)	1.0 (0.7; 1.4)	0.7**(0.6;0.9)	1.0 (0.8; 1.2)
Child level variables					
Sex of the child					
Female	1	1	1	1	1
Male	1.2**(1.1; 1.4)	0.9 (0.8; 1.2)	1.2* (1.04; 1.4)	1.2***(1.1;	1.0 (0.9; 1.1)
Age in months					
0-6	1	1	1	1	1
07-12	2.9***(2.3; 3.9)	2.7***(1.9; 3.8)	2.2***(1.7; 3.01)	2.6***(2.2;	3.2***(2.7; 3.8)
13-18	3.1***(2.4; 4.1)	2.4***(1.7; 3.4)	2.7***(1.9; 3.6)	2.7***(2.3;	3.0 (2.6; 3.6)
19-24	2.4***(1.8; 3.2)	2.5*** (1.7; 3.7)	2.9***(2.1; 4.0)	2.1***(1.7;	2.6***(2.2; 3.1)
25-30	1.8***(1.3; 2.4)	1.6*(1.1: 2.4)	1.6**(1.2;2.2)	1.6***(1.4;	1.8*** (1.5; 2.2)
31-36	1.5* (1.1; 2.1)	1.8* (1.1; 2.8)	1.4 (0.9; 1.9)	1.1 (0.9; 1.4)	1.6*** (1.3; 1.9)
37-42	0.8 (0.6; 1.1)	-	0.9 (0.7; 1.4)	1.1 (0.9; 1.4)	1.1 (0.9; 1.4)
42-48	0.7 (0.5; 1.1)	-	0.6* (0.4; 0.9)	0.9 (0.7; 1.1)	0.9 (0.8; 1.2)
48-59	0.6**(0.5; 0.9)	-	0.4***(0.3; 0.6)4	0.7**(0.6; 0.9)	0.7 (0.6; 0.9)
Has Measles vaccine					
No	0.8(0.7; 1.0)	0.9 (0.8; 1.3)	0.7 (0.6; 0.9)	0.9 (0.8; 1.0)	0.8 (0.8; 0.9)
Yes	1	1	1	1	1
Size of child at birth					
Large	1	1	1	1	1
Average	1.2 (0.9; 1.4)	1.2 (0.9; 1.6)	1.2 (0.9; 1.4)	0.8* (0.8; 0.9)	0.8***(0.7; 0.9)
Small	1.4**(1.1; 1.7)	1.2 (0.8; 1.7)	1.4**(1.1; 1.8)	1.2**(1.1; 1.4)	1.1 (0.9; 1.2)
DK (Don't know)	1.8 (0.8; 4.2)	1.5(0.6; 3.5)	1.8 (0.7; 4.5)	0.6 (0.4; 0.1)	0.4 (0.3; 1.0)
Constant	0.5*** (0.03;	0.08***(0.04;0.2)	0.09***(0.05;	0.07*** (0.05;	0.06*** (0.04;
Community Level SD	0.71 (0.60; 0.84)	0.63 (0.47; 0.84)	0.77 (0.6; 0.9)	0.82 (0.75;	0.87 (0.80; 0.95)
ICC	0.13 (0.10; 0.17)	0.11 (0.06; 0.18)	0.15 (0.11; 0.21)	0.17 (0.14;	0.19 (0.16; 0.21)
Wald chi2 (Prob>chi2)	382.1(0.0001)	78.2(0.0001)	282.7(0.0001)	649.8(0.0001)	783.4(0.0001)

*=p-value<0.05; **=p-value <0.01; ***=p-value <0.001

Appendix 2: Multilevel Logistic Regression (Count…)

	Niger			
	1992	**1998**	**2006**	**2012**
Variable	**AOR (95% CI)**	**AOR (95% CI)**	**AOR (95% CI)**	**AOR (95% CI)**
n				
Household size				
1-3	1	1	1	1
4-6	0.8 (0.62; 1.1)	0.9 (0.7; 1.2)	0.9 (0.7; 1.2)	08 * (0.6; 0.9)
7&+	0.8 (0.6; 1.1)	0.9 (0.8: 1.3)	0.9 (0.7; 1.2)	0.7(0.6; 0.9)
Sex of the head of household				
Male	1	1	1	1
Female	1.4*(1.03; 1.8)	0.9(0.7; 1.2)	1.0 (0.9; 1.2)	0.9 (0.7; 1.1)
Age of the mother				
15-19	1	1	1	1
20-24	0.9 (0.7; 1.2)	1.1 (0.9; 1.4)	1.0 (0.8; 1.3)	0.9 (0.7; 1.1)
25-29	0.9 (0.8; 1.3)	1.1(0.8;1.4)	1.0(0.8; 1.2)	0.9 (0.7; 1.1)
30-34	1.0 (0.7; 1.3)	1.1(0.9; 1.4)	0.9 (0.7; 1.1)	0.9 (0.7; 1.2)
35-39	1.1 (0.8; 1.5)	1.1 (0.9; 1.5)	0.8 (0.6; 1.1)	1.0 (0.8; 1.3)
40-44	1.1 (0.8; 1.6)	1.3 (0.9; 1.8)	0.1(0.8; 1.5)	0.9 (0.7; 1.3)
45-49	1.0 (0.6; 1.8)	1.6 (0.9; 2.9)	1.1 (0.7; 1.7)	0.9 (0.6; 1.5)
Place of residence				
Urban	1	1	1	1
Rural	1.4*(1.0; 1.9)	1.1 (0.8; 1.5)	1.0 (0.7; 1.4)	0.9 (0.7; 1.3)
Mother Occupation				
Not working	1	1	1	1
Sale	1.1(0.9; 1.3)	1.3**(1.1; 1.5)	1.3**(1.1; 1.5)	1.1 (0.9; 1.3)
Agriculter	1.4**(1.1; 1.7)	1.1 (0.9; 1.4)	1.4***(1.2; 1.7)	1.5**(1.1; 2.1)
Manual	1.4**(1.1; 1.8)	1.0 (0.8; 1.2)	1.2 (0.9; 1.5)	1.0 (0.8; 1.3)
Mother's education level				
No Education	1	1	1	1
1-6 years	0.9 (0.7; 1.2)	1.1 (0.8; 1.3)	0.9 (0.7; 1.1)	1.1 (0.9; 1.3)
7&+ years	0.5** (0.4; 0.8)	0.8 (0.5; 1.2)	0.6* (0.4; 1.5)	1.0 (0.8; 1.3)
Has Electricity				
No	1.2 (0.8; 1.7)	1.0 (0.7; 1.5)	1.2 (0.9; 1.6)	1.1 (0.9; 1.5)
Yes	1	1	1	1
Has Television				
No	0.9 (0.6; 1.3)	1.2 (0.8; 1.9)	1.0 (0.7; 1.4)	0.9 (0.7; 1.3)
Yes	1	1	1	1
Has Refrigerator				
No	1.1 (0.7; 1.8)	0.8 (0.5; 1.4)	0.8 (0.5; 1.2)	0.8(0.6; 1.1)
Yes	1	1	1	1
Has Bicycle				
No	0.9 (0.7; 1.3)	1.2 (0.9; 1.5)	0.8 (0.7; 1.0)	0.9 (0.8; 1.2)
Yes	1	1	1	1
Has Motorcycle				
No	1.03 (0.7; 1.4)	0.8 (0.5; 1.1)	0.9 (0.8; 1.2)	1.0 (0.9; 1.2)
Yes	1	1	1	1
Immediat environment and				
Type of toilette				
Flush/upgraded latrin	1	1	1	1
Traditional latrines	1.3 (0.7; 2.4)	0.8 (0.4; 1.8)	1.2 (0.7; 2.0)	1.3 (0.9; 1.8)
Lack of toilet	1.5(0.8; 2.8)	0.9 (0.4; 1.9)	1.2 (0.7; 2.2)	1.3(0.9; 1.9)
Other type	2.2 (0.9; 5.9)	2.5 (0.7; 9.4)	2.0 (0.8; 4.9)	1.7 (0.8; 3.4)
Quality of Main floor material				
Poor	1	1	1	1
Middle	1.0 (0.8; 1.3)	0.7* (0.5; 0.9)	0.8 (0.7; 2.0)	0.9 (0.7; 1.2)
Rich	1.1 (0.5; 2.6)	0.6 (0.2; 1.5)	0.7 (0.3; 1.4)	1.4**(1.1; 3.4)
Sources of drinking water				
Piped/Public tap/stan	1	1	1	1

Tube well or borehole	1.0 (0.8; 1.4)	0.9 (0.7; 1.3)	-	0.9 (0.8; 1.2)
Well	0.9 (0.5; 1.4)	0.8 (0.5; 1.4)	1.1 (0.8; 1.4)	0.8 (0.7; 1.0)
Spring/river/lake/other	0.7 (0.6; 1.0)	1.1 (0.8; 1.5)	0.7 (0.4;1.2)	1.3 (0.9; 1.9)
Child level variables				
Sex of the child				
Female	1	1	1	1
Male	1.1 (0.9; 1.2)	1.1(0.9; 1.2)	1.0 (0.9; 1.1)	1.1(0.9; 1.2)
Age in months				
0-6	1	1	1	1
07-12	2.6***(2.1; 3.3)	2.3***(1.9; 2.8)	2.4*** (1.9; 2.9)	2.4***(1.8; 2.9)
13-18	1.9***(1.5; 2.5)	1.4**(1.1; 1.8)	2.4***(1.9;2.9)	1.7***(1.3; 2.1)
19-24	1.9***(1.4; 2.4)	1.3* (1.1; 1.7)	1.9***(1.5; 2.4)	1.2(0.9; 1.5)
25-30	1.1 (0.9; 1.4)	1.1 (0.9; 1.4)	1.4**(1.1; 1.8)	1.1(0.8; 1.3)
31-36	0.8 (0.6; 1.02)	0.8 (0.6; 1.1)	1.1(0.9; 1.4)	0.6 (0.5; 0.8)
37-42	0.5***(0.4; 0.7)	-	0.7 (0.5; 0.9)	0.5***(0.3; 0.6)
42-48	0.5***(0.3; 0.6)	-	0.7 **(0.5; 0.9)	0.4***(0.3; 0.5)
48-59	0.4***(0.3; 0.5)	-	0.5***(0.4; 0.6)	0.2***(0.2; 0.3)
Has Measles vaccine				
No	1.0 (0.9; 1.2)	1.0 (0.8: 1.2)	0.8 (0.7; 0.9)	1.0 (0.9; 1.2)
Yes	1	1	1	1
Size of child at birth				
Large	1	1	1	1
Average	1.0 (0.9; 1.2)	0.9 (0.8; 1.1)	0.8* (0.7; 0.9)	0.9 (0.8; 1.1)
Small	1.4***(1.2; 1.7)	1.02 (0.8; 1.2)	1.1 (0.9; 1.3)	1.2*(0.1; 1.5)
DK (Don't know)	1.3 (0.6; 3.2)	0.4 (0.1; 2.2)	0.9 (0.5; 1.7)	0.6 (0.4; 1.0)
Constant	0.16***(0.07; 0.3)	0.4***(0.2; 1.1)	0.2***(0.1; 0.4)	0.16***(0.10; 0.27)
Community Level SD	0.50(0.40; 0.60)	0.43 (0.35; 0.56)	0.60 (0.51; 0.70)	0.65 (0.56; 0.75)
ICC	0.07 (0.05; 0.10)	0.06 (0.04; 0.09)	0.10 (0.07; 0.13)	0.11(0.09; 0.15)
Wald chi2 (Prob>chi2)	429.0(0.0001)	141.5(0.001)	408.8(0.0001)	583.3(0.0001)

*=p-value<0.05; **=p-value <0.01; ***=p-value <0.001