NAMIBIA UNIVERSITY OF SCIENCE AND TECHNOLOGY

# DETERMINANTS OF UNDER-FIVE MORTALITY IN NAMIBIA: AN ANALYSIS OF THE 2013 NAMIBIA DEMOGRAPHIC AND HEALTH SURVEY DATA

By

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Thesis submitted in fulfilment of the requirements for the degree of Master of Science in Applied Statistics, Faculty of Health and Applied Sciences, Namibia University of Science and Technology, Windhoek, Namibia

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## DECLARATION

I, NDAPUNIKWA NGHIPUULENGA LAVINIA HAMUNYELA, hereby to undertake that "Determinants of Under-Five Mortality in Namibia: An Analysis of 2013 Namibia Demographic and Health Survey Data" this research project is my own work and it has not been submitted before at any University and here undersigned

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**DEDICATION**

I dedicate this report to my son, Blessing Panduleni Uyage, who was born during the time I was writing this research. His birth has given me so much courage and energy to complete this thesis. As well as my lovely nephew, Nathan Nghishiililwa and those that are still on their way. Thank you for being the motive behind my selection for this research topic. I hope you grow up to be Statisticians someday. Furthermore, I don't want to forget the two most important women in my life, they have been with me through my studies; my mom, Ndilimeke Mweshixwa and my sister, Loide Panduleni Muunda Nghiishililwa. I could not have come this far if it was not for their support; thank you once more. I love you all so much.

## ABSTRACT

This thesis reports on a statistical analysis on risk factors associated with under-five mortality in Namibia. Secondary data were obtained from the 2013 Namibia Demographic and Health Survey data. Children survival was measured by age at death and the event variable was whether the children were still alive or dead after the first five (years) of their lives. Variables included were maternal education, mother's marital status, the age of the mother at first birth, preceding birth interval, type of birth, place of residence, household wealth index, status of breastfeed and the place of delivery. Descriptive summary statistics in the form of tables and graphs were used to profile the background characteristics of the children. Survival analysis techniques (Kaplan-Meier curves, Log Rank Test and Cox Proportional Hazards model) were used to establish the determinants of survival among under-five children. Frailty model with regions as a random effect was fitted- to determine the influence of unobserved risk factors on under-five mortality. Results revealed that maternal highest level of education (higher/tertiary level), status of breastfeed (children who have been breastfeed), the place of delivery (those born in private medical facilities) and type of birth (single births), were found to be the risk factors associated with under-five mortality in Namibia. Policy efforts should focus on encouraging mothers to breastfeed the children as children who were breastfed are 54 times less likely to die below the age of five (5) compared to those who were not breastfed and more focuses on programs that empower women such as free education to all, especially tertiary education. Children born at private facilities are at lower risk of death compared to those born at home and this calls for further research on the reasons behind.

***Keywords: Under-Five Mortality, Survival Analysis, Cox Proportional Hazard, Frailty Models, Namibia***

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| | |
|---|---|
| AIC | Akaike Information Criterion |
| BIC | Bayesian Information Criterion |
| CEE/CIS | Central and Eastern Europe/Commonwealth of Independent States |
| CMR | Child Mortality Rate |
| EA | Enumeration Area |
| HR | Hazard Ratio |
| IMR | Infant Mortality Rate |
| MDG | Millennium Development Goals |
| MoHSS | Ministry of Health and Social Services |
| NDHS | Namibia Demographic and Health Survey |
| NDP5 | Fifth Namibia Development Plan |
| NPC | National Planning Commission |
| NPHC | Namibia Population and Housing Census |
| NSA | Namibia Statistics Agency |
| NUST | Namibia University of Science and Technology |
| PH | Proportional Hazard |
| SDG | Sustainable Development Goals |
| SPSS | Statistical Package for Social Sciences |
| UNDP | United Nation Development Programme |

# CHAPTER ONE

## INTRODUCTION

1.0. This chapter presents background information concerning under-five child mortality in Namibia, problem statement, study purpose, objectives of the study, research questions and the significance of the study.

### 1.1. Background of the study

Globally, over the last 17 years, under-five mortality rate reduced by almost 50 percent from 90 percent to 46 percent deaths per 1000 birth. Furthermore, during the same period, the total number of under-five deaths was cut in half, from 12.7 million to 6.3 million, which saved around 17 000 lives daily (United Nations Children's Fund, 2015). However, other countries in Africa such as those in Sub-Sahara Africa the percentage has barely fallen (United Nations Children's Fund, 2015). Furthermore, world infant mortality rate reduced with almost 46 percent from 63 to 34 per 1000 live births (United Nations Children's Fund, 2015 and Ministry of Health and Social Services, 2014).

As per the regional classifications available at http://data.unicef.org/regionalclassifications./, Sub-Sahara Africa is a group of countries in Eastern & Southern Africa, these are ; Botswana; Burundi; Comoros; Djibouti; Eritrea; Ethiopia; Kenya; Lesotho; Madagascar; Malawi; Mauritius; Mozambique; Namibia; Rwanda; Seychelles; Somalia; South Africa; South Sudan; Sudan; Swaziland; Uganda; United Republic of Tanzania; Zambia and Zimbabwe plus West & Central African countries such as: Benin; Burkina Faso; Cabo Verde; Cameroon; Central African Republic; Chad; Congo; Côte d'Ivoire; Democratic Republic of the Congo; Equatorial Guinea; Gabon; Gambia; Ghana; Guinea; Guinea-Bissau; Liberia; Mali; Mauritania; Niger; Nigeria; Sao Tome and Principe; Senegal; Sierra Leone and Togo.

Moreover, among the poorest countries in the world, under-five mortality had been slightly falling, between 1990 and 2010 but, the gap between the poorest (non-wealthy) and richest (wealthy) households decreased in all regions of the world except countries that are in Sub-Sahara Africa. However, large differences between under-five mortality remain high in most of the regions/countries, United Nations Children's Fund (2015). However, despite this progress of the under-five mortality slightly falling in the poorest countries, the toll of under-five deaths over the past 20 years is surprising: between 1990 and 2013, more than 223 million children in the whole world died before their fifth birthday. Causes of some of these deaths are deaths that are preventable, had the world put more effort into stopping them. Thus, improvement is not enough to meet MDG 4. If in all countries the current trends remain constant, the target to meet the MDG 4 will only be reached worldwide by round 2026, which will be 11 years late, United Nations Children's Fund (2015).

Figure 1.1 shows that substantial global progress has been made in reducing under-five deaths since 1990. The total number of under-five deaths worldwide has declined by approximately 49 percent, from 90 to 46 per 1,000 live births deaths in 2013. Meanwhile in 1990, under-five mortality rate has lowered by around 44 per cent in every region as shown below. Yet, the speed or pace of regional progress differs as Sub-Sahara Africa and West & Central Africa still have the highest under-five mortality with only a reduction from 179 to 92 deaths per 1000 live births and 197 to 109 deaths per 1000 live births respectively. East Asia & the Pacific and Latin America & the Caribbean are the two best performing regions.

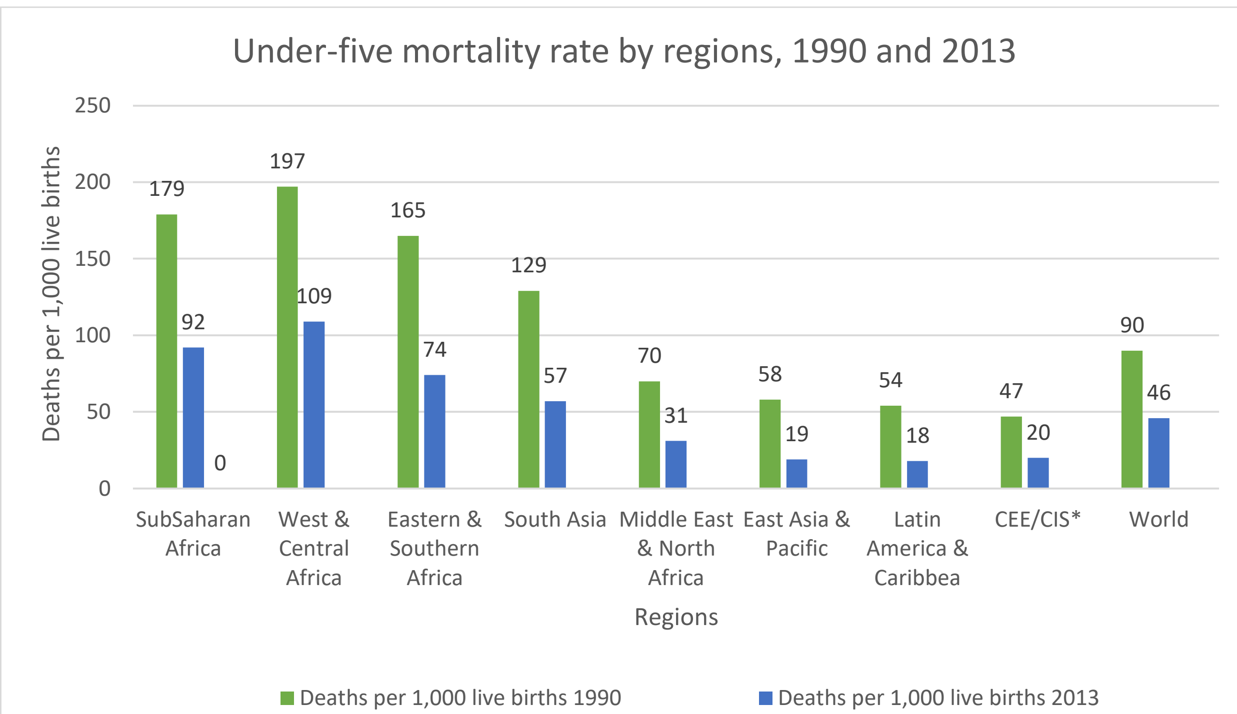



**Figure 1. 1: World under-five mortality rate by region, 1990 and 2013**

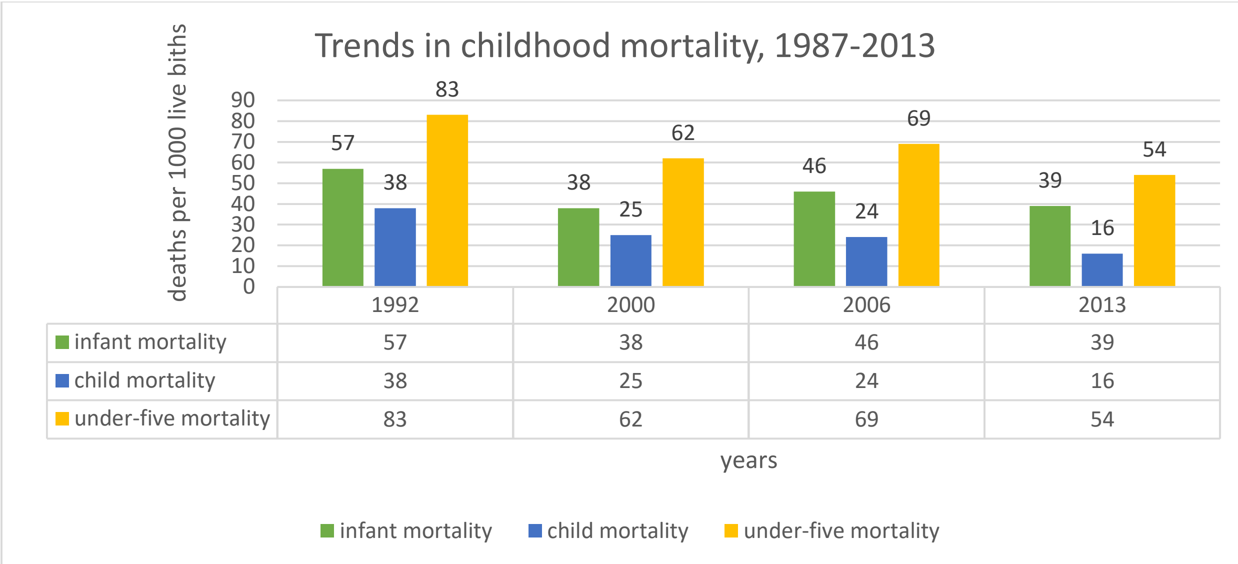
(Source; United Nations Children's Fund, Committing to Child Survival: A Promise Renewed Report 2015)

According to United Nations Children's Fund (2015), Namibia is ranked at 53 in under-five mortality rankings worldwide, with Angola, Sierra Leone and Chad being in the top three (3) respectively. As it is in most countries, Namibia's position is a main health concern.

Under-five mortality is a combination of the two basic crucial indicators that measures the survival status of the population; infant mortality and child mortality. Under-five mortality is the probability of dying between birth and the age of five of life while under-five mortality rate is the number of children dying under the age of 5 per 1000 live births in a given population. Whereas, infant mortality is the number of deaths of children younger than one year in a given population. Whilst, child mortality rate is the number of death of children age 1 year to 4 years per 1000 live births in a given population, (Namibia Statistics Agency, 2014; Ministry of Health and Social Services and Namibia Statistics Agency, 2014; United Nations Children's Fund, 2015).

In Namibia, under-five mortality rate has been fluctuating as indicated in Figure 1.2 below from 83 deaths per 1000 live births in 1992 and decreased to 62 deaths per 1000 in 2002, again rises to 69 deaths per 1000 in 2006-2007 and finally declined 54 deaths per 1000 live births in 2013. Fluctuating trends can also be observed in infant mortality rate when comparing 2013 NDHS data with that from NDHS surveys carried out in 1992, 2000 and 2006-07. Infant mortality has dropped from 57 deaths per 1,000 live births in 1992 to 38 deaths per 1,000 live births in 2000 then rose to 46 deaths per 1000 live births in 2006-07 and finally declined to 39 deaths per 1000 live births in 2013.

On the other hand, child mortality has been declining since 1987-1992 until 2013. In 2013, it dropped by more than a half (22 deaths per 1000 live births) to 16 deaths per 1000 live births from 38 deaths per 1000 live in 2008-2013 (Ministry of Health and Social Services & Namibia Statistics Agency, 2014).




| | 1992 | 2000 | 2006 | 2013 |
|---|---|---|---|---|
| infant mortality | 57 | 38 | 46 | 39 |
| child mortality | 38 | 25 | 24 | 16 |
| under-five mortality | 83 | 62 | 69 | 54 |

**Figure 1. 2: Trends in childhood mortality, 1987 to 2012**

(Source; 2013 NDHS report)

There are wide differentials in infant mortality by region. It can be observed from Figure 1.3 below that the IMR has been on the rise since 2006-07 until 2013 for regions such as Kavango, Kunene and Omaheke.

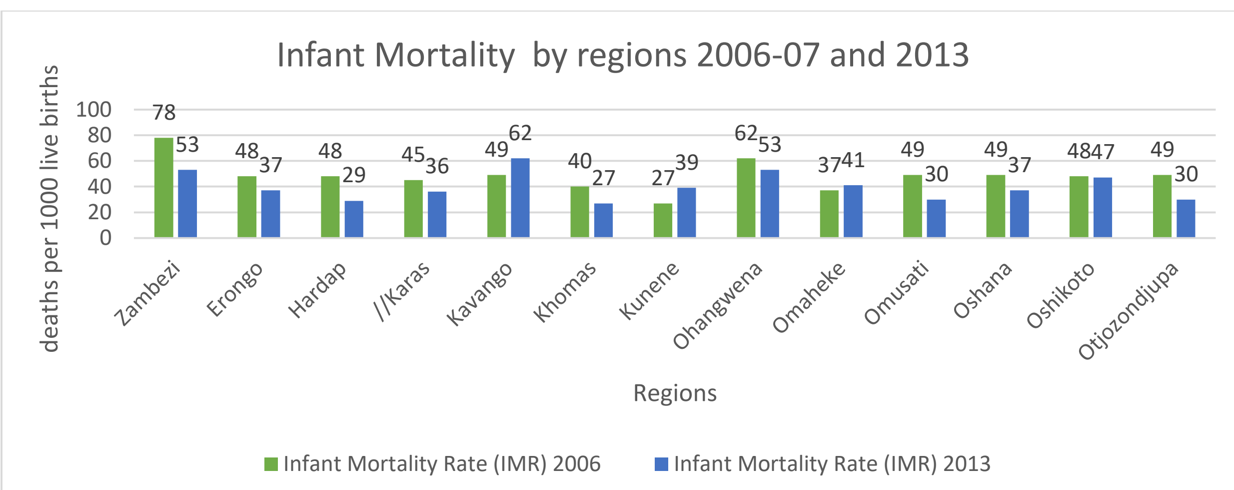



**Figure 1. 3: Trends in infant mortality rate by region, 2006-07 to 2013**

(Source from 2013 NDHS report)

Child mortality rate by region from 2006 to 2013 varies. It can be observed in Figure 1.4 that the CMR has been increasing since 2006-07 until 2013 for Regions such as Zambezi, Kavango, Khomas, Oshikoto and Otjozondjupa.

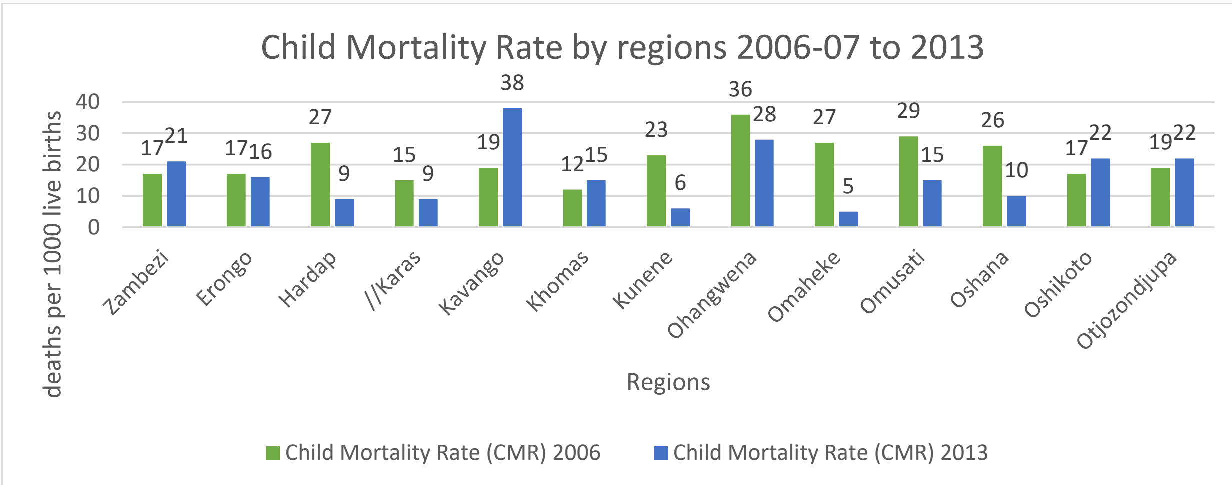



**Figure 1. 4: Trends in child mortality rate by region, 2006-07 to 2013**

(Source; 2013 NDHS report)

There are discrepancies in under-five mortality by regions as shown in Figure 1.5 below. Regions such as Kavango, Ohangwena, Zambezi and Oshikoto have  the topmost under-five mortality rate of 97, 79, 73 and 68 deaths per 1000 live deaths respectively, whilst Hardap and Khomas have the least of 38 and 41 deaths per 1000 live births, respectively in the year 2008-2012 as shown by the 2013 survey data. Since 2006-07 to 2013, under-five mortality rate has risen in some of the regions such as Kavango and Oshikoto.

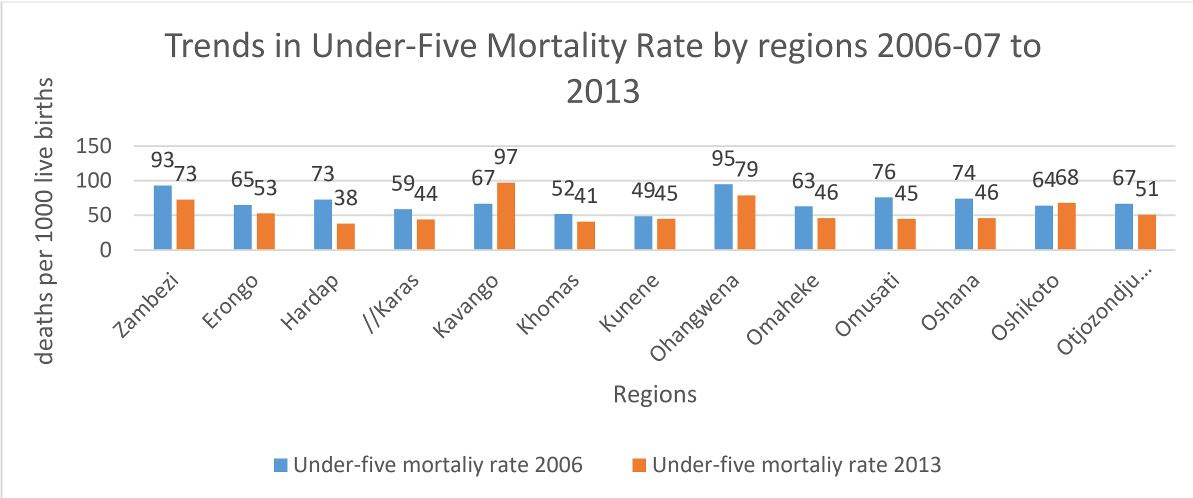
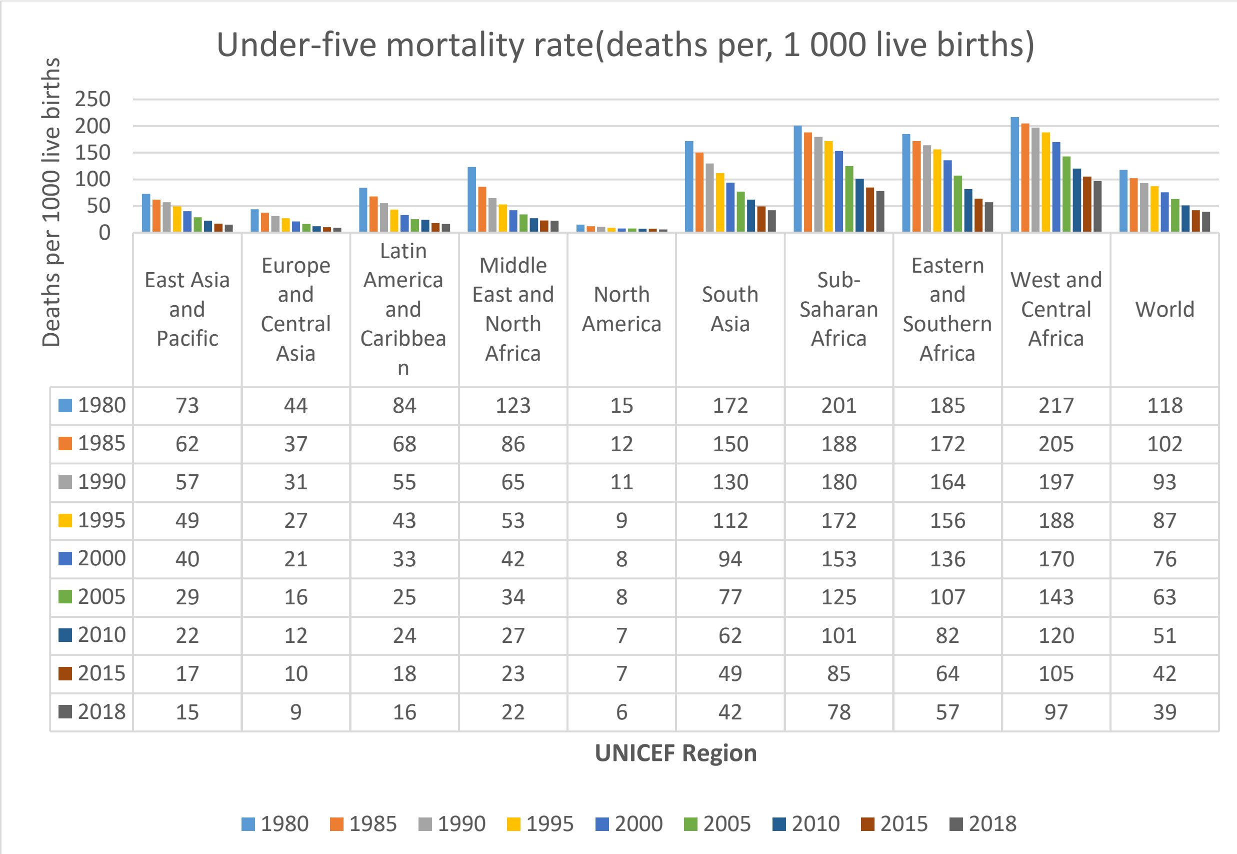



**Figure 1. 5: Trends in under-five mortality rate by region 2006-07 to 2013**

(Source; 2013 NDHS report)

Figure 1.6 Under-five mortality rate (deaths per, 1 000 live births) for the period of 1980 until 2018. It can be seen that the under-five mortality rate is decreasing from the period of 1980 until 2018. In Eastern and Southern Africa which includes Namibia, dropped from 185 deaths per 1000 live birth in 1980 to 57 deaths in 1 000 live births. Worldwide, the under-five mortality rate decreased from 118 deaths in 1 000 live births in 1980, then 102 deaths in 1 000 live births in 1985 and finally to 39 deaths in 1 000 live births in 2018. North America is the best performing region for the under-five mortality rates since 1980 until 2018, with under-five mortality rates lower than 15 deaths in 1 000 live births for all the years.




| | East Asia and Pacific | Europe and Central Asia | Latin America and Caribbean | Middle East and North Africa | North America | South Asia | Sub-Saharan Africa | Eastern and Southern Africa | West and Central Africa | World |
|---|---|---|---|---|---|---|---|---|---|---|
| 1980 | 73 | 44 | 84 | 123 | 15 | 172 | 201 | 185 | 217 | 118 |
| 1985 | 62 | 37 | 68 | 86 | 12 | 150 | 188 | 172 | 205 | 102 |
| 1990 | 57 | 31 | 55 | 65 | 11 | 130 | 180 | 164 | 197 | 93 |
| 1995 | 49 | 27 | 43 | 53 | 9 | 112 | 172 | 156 | 188 | 87 |
| 2000 | 40 | 21 | 33 | 42 | 8 | 94 | 153 | 136 | 170 | 76 |
| 2005 | 29 | 16 | 25 | 34 | 8 | 77 | 125 | 107 | 143 | 63 |
| 2010 | 22 | 12 | 24 | 27 | 7 | 62 | 101 | 82 | 120 | 51 |
| 2015 | 17 | 10 | 18 | 23 | 7 | 49 | 85 | 64 | 105 | 42 |
| 2018 | 15 | 9 | 16 | 22 | 6 | 42 | 78 | 57 | 97 | 39 |

**Figure 1. 6: Under-five mortality rate (deaths per, 1 000 live births) for the period of 1980 until 2018**

(Source; United Nations Children's Fund, 2019).

Under-five mortality in Namibia is higher in rural areas or regions compared to urban parts of the country. The fact that Indicator 2 of Goal 3 in the Sustainable Development Goal (SDG) and the Fifth Namibia Development Plan (NDP5) both strive to end preventable deaths of newborns and children under 5 years of age, is evident enough that the rise of under-five mortality is a concern to the government of Namibia. Likewise, all countries are aiming to reduce neonatal/newborn mortality to at least as low as 12 deaths per 1,000 live births and under-five mortality to at least as low as 25 deaths per 1,000 live births by 2030, thus it is crucial that under-five mortality be minimized (United Nation Development Programme, 2011)
.

As per Pact Namibia (2015), the first five (5) years of a child are the most vital to the development of children and can determine their potential to learn and prosper for a lifetime. Hence children need to be well cared for and understand issues that are a potential danger/harm to them.

According to World Health Organization (2018), birth complications, diseases, malnutrition/undernourishment and environmental factors are a few risk factors that are significantly leading to under-five death worldwide. About 45 percentages of all child deaths are related to malnutrition/undernourishment. Moreover, children who reside in sub-Saharan Africa are more than 14 times more likely to die before the age of five compared to children in developed regions-(World Health Organization, 2018).

Thus, the purpose of the study is to determine the leading causes of under-five mortality in Namibia and also to assess the extent at which the socio-economic factors influence regional variations in under-five mortality. The study used survival analysis techniques that include Kaplan-Meier survival curves which estimated the survival function curves for urban and rural areas of children surviving past five (5) years in Namibia. Furthermore, Log rank survival test was used to assess significance carried out using Stata version 14.2. Cox proportional hazards model was used to investigate the association between the survival time of the children beyond five (5) years and the predictor variables. Lastly, frailty random effects on unobserved heterogeneity on Under-five mortality in Namibia was explored using individual frailty models as well as region as the shared frailty variable.

### 1.2. The research problem

Under-five mortality has been a concern in many countries, especially in the Sub-Sahara countries such as Nigeria and Kenya (Wambugu ,2014 & Mutunga, 2003). Though there has been a significant reduction in under-five mortality in most developing countries such as Namibia, Kenya, and Uganda in the past years, it still remains a main public health issue, particularly in Namibia (Wambugu, 2014). Even though, many studies such as Wambugu (2014) and Mamum (2014)-have been conducted on other developing countries, it appears that few studies have been done in Namibia, thereby creating a gap for this study. For this reason, there is a need to conduct an under-five mortality study in Namibia that focuses on modelling the effect of different mortality risks' of under-five children through examining the influences of socio-economic factors on regional inequalities in under-five mortality in Namibia, as well as modelling the underlying risk factors associated with under-five mortality in Namibia.

### 1.3. Purpose/aim of the study

The main objective of this study is to identify the risk factors associated with under-five mortality in Namibia. The following sub-objectives were used to achieve this main objective.

(i) Determine the survival patterns of under-five children between rural and urban areas per region in Namibia, using the 2013 Namibia Demographic and Health Survey data.

(ii) Examine the extent at which socio-economic factors influence under-five mortality in Namibia.

(iii) To use individual and shared frailty models to identify determinants of under-five mortality in Namibia.

### 1.4. Research questions

The following research questions were answered:

i. What are the leading causes of under-five mortality in Namibia?

ii. Is the probability of a child surviving until the age of 5 the same in the urban and rural areas in Namibia?

iii. Is the probability of a child surviving until the age of 5 the same in the urban and rural areas per region in Namibia?

iv. Which region has the highest number of child surviving past 5 years in Namibia?

v. How do socio-economic factors influence regional variations in under-five mortality in Namibia?

vi. Do regions as a random effect account for heterogeneity in the under-five mortality across the country?

### 1.5. Significance of the study

This study has the potential to inform and update policymakers, academics, researchers, non-profit organizations and most importantly the government (Ministry of Health and Social Services) about the factors affecting under-five mortality in Namibia as a whole, as well as across each region. Moreover, this study can further aid the development of the strategies to achieve Indicator 2 of Goal 3 in the Sustainable Development Goal (Ministry of National Planning Commission, 2017) and the Fifth Namibia Development Plan (Ministry of National Planning Commission, 2017) of decreasing avoidable deaths of newborns and children under-five years of age by the year 2030.

### 1.6. Contribution of the study

Since no study has been done to investigate the effects of socio-economic factors on under-five mortality in Namibia, this study will help bridge that information gap and inform under-five children health policies in Namibia.

### 1.7. Organization of the study

This study is organized as follows:

Chapter two provides theoretical and empirical literature review on the under-five mortality. The third chapter covers data, research design and methodology. Chapter four presents the findings of the study and discussions of the results and Chapter five contains conclusions and recommendations.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.0. Introduction

In this chapter, the literature related to the risk factors associated with mortality incidences in children below five years was reviewed. The chapter first looked at the theoretical perspective on under-five mortality, then an in-depth analysis of the socio-economic and proximate determinants of under-mortality as depicted in Mosley and Chen‘s framework, which is the operational framework the study adopted. Lastly, the definition of key concepts and variables and the review of methods of data analysis used in the study as outlined by other researchers.

## 2.1. Theoretical framework

According to Mosley and Chen (1984), all social and economic determinants of child mortality necessarily operate through a set of biological mechanisms, or proximate determinants (intermediate variables) to directly influence the risk of mortality. This study adopts this approach to compare how socio-economic factors contribute to under-five mortality in Namibia.

### 2.1.1 Socio-economic determinants of child mortality

The researcher first examine a range of socioeconomic determinants (independent variables) as defined in section 2.4.5, as per Mosley and Chen(1984) and show how these independent variables operate through the proximate determinants to effect the level of growth of mortality.

#### 2.1.1.1. Individual-level variables

**Individual productivity** – There are three elements that determine the "productivity" of household members and these include the health status of the household members, their skills (measured by their educational level) and the time or effort they put in when producing something at home.

According to Mosley and Chen (1984), there is a strong correlation between education level, occupation and household income especially in urban location. Mothers' skills, time, and health operate directly on the intermediate determinants. Due to the biological links between the mother and infant during pregnancy and lactation (the secretion of milk by the mammary gland) the mother's health and nutritional status as well as her reproductive pattern influence the health and survival of the child. It is the responsibility for the pregnant mother to take care of herself and her unborn child during the weakest stages of its life, as well as after the baby is born. The child's survival is affected by the mother's educational level because it influences her choices (mother) and increases her skills in health care practices related to contraception, nutrition, hygiene, preventive care, antenatal care and disease treatment, (Mosley & Chen, 1984).

#### 2.1.1.2. Traditions/norms opportunities

In most traditional societies, the mother might have or might not have full responsibility for childcare. In most cases, most decisions like the allocation of resources (food) to her child or to the household members or other critical child care practices (diet, sickness care) may lie with the husband or elders in the household and she might have little or no control of such decisions (Mosley & Chen, 1984).

#### 2.1.1.3. Household-level variables

2.2.1. Income / wealth effects - a variety of goods, services, and assets at the household level operate on child health and mortality through the proximate determinants. Food and clean water – Child mortality is reduced when the child has sufficient food supply and clean water to ensure she/he gets all the required nutrients, this prevents disease transmission and illness. Clean clothing/beddings, a well ventilated house, access to transportation when medical need arises and an adequate energy for heating and refrigerating food to prevent it to get contaminated with disease are important aspects to ensure a child lives healthy and survive past five years (Mosley & Chen, 1984).

#### 2.1.1.4. Community-level variables

Mosley and Chen (1984) state that community-level variables are such as climate, soil, rainfall, temperature and seasonality. In rural subsistence societies, the child survival can be affected by the amount and variety of food crops produced, the availability and how safe/clean the water is (Mosley & Chen, 1984).

### 2.2. Risk factors associated with under five mortalities as previously identified by other researchers

Kaundjua (2013), was able to explore some risk factors that determine the child mortality rate in Namibia where she used the 2006/2007 NDHS' dataset. However, her main focus was more on trying to explore the effect of the individual level risk factors to the child deaths in the rural part of the country; comparing the child mortality rate between Namibian Northeast and Northwest regions. Furthermore, Kaundjua (2013) did not go as far as exploring the extend to what way the environment in which a child grows up affect his/her surviving odds, neither examined the effect of geographical effects of location on child mortality.

Kaundjua (2013) and Wambugu (2014) also found out that some of the household and environmental factors such as the type of toilet facility, household income and socio-economic characteristics such as mother's education are some of the factors that cause under-five mortality.

According to studies by (Adedini et al., 2012; Antai & Moradi, 2010; Wambugu, 2014) authors indicated that mortality risks for the children can sometimes be influenced by some characteristics of the community where children are raised. For example, those children raised up in a community with limited access to good drinking water, good health facilities, clean toilet facilities and lack of electricity are likely to suffer from the same deficiency, which can directly or indirectly influence their health. Since children from the sampled households are nested within the same mother who shares the same characteristics from the same location/constituencies and those mothers nested within different communities such as regions, they tend to share similar characteristics as those from the same communities. Persons in the same community/societies were likely to be more similar than those from different communities. Similarities were expected in the health outcomes of children who were exposed to the same environmental conditions.

Furthermore, Wambugu (2014) and Mamum (2014) stated that child survival is also linked to their mother's highest education level. Mother's that attained highest levels of educational are exposed to better nutrition and knowledge about childhood illness and treatment, which lowers the child mortality rates.

Root (2001), stated that some socio-economic factors including education may not have a greater effect on children mortality since well-educated mothers may be unable to reduce risk of exposure due to factors beyond their control. This can be factors such as contaminated community environment, lack of water and lack of access to toilet facility, which together might expose their children to diseases and accelerate their death.

**2.3. Conceptual framework**

The study makes use of Mosley and Chen (1984) framework modified by the writer to guide the investigation into the risk factors associated with under five mortalities in Namibia.

*"The framework combines both the social and biological variables and integrates research methods employed by social and medical scientists. It also provides for the measurement of morbidity (illness/injury) and mortality in a single variable. The framework is based on the foundation that all social and economic determinants of child mortality necessarily operate through a common set of biological mechanisms, or proximate determinants, to exert an impact on mortality. The framework is intended to advance research on social policy and medical interventions to improve child survival" (Mosley* & Chen, 1984).

The Social science approach focuses on the effect of socio-economic determinants on child mortality, whereas the Medical science approach examines the effect of Medical factors such as Environmental Contamination/Dietary intake, Disease Infections/Malnutrition on child mortality and used morbidity (sickness) as the outcome variable. Medical research mainly concentrates on the biological processes of diseases and less frequently on mortality. These medical studies model the cause of death assigning mortality to specific disease such as infections or malnutrition, using information obtained from death reports or clinical case records (Mosley & Chen, 1984). Therefore, this study used the Social science approach to model the effect of socio-economic determinants on child mortality.

This Mosley and Chen (1984), framework was chosen to be the operational framework for this study because of the following reasons: One, this is one of the frameworks that tries to address the connection between child mortality due to public interventions on one hand and social, economic and intermediate variables on the other hand. Also, the framework recommends a set of proximate determinants of mortality which if supposedly comprehensive/complete child mortality would change if and only if one or more of the determinants also changes. Lastly, and also very important in measurement of variables, is exception of injury related factors-which will be exempted in this study (Wambugu, 2014).

Mosley and Chen (1984) differentiated between variables considered being socio-economic, these are variables related to cultural, social, economic and community/ environmental factors. Also, biomedical factors such as the patterns of breastfeeding, cleanliness, healthy measures, and nutrition are also clearly defined. The effects of the socio-economic variables are considered indirect because they operate through the biomedical factors to bring about injury/diseases or mortality. Moreover, bio-medical reasons are called intermediate variables or proximate determinants because they constitute the middle step between the socio-economic variables and child mortality (Mosley & Chen, 1984; Wambugu, 2014).

Mosley and Chen (1984) classified a set of proximate determinants into five general groups that directly affect under-5 mortalities as follows:

1. **Maternal factors**: these are the mother's age, parity (the number of times a woman has been pregnant, regardless of the pregnancy outcome) and birth interval.

2. **Environmental contamination**: these are the air, food/water/fingers, skin/soil/inanimate objects, insect vectors. This refers to the transmission of infectious agents to children (and mothers). The four categories representing the main routes whereby infectious agents are transmitted to the human host are air- the route of spread for the respiratory and many "contact"-transmitted diseases; food, water, and fingers-the principal routes of spread for diarrheas and other intestinal diseases; skin, soil, and inanimate objects-the routes for skin infections; and insect vectors, which transmit parasitic and viral diseases.

3. **Nutrient deficiency**: This is the mother's (pregnant or breastfeeding) or the child intake of food for that contains calories; protein; micronutrients (vitamins and minerals). This relates to the intake of the three major classes of nutrients-calories, protein, and the micronutrients. The survival of children is influenced by nutrients available not only to the child but also to the mother. Maternal diet and nutrition during pregnancy affect birth weight and, during lactation, influence the quantity and nutrient quality of breastmilk.

4. **Injury**: accidental; intentional. This includes physical injury, burns, and poisoning.

5. **Personal illness control**: healthy people take preventive measures to avoid disease. These might include modern practices such as immunizations, as well the use of mosquito nets to protect themselves against malaria. Some individuals might take traditional behaviors like observing taboos, as preventative measures to avoid catching diseases.

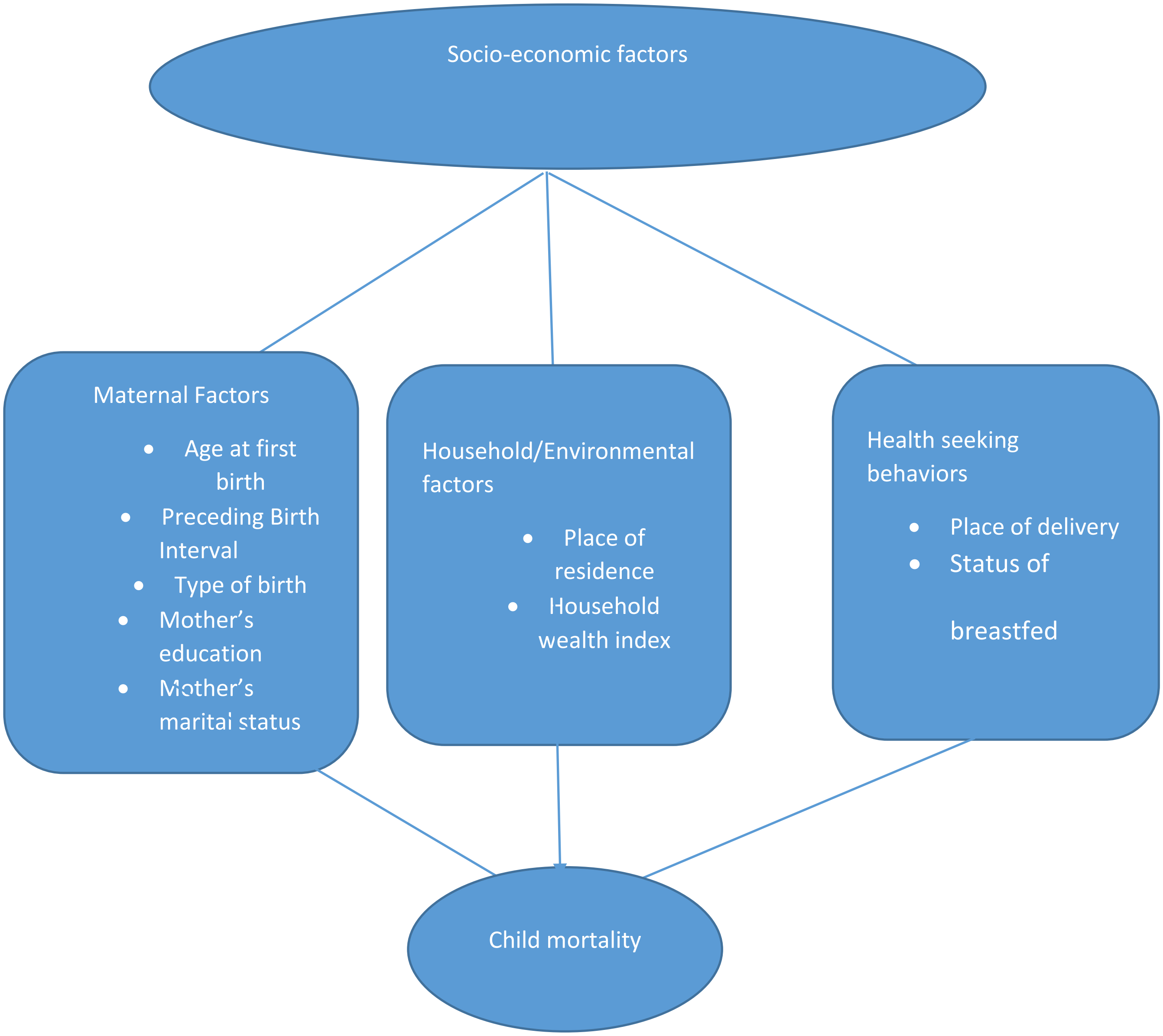



**Figure 2. 1: A modified Mosley and Chen (1984) conceptual framework adopted by the study**

(Source: Adopted from Mosley and Chen's (1984) Conceptual Framework)

## 2.4. Definition of terms

### 2.4.1. Under-five mortality

This is the probability of dying between birth and the age of 5 of life (Namibia Statistics Agency, 2014).

### 2.4.2. Under-five mortality rate

This is the number of children dying under the age of 5 per 1000 live births in a given population (Namibia Statistics Agency, 2014).

### 2.4.3. Direct determinants/proximate

These are leading factors that are directly linked to children's deaths such as;

- maternal factors (place of delivery, child birth weight (kg) and nutrition status),
- environmental factors (household food contaminated with diseases),
- nutrition deficiency that leads to many diseases such as malnutrition and kwashiorkor,
- injuries or accidents,
- diseases such as malaria & diarrhea and
- The child not being immunized against diseases like polio etc.

### 2.4.4. Indirect risk factors

These are additional factors that might be leading risk factors to the children's deaths. These are factors such as parental education, household welfare, availability of clean water and sanitation, household conditions and location, access to health care, etc.

### 2.4.5. Socio-economic factors

According to Wambugu (2014), Mosley and Chen (1984) and Ogada (2014), these are the independent variables that act through proximate determinants to influence the level of morbidity and mortality. The socioeconomic determinants are grouped into three broad categories of variables that are commonly followed in the social science.

- Individual-level variables: individual productivity (mothers); traditions/norms/attitudes
- Household-level variables: income/wealth

- Community-level variables: ecological setting; political economy; health system

2.4.5.1. Educational level (Maternal education)

This variable refers to the highest level of education attained by the mother (Wambugu, 2014).

2.4.5.2. Marital status

Marital status defines the state of the household and its relation to the protective effect. Children from never married and single parents are at higher risks of mortality that those of currently married couples. The study will use 3 categories; currently married, never married and formerly married in the analysis (Wambugu, 2014).

2.4.5.3. Household income/wealth

These are varieties of goods, services, and assets that the household owns, which can be the accessibility to clean flushed toilets (the type of toilet facility used), clean drinking and cooking water, the mother's occupational statuses and many more Mosley and Chen (1984). If the household has clean water, this prevents the spread of water-borne diseases, such as infections and cholera which might lead to the child's death if he/she gets infected (Wambugu, 2014). As for the type of toilet facility this refers to how the household disposes human excreta. Respondents were asked whether the dwelling had some kind of toilet facilities. It is hypothesised that if the household has access to a toilet facility, infections are minimised, hence it is expected that households without any form of facility for human waste disposal will tend to adversely suffer the worse under-five mortality from the consequences of poor sanitation as compared to the rest.

2.4.6. Age at first birth

This is the woman's age, in years, at the time of birth of her firstborn.

2.4.7. Preceding Birth Interval

The time passed between a full term pregnancy and the termination or completion of the next pregnancy (the interval between succeeding births/pregnancies). If it is less than 24 months it is short birth interval, while longer than 24 months the study will regard it as a long time birth interval.

2.4.8. Type of birth

The study will regard this in two categories, single birth and multiple. Multiple birth is a birth of two or more babies produced in the same gestation period and a single birth is the birth of one offspring produced in that gestation period.

### 2.4.9. Place of residence

This is the place in which a person lives or resides, categorized in to two categories, those living in towns, cities and suburbs are regarded as living in urban area while the ones in villages and communal areas will be regarded as living in rural areas.

### 2.4.10. Place of delivery

This refers to the place where the child was born. It is believed that there is a higher risk of experiencing under-five mortality for those children who are born outside a health facility (Wambugu 2014), since children born outside the health facility, either at home, mothers tend to have health complications and not enough medical attention compared to children's born in hospitals.

### 2.4.11. Status of breastfed

This is the action of feeding a baby with milk from the breast. Breast milk contains antibodies that help babies fight off viruses and bacteria.

### 2.4.12. Covariate

These are referred to as explanatory variable or independent variable or predictor variables. This variable is a possibly predictive of the result under study. A covariate may be of direct interest or it may be a confounding or interacting variable.

## 2.5. Methods of Data Analysis

Survival analysis is a branch of statistics that is used to analyze data in which the time until the event is of interest. The response is often referred to as a failure time, survival time or event time.

For examples:

- Time until tumor recurrence, time until AIDS for HIV patients and in the study's case, the time until the death is observed for the under-five children

According to Box-Steffensmeier and Jones (2004), Survival models have three main characteristics, these are

- Dependent variable or response variable is the waiting time until the occurrence of a well-defined event.
- Observations are censored, in the sense that for some units the event of interest has not occurred at the time the data are analyzed / corrected.
- There are predictors or explanatory variables whose effect on the waiting time we wish to access or control.

**Assumptions of survival analysis**

- Censoring is random
- Non-normally distributed outcome
- There may or may not be a multivariate relationship – there can be no relationship between the dependent and the independent variable (Analytics University, 2014).

**Density function**

Let $t$ be a continuous random variable, the density function is the probability of an event happening at time t; the unconditional probability (Analytics University, 2014).

$$\boldsymbol{f(t) = Pr(T = t) = 0} \qquad \textbf{(Equation 2. 1)}$$

**Survival function**

Survival function is the probability that the event happened; death of a child happened after time t is given by, (the probability of a child surviving past 5 years). The survival function can either be of continuous or discrete time. Survival function is given by the formula

$$\boldsymbol{S(t) = Pr(T \geq t)} \qquad \textbf{(Equation 2. 2)}$$

Whereby $S(t)$ is known as the decreasing function of t with $S(t) = 1$ and $S(t) \to 0$ as $t \to \infty$ whie $t$ denotes the survival time. The complement of the survival function is known as cumulative distribution function that is the probability that an event occurs before time t (Kandjimbi, 2014; Analytics University, 2014; Maposa, 2017; Box-Steffensmeier & Jones, 2004). The cumulative distribution function is given by

$$\boldsymbol{F(t) = 1 - S(t) = Pr(T < t)} \quad \textbf{(Equation 2. 3)}$$

**Hazard function**

This is a conditional probability, the instantaneous event rate. Given that a child survived till time t, what is the probability that the child is going to die at that very same time t? This gives the conditional failure rate and is defined as the probability of failure during a very small interval, assuming the individual has survived to the beginning of the interval (Maposa, 2017).

The formula is given by

$$\boldsymbol{h(t) = \lim_{\Delta t \to 0} \frac{P[an\ individual\ fails\ in\ \{(t, t + \Delta t)|T \geq t\}]}{\Delta t}} \quad \textbf{(Equation 2. 4)}$$

Where by $P[an\ individual\ fails\ in\ \{(t, t + \Delta t)|T \geq t\}]$ is the probability that an event occurs during the interval $(t, t + \Delta t)$ given that no event has occurred before time t (Kandjimbi, 2014).

**<u>In simple terms:</u>**

Let $i$ be a positive random variable denoting survival times, for example days. The hazard for day $i$ is

$h_i = 1 - (the\ survival\ proportion\ or\ probability)$

$$h_i = \frac{number\ of\ children\ died\ on\ day\ i}{number\ of\ children\ who\ were\ alive\ at\ the\ beginning\ of\ day\ i}$$

We can also calculate the survival function $\boldsymbol{S(i)}$ = proportion alive at the end of day $\boldsymbol{i}$ using hazards as $\boldsymbol{S(i)} = (1 - h_1)(1 - h_2) \ldots \ldots . (1 - h_i)$

**2.5.1. Survival analysis in Continuous Time**

The applications of event history methods discussed to this point have all presumed that the event history process is absolutely continuous. This assumes change can occur anywhere in time (Box-Steffensmeier & Jones, 2004).

Let $T$ be a positive random variable denoting survival times. The actual survival time of a unit is a realization or value of *T*, which can be denoted as *t*. The possible values of *T* have a *probability distribution* that is characterized by a probability density function, $f(t)$and a cumulative distribution function, $F(t)$ (Box-Steffensmeier & Jones, 2004).

The distribution function of $T$, providing the probability of exit before time $T = t$, is then $F(t) = \Pr(T \ \leq \ t)$ , while the probability of surviving beyond $t$ is $(t) = 1 - F(t) = \Pr(T \ > \ t)$ . Since $(\infty) = 0$ , the density of $T$ can be expressed as $f(t) = \frac{dF(t)}{dt} - \frac{dS(t)}{dt}$. The density $F(t)$ captures the chance of an event occurring in a short time interval, $(t, t + dt)$ , given survival to $t$ is $\Pr(\{t \leq T < t + dt | T \geq t\}) = \frac{\Pr(\{t \leq T < t + dt | T \geq T\})}{dPr(T>t)} = \frac{F(t+dt) - f(t)}{S(t)}$ (Box-Steffensmeier & Jones, 2004; Kandjimbi, 2014 ).

Having defined the survivor function $S(t)$ and the density of failure times, hazard function, $h(t)$, the idea of failure and survival relate to one another is captured by an important face of duration analysis: the *hazard rate*. The relationship between failure times and the survival function is captured through the hazard rate in the following way (Box-Steffensmeier & Jones, 2004):

$$\boldsymbol{h(t)} = \frac{\boldsymbol{f(t)}}{\boldsymbol{S(t)}}$$ **(Equation 2. 5)**

The hazard rate gives the rate at which units fail (or durations end) by *t* given that the unit had survived until *t*. Thus, the hazard rate is a *conditional* failure rate. (Box-Steffensmeier & Jones, 2004).

(2.5) can be expressed as

$$\boldsymbol{h(t)} = \lim_{\Delta t \to 0} \frac{\boldsymbol{Pr(t \leq T \leq t + \Delta t | T \geq t)}}{\Delta t}$$ **(Equation 2. 6)**

Where (2.6) denotes the rate of failure per time unit in the interval [*t, t*+Δ*t*], conditional on survival at or beyond time *t*. The hazard rate, survivor function, and distribution and density functions are mathematically linked (Box-Steffensmeier & Jones, 2004).

To illustrate these relationships, since the probability that a survival time $T$ is less than or equal to some value$t$. For all points that $F(t)$ is differentiable, we define a density function$f(t)$, which gives the unconditional failure rate of event occurrences in an infinitesimally small differentiable area (Box-Steffensmeier & Jones, 2004).

$$\boldsymbol{f(t) = \frac{dF(t)}{d(t)} = F'(t),}$$ **(Equation 2. 7)**

Implying that

$$\boldsymbol{f(t) = \lim_{\Delta t \to 0} \frac{F(t+\Delta t) - F(t)}{\Delta t}}$$ **(Equation 2. 8)**

Which is expressed as the equation (2.6).

The density function in (2.7) can be written as $(t) = \frac{-d\,S(t)}{dt}$, leading to the hazard rate expressed as,

$$\boldsymbol{h(t) = \frac{-d\,S(t)/dt}{S(t)}}$$ **(Equation 2. 9)**

Which is thus equivalent to;

$$\boldsymbol{h(t) = \frac{-d\,log\,S(t)}{dt}}$$ **(Equation 2. 10)**

By integrating (2.10) using $S(0) = 1$, the survival function can be written as

$$\boldsymbol{S(t) = exp(-\int_0^t h(u)du\,) = \ exp^{-Ht,}}$$

Where the term $H(t) = \int_0^t h(u)du,$ is the integrated hazard rate or equivalently the cumulative hazard rate. By (2.11), it is noted that $H(t)$ can be expressed in terms of the log survival function,

$$\boldsymbol{H(t) = -\,log\,S(t)}$$ **(Equation 2. 11)**

This relationship is useful in model diagnostics (Box-Steffensmeier & Jones, 2004).

### 2.5.2. Survival analysis in Discrete Time

Discrete data for discrete-time processes generally record the dependent variable as a series of binary outcomes denoting whether or not the event of interest occurred at the observation point (Box-Steffensmeier & Jones, 2004; Kandjimbi, 2014). The event of interest for this study is "death", whether a child under 5 years died or not.

Let the random variable $T$ denote a discrete random variable indicating the time of an event occurrence. Since we assume events are observable at specific, discretely defined points, $t_i$, the probability mass function for a discrete random variable is

$$\boldsymbol{f(t) = Pr(T = t_i)} \qquad \textbf{(Equation 2. 12)}$$

Which denotes probability of an event occurring at time $t_i$. However, there can be multiple failures occurring at the same time, thus the survival function for the discrete random variable $T$ is given by $T$

$$\boldsymbol{S(t) = Pr(T \geq t_i) = \sum_{j \geq i} f(t_j)} \qquad \textbf{(Equation 2. 13)}$$

Where j denotes the failure time (Kandjimbi, 2014).

Using the results shown in (2.5) for the continuous case, the hazard rate for the discrete case is given by

$$\boldsymbol{h(t) = \frac{f(t)}{S\prime(t)}} \qquad \textbf{(Equation 2. 14)}$$

Which demonstrates that the risk of an event occurrence is equivalent to the ratio of the probability of failure to the probability of survival. The ratio in equation (2.14) can be re-expressed in terms of the conditional probability of failure given survival; hence the hazard probability for the discrete-time case is given by,

$$\boldsymbol{h(t) = (Pr(T = t_i | T \geq t_i)} \qquad \textbf{(Equation 2. 15)}$$

### 2.6.3. Censoring

According to Analytics University (2014), censoring is present when we have some information about a subject's event time, but we don't know the exact event time. There are generally three reasons why censoring might occur:

- A subject does not experience the event before the study ends
- A person is lost to follow-up during the study period
- A person withdraws from the study

**Types of censoring**

**Right censoring**

This occurs when the subject leaves the study before an event can occur, or the study ends before the event has occurred. For example, since we are modelling the children's survival after their $5^{th}$ birthday, given that they are exposed to certain risk factors during their childhood, those children who survived past 5 years are censored.

**Left censoring**

This occurs when the event of interest has already occurred before the study begins.

**Interval censoring** occurs when time to event of interest occurs within an interval.

**Informative censoring**

This occurs when a patient is withdrawn from the study for reasons associated with the event of interest, e.g. when a subject becomes too ill and cannot continue in a clinical trial (Maposa, 2017).

### 2.5.4. Kaplan-Meier Survival function

Survival functions are estimated using a Kaplan Meier estimate of the survival function. Kaplan Meier survival function estimates the probability of survival up to each event time in data from the beginning of follow up time – the unconditional survival probability at each point in time (Analytics University, 2014).

Each term is the product of the conditional probability of surviving beyond time t, given the subject has survived up to time t

$$\widehat{S(t) = \prod}_{t_i \leq t} \frac{n_i - d_i}{n_i} \qquad \textbf{(Equation 2. 16)}$$

$n_i$ being the total number of population entering at time t and $d_i$ the number of people dying or number of events happening.

**2.5.5. Log rank survival test**

The log-rank test is a large-sample chi-square test that uses as its test criterion on statistic that provides an overall comparison of the Kaplan Meier curves being compared (significance test applied to compare Kaplan Meier curves) (Maposa, 2017).

Let $O_1$ and $O_2$ be the observed numbers and $E_1$ and $E_2$ be the expected numbers of deaths in the two treatment groups.

The test statistic:

$$X^2 = \frac{(O_1 - E_1)^2}{E_1} + \frac{(O_2 - E_2)^2}{E_2} \qquad \textbf{(Equation 2. 17)}$$

has approximately the chi-square distribution with 1 degree of freedom and a large value results in the rejection of the null hypothesis (Maposa, 2017).

The expected deaths at time t are computed as;

$$e_{1t} = \frac{n_{1t}}{n_{1t} + n_{2t}} * d_t \text{ and } e_{2t} = \frac{n_{2t}}{n_{1t} + n_{2t}} * d_t \qquad \textbf{(Equation 2. 18)}$$

$d_t$ being the total deaths for both groups at time $t$ and $e_{1t}$ & $e_{2t}$ the expected deaths in group 1 and 2 respectively at time $t$.

Hence, the total number of deaths expected in the two groups are:

$$E_1 = \sum_{\forall t} e_{1t} \text{ and } E_2 = \sum_{\forall t} e_{2t} \qquad \textbf{(Equation 2. 19)}$$

Therefore, the log rank statistics for two group is computed at

$$\boldsymbol{log-rank\ statistics} = \frac{(O_i - E_i)^2}{var(O_i - E_i)} \quad \textbf{(Equation 2. 20)}$$

where $\boldsymbol{var(O_i - E_i)}$ is the variance and $\boldsymbol{i = 1, 2}$

**An assumption of Log rank survival test**

This test depends on a single assumption - that the hazards in one group are equally higher (or lower) than in the other group by some proportionality factor $\in \geq 0$.

**2.5.5. Cox proportional hazard model**

According to Mohamad Amin Pourhoseingholi et al., (2007), there are two major regression models used for right censored data to assess the effects of various factors on survival analysis: proportional hazards model (Cox) as a semi parametric method and accelerated failure time model as a parametric model. Many of the standard parametric models such as Weibull, Exponential and Lognormal are accelerated failure time models.

In the proportional hazard regression model, the effect of covariates is obtained on the hazard function. In this case, if baseline hazard is considered parametric, one of the Weibull, exponential and Gompertz models will be achieved. If the baseline hazard is considered non-parametric, the Cox proportional hazard model will be obtained. In the accelerated failure-time regression model, the effect of covariates on the logarithm of the survival time is assessed. The obtained models in this case include generalized gamma, Log-logistic, Log-normal, Weibull and exponential. Weibull and exponential are the only parametric regression models which have both a proportional hazards and an accelerated failure-time representation (Persson, 2002).

However, quoting from Pourhoseingholi et al., (2007)," *the* proportional hazard model does not need to consider a specific probability distribution for the survival time; therefore, it is the most helpful model in analysing survival data. But the efficiency of the model is severely dependent to proportional hazards assumption and, for this reason, The Cox model is often called proportional hazards model" (Pourhoseingholi et al., 2007, p.01).

The basic form of the Cox proportional hazards model is as follows;

$$\boldsymbol{h(t/X) = h_0(t)\, e^{(B_1X_1 + B_2X_2 + \cdots \ldots + B_kX_k)}} \qquad \textbf{(Equation 2. 21)}$$

Where

$X = (X_1, X_2, \ldots \ldots \ldots, X_k)$ are the explanatory/predictor variables

$h_0(t)$ is called the baseline hazard and $B = (B_1, B_2, \ldots \ldots \ldots, B_k)$ are the parameters to be estimated.

**Assumptions of the Cox proportional hazards Model**

Cox proportional hazards model relies on the hazards to be proportional. In a regression type setting this means that the survival curves for two strata (determined by the particular choices of values for the x-variables) must have hazard functions that are proportional/parallel over time (that the effect of a given covariate does not change over time). This means that the Kaplan Meier curves for the different groups should not cross each other. If this assumption is violated, the simple Cox model is invalid, and more sophisticated analyses such as including in frailty models are required to capture the random effect (Persson, 2002).

Making special assumptions about $h_0(t)$ leads to parametric models, e.g. the exponential and Weibull distributions. However, the benefit of using the Cox's model is the fact that such assumptions can be avoided. This approach is said to be semiparametric (Persson, 2002).

The assessment of the proportional hazards assumption can be done numerically or graphically. This can be tested with "log-log" plots in the two-sample comparison case or Kaplan Meier curves, the graphs of the two groups, which should not intersect (Persson, 2002).

### 2.5.6. Unobserved heterogeneity

This section considers survival models with a random effect representing unobserved heterogeneity of frailty. Heterogeneity can be induced in a model any time relevant covariates are not included in the model's specification. Relevant covariates may be left out because they are unmeasurable, unobservable, or because the analyst may not know that a particular covariate is even important (Box-Steffensmeier & Jones, 2004). In medical and demographic researches, survival time models often assume that the study populations are homogeneous conditional on observed factors (covariates) (Adeniyi et al., 2014).

When the Cox proportional hazards models for survival data are extended where allowance is made for unobserved heterogeneity and for correlation between the life times of several individuals, the extended models are frailty models and estimation is carried out using the EM algorithm (Petersen et al., 2001).

**2.5.6.0. Frailty models**

Frailties are group specific factors acting on a children's survival, which together with other individual factors may protect or accelerate death (Vaupel et al., 1979). The term frailty is used to represent unobservable random effects shared by subjects with similar (unmeasured) risk in the analysis of mortality.

*"A frailty model is a multiplicative hazard model consisting of three components: a frailty (random effect), a baseline hazard function (parametric or nonparametric), and a term modelling the influence of observed covariates (fixed effects)*" (Wienke, 2011).

**2.5.6.1. Individual frailty**

Models based on individual-level frailties (i.e. each observation in the sample has potentially its own unique frailty) are conventionally referred to as frailty models or individual-level frailty models (Box-Steffensmeier & Jones, 2004).

Box-Steffensmeier & Jones (2004) defined frailty as follows;
Assume, a sample of observations are more failure prone due to reasons unknown (or unmeasured). The hazard rate (using the proportional hazards framework) with covariates, is given by;

$$\boldsymbol{h(t)_j = h_o(t)\, exp\, B'x_j} \qquad \textbf{(Equation 2. 22)}$$

In this setup, the covariates act multiplicatively on the baseline hazard ($h_o(t)$) and as such, reveal information on how the relative hazard is increasing or decreasing as a function of $x$. However, if there are unmeasured or unobserved "frailties" among individuals in the sample, then the hazard rate shown above will not only be a function of the covariates, but also a function of the frailties associated with the $j$ individuals. In this case, the hazard could be expressed as

$$\boldsymbol{h(t)_j = h_o(t)\, exp(B'x_j + \omega_j)} \qquad \textbf{(Equation 2. 23)}$$

Where $\omega_j$ are the frailties and are assumed to be an independent sample from a distribution with mean 0 and variance 1.

#### 2.5.6.2. Shared frailty

Models constructed in terms of group level frailties are sometimes referred to as *shared frailty* models because observations within a subgroup share unmeasured "risk factors" that prompt them to exit earlier (or later) than other sub-groups in the population (Box-Steffensmeier & Jones, 2004).

According to Adeniyi et al., 2014, Shared frailty arises due to cluster specific heterogeneity resulting when individuals are grouped into clusters (groups), in which case observations within the same cluster are assumed to share the same frailty which is different from those from neighboring/nearby clusters. The designs of demographic surveys often group individuals into clusters, for example, children may be grouped by mothers or households, communities or districts.

Box-Steffensmeier and Jones (2004) defined shared frailty as follow:
Suppose we have $j$ observations and $i$ subgroups (for repeated measures data, the $j$ observations will simply be the period- specific records of data for the individual. The hazard rate for the $j.th$ individual in the $i.th$ subgroup (with frailties) is:

$$\boldsymbol{h(t)_{ij} = h_o(t)\, exp(B'x_{ij} + \omega_{f_i})} \qquad \textbf{(Equation 2. 24)}$$

Where $f_i$ are the subgroups of the frailties which are assumed to be an independent sample from a distribution with mean =0 and variance=1.

If $\omega = 0$, then the standard proportional hazards model is obtained, thus implying the absence of group-level heterogeneity, we can re-express the equation (2.24) as

$$\boldsymbol{\left(h(t)_{ij} \middle| B', x_{ij}, v_i = h_o(t)\, v_i\, exp(B'x_{ij}\right)} \qquad \textbf{(Equation 2. 25)}$$

Where $\boldsymbol{v_i = \exp(f_i)}$ and denotes the shared frailties.

## 2.5. Model assessment or selection

According to Kandjimbi (2014), the need to select a model is of great importance in statistics in order to ensure goodness of fit. The observed data is usually from an unknown probability distribution. As a result, several models are fitted in order to find the best. The models that are not very close to the actual distribution have to be thrown away.

Below is a few statistical test used to assess the goodness of the fitted models:

### 2.5.1. The likelihood ratio test

"*A likelihood ratio test is a statistical test used to compare the fit of two models. The test is based on the likelihood ratio, which expresses how many times more likely the data are under one model than the other. This likelihood ratio, or equivalently its logarithm, can then be used to compute a p-value, or compared to a critical value to decide whether to reject the null model in favor of the alternative model*", (Kandjimbi, 2014).

### 2.5.2. Akaike Information Criterion (AIC)

*"Akaike Information Criterion is a useful statistic for statistical model identification and evaluation. This criterion was developed by Akaike. A model with a best minimum AIC value is chosen to be the best fitting model among several competing models"* (Takane, 1987).

AIC does not intend to identify the true model; the best fitting model doesn't mean it is the true model. But it means that the model is the best among the competing models, as it gives the best model for the closest approximation to the true model approximation (Takane, 1987).

$$\boldsymbol{AIC = 2P - 2\,ln(L)} \quad \textbf{(Equation 2. 26)}$$

Where p is the number of parameters and L the maximized value of the log likelihood function for the estimated model.

### 2.5.3. Bayesian Information Criterion (BIC)

The BIC is another model selection in statistic that was introduced by Schwarz in 1978. It is related to the AIC and both statistics penalize model complexity. The best model fitted is identified by the minimum value of BIC (Kandjimbi, 2014). Mathematically, the BIC is given by:

$$\boldsymbol{BIC} = \ \boldsymbol{2ln}(\boldsymbol{L}) + \boldsymbol{p}\ \boldsymbol{ln}(\boldsymbol{n}) \qquad \textbf{(Equation 2. 27)}$$

Where by L = the maximized value of the likelihood function of the model and

p = the number of free parameters to be estimated

n = the number of observations or the sample size

### 2.7. Summary

Chapter 2 highlighted research work of other scholars whose focus is generally to the area of survival analysis. Theories and literature related to the risk factors associated with mortality incidences in children below five years were reviewed. The conceptual model or framework was provided. The following chapter, presents the research methodology used to collect and analyze data for the study.

# CHAPTER THREE

# METHODOLOGY

## 3.0. Introduction

This chapter examines the techniques to be used to conduct the research as well as the data source(s), study design, the data collection methods and the data analysis process.

## 3.1. Data source

This study made use of secondary data from the 2013 Namibia Demographic and Health Survey. 2013 NDHS is the fourth comprehensive, national-level population and health survey conducted in Namibia as part of the global Demographic and Health Surveys (DHS) programme. The 2013 NDHS was implemented by the Ministry of Health and Social Services (MoHSS) in collaboration with the Namibia Statistics Agency (NSA) and the National Institute of Pathology (NIP). The data collection was carried out from May to September 2013. The study collected data on demographic, socioeconomic, and health data such as fertility, family planning, infant and child mortality, maternal and child health, nutrition, domestic violence, and knowledge and prevalence of HIV/AIDS and other non-communicable diseases.

The 2013 Namibia Demographic and Health Survey (2013 NDHS) follows similar surveys conducted in 1992, 2000, and 2006-07. A national sample of about 10 000 households was selected. All women age 15-49 who were usual residents of the selected households, or who slept in the households the night before the survey, were eligible to participate. The survey resulted in about 10,500 interviews of women aged 15-49 and a total of 5046 children that are less than 5 years old. However, from data cleaning and removing of missing data plus the removal of those whose nationality were none Namibians the study resulted into 4897 under-five children that were considered under study. The window period (the data collected) under study was a five (5) years period from the year 2008-2013.

## 3.2. Study design

The 2013 NDHS used a two-stage stratified sampling technique to select a sample of households for the data collection. The sampling frame used for the 2013 NDHS is the preliminary frame of the Namibia Population and Housing Census conducted in 2011 with partial updating of the frame provided by the Namibia Statistics Agency (NSA). The sampling frame is a complete list of all EAs in the country. In the first stage, 554 EAs were selected with a stratified probability proportional to size within the sampling flame.

Stratification was achieved by separating each region into urban and rural areas. Therefore, the 13 regions were stratified into 26 sampling strata: 13 rural strata, and 13 urban strata.

After the selection of EAs and before the main survey, a household listing operation was carried out in all selected EAs, and the resulting lists of households served as a sampling frame for the selection of households in the second stage. In the second stage, a fixed number of 20 households were selected for each EA by equal probability systematic sampling. A total number of selected household was 11 080.

**3.3. Study population**

The study population were all children born in the preceding 5 years before the survey reference period; age 0 to 59 months. After the data cleaning (removal of missing values) the total population of under-five children considered for the study was 4897 children.

**3.4. Study sample**

Children born within the five years before the survey date were included in the analysis. This mean that every child who was born from the year 2008 to the year 2013 regardless if he or she is alive or not during the time of the survey in 2013, were included in the study. Specifically, all deaths that occurred from age 0 to 59 months (from the year 2008 to the year 2013) were regarded as cases and were studied relating their deaths to the socio-economic characteristics of their mothers, whilst, children who survived past 59 months were treated as right censored.

**3.5. Data analysis methods**

In this study, survival analysis was conducted to find out the determinants of under-five mortality in Namibia. Furthermore, a comparison between urban and rural under-five mortality was done. Analysis of how socio-economic factors affects regional under-five inequalities in Namibia was carried out. Survival function curves for urban and rural areas per regions in Namibian and a Log rank survival test to assess significance was carried out using Stata version 14.2. Furthermore, frailty random effects on unobserved heterogeneity on Under-five mortality in Namibia was explored using region as the shared frailty variable.

**3.5.1. Introduction**

The major methods that were employed in the data analysis were; Frequency distributions, Kaplan-Meier Survival functions (Log rank survival test) and Frailty models as per the review in chapter 2, section 2.5. The significance of the associations between the outcome (child dead) and the predictor variables was tested by simple cross tabulation, chi-square test, Log rank test and Cox proportional hazards regression. Chi-square test for associations, the Log rank test and the Cox proportional hazards regression were set to be significant at a significance level of 0.05.

#### 3.5.1.1. Kaplan-Meier Survival function

Survival functions are estimated using a Kaplan Meier estimate of the survival function. Kaplan Meier survival function estimates the probability of survival up to each event time in data from the beginning of follow up time – the unconditional survival probability at each point in time (Analytics University, 2014).

Each term is the product of the conditional probability of surviving beyond time t, given the subject has survived up to time t

$$\boldsymbol{S}(\boldsymbol{t}) = \widehat{\prod}_{t_\iota \leq t} \frac{n_\iota - d_\iota}{n_\iota}$$

$n_i$ being the total number of population entering at time t and $d_i$ the number of people dying or number of events happening.

#### 3.5.1.2. Log rank survival test

The log-rank test is a large-sample chi-square test that uses as its test criterion on statistic that provides an overall comparison of the Kaplan Meier curves being compared (significance test applied to compare Kaplan Meier curves) (Maposa, 2017).

Let $O_1$ and $O_2$ be the observed numbers and $E_1$ and $E_2$ be the expected numbers of deaths in the two treatment groups.

The test statistic:

$$\boldsymbol{X}^2 = \frac{(O_1 - E_1)^2}{E_1} + \frac{(O_2 - E_2)^2}{E_2}$$

has approximately the chi-square distribution with 1 degree of freedom and a large value results in the rejection of the null hypothesis (Maposa, 2017).

Hence the log-rank test is;

$$\boldsymbol{log - rank\ statistics} = \frac{(\boldsymbol{O_i - E_i})^2}{\boldsymbol{var(O_i - E_i)}}$$

where $\boldsymbol{var}(\boldsymbol{O_i} - \boldsymbol{E_i})$ is the variance and $\boldsymbol{i = 1, 2}$

### 3.6.1.3. Cox proportional hazards regression Model

The Cox proportional hazards model;

$$\boldsymbol{h(t/X) = h_0(t)\ e^{(B_1X_1 + B_2X_2 + \cdots \ldots + B_kX_k)}}$$

Where

$X = (X_1, X_2, \ldots \ldots \ldots, X_k)$ are the explanatory/predictor variables

$h_0(t)$ is called the baseline hazard or the hazard for an individual when the value of all the explanatory variables are zero(reference group) and $B = (B_1, B_2, \ldots \ldots \ldots, B_k)$ are the parameters to be estimated.

.

On the log scale

$$\log[\boldsymbol{h}\left(\frac{\boldsymbol{t}}{\boldsymbol{X}}\right)] = \boldsymbol{log}\ [\boldsymbol{h_0(t)}\ \boldsymbol{e^{(B_1X_1 + B_2X_2 + \cdots \ldots + B_kX_k)}}]$$

$$= \log[\boldsymbol{h_0(t)}] + \boldsymbol{B_1X_1} + \boldsymbol{B_2X_2} + \cdots \ldots . . + \boldsymbol{B_kX_k}$$

From the above equation, the effects of the explanatory variables are additive and linear on the log-rate scale.

**Estimation of parameters (B)**

The parameters are estimated by maximizing log Likelihood$L(\beta)$. Due to the large sample sizes, the Betas are estimated using STATA 14.2 software. This is achieved by Cox's partial likelihood function is given by;

$$L(\beta) = \prod_{k=1}^{n} (\frac{\exp(\boldsymbol{BX_k})}{\sum_{J \in R(t_k)} \exp(\boldsymbol{BX_j})}\ D_k$$

Where

$R(t_k)$ is the risk of death of the child at time $t_k$ , $\exp(\boldsymbol{BX_k}$ is the hazard ratio (HR) between two groups for the explanatory variables. E.g. for the explanatory variable (Maternal highest education level) this will be the hazard ratio between the reference group (No education) and primary level and $D_k$ the total deaths for both groups at time $k$

**3.5.1.4. Frailty models**

The term frailty is used to represent unobservable random effects shared by subjects with similar (unmeasured) risk in the analysis of mortality (Box-Steffensmeier & Jones, 2004).

**Individual frailty**

For the individual frailty models, each observation in the sample has potentially its own unique frailty independent from other observations, (Box-Steffensmeier & Jones, 2004).

$$\boldsymbol{h(t)_j = h_o(t)\, exp(B'x_j +\ \omega_j)}$$

Where $\omega_j$ the frailties and are assumed to be an independent sample from a distribution with mean 0 and variance 1 and $\boldsymbol{h(t)_j = h_o(t)\, exp(B'x_j)}$ is the cox proportional hazard model.

**Shared frailty**

While for the shared frailty models, observations within a subgroup share unmeasured “risk factors” that prompt them to exit earlier (or later) than other sub-groups in the population (Box-Steffensmeier & Jones, 2004). Since children are clustered into communities, communities clustered within regions, mothers or children from the same communities tend to have similar characteristics with those from the same communities which might affect their rate of survival.

Suppose we have $j$ observations and $i$ subgroups (for repeated measures data, the $j$ observations will simply be the period- specific records of data for the individual. The hazard rate for the $j.th$ individual in the $i.th$ subgroup (with frailties) is:

$$h(t)_{ij} = h_o(t)\, exp(B' x_{ij} + \omega_{f_i})$$

Where $f_i$ are the subgroups of the frailties which are assumed to be an independent sample from a distribution with mean =0 and variance=1.

### 3.5.2. Data Management

Several categories of certain variables were grouped, since some categories had few recorded cases. Statistical Package for Social Sciences (SPSS) was used for data cleaning to remove missing data. The data were then exported to Stata for further analysis. One aspect of the data cleaning was to reduce the number of variables in the dataset, in order to remain with variables of interest for the analysis of the study. The data were cleaned to remove missing cases. Variable of interest were grouped to form categorical variables and dummy variables were created for all explanatory variables of interest for the study. After the data cleaning in SPSS and applying sample weights, the data resulted into 4897 under-five children's, with 218 dead cases.

### 3.5.3. Frequency Distributions

The frequency distributions were used to show the distribution of children dead according to the various categories of the study variables. Likewise, the chi-square test was performed to access the association between the outcome variable (child dead) and the predictor variables. These are presented in table 4.1 in the next chapter.

## 3.6. Description of key variables

### 3.6.1. The outcome variable

The outcome variable for this study is the risk of death in childhood which is measured as the duration of survival since birth in months. It is important to note that the study focus only on modelling the risk of the children dying between birth and fifth birthday (under-five mortality), and not on modelling infant mortality separately (the risk of a child dying between birth and first birthday) like other studies did, such as (Kaundjua, 2013; Mwangi, 2014; Adedini, et. al, 2012).

Hence, all children born within the five years before the survey date were included in the analysis. Specifically, all deaths that occurred from age 0 to 59 months were regarded as cases. The children's survival status and the age at death in months (if the child had died) or the last month that they were known to be alive (if child is still living) were combined to generate the outcome variable for the survival analysis. Children known to have died (i.e. non-censored) were regarded as the cases, whereas children who were still alive after 59 months were treated as right-censored.

### 3.6.2. Explanatory variables

The independent variables used in the study are the socio-economic factors as explained in chapter 2. These are as follows;

**Table 3. 1: Description of socio-economic factors considered in this study**

| Variable | Variable code | Operational definition | Role of variable |
|---|---|---|---|
| Maternal education | V106 | 1=no education<br>2=primary<br>3=secondary<br>4=higher | Independent variable<br>Socio-economic |
| Mother's marital status | V501 | 1=never married<br>2=currently married<br>3=formerly married | Independent variable<br>Socio-economic factors |
| Age at first birth | V212 | 1=less than 20 years<br>2=20-34 years<br>3=more than 34 years | Proximate determinant-Maternal factor |
| Preceding Birth Interval | B11 | <24=short<br>>24=long | Proximate determinant-Maternal factor |
| Type of birth | B0 | 1=single<br>2=multiple | Proximate determinant-Maternal factor |
| Place of residence | V025 | 1=urban<br>2=rural | Proximate Determinant-Household/Environmental factors |
| Household wealth index | V190 | 1=poor<br>2=rich<br>3=richer | Proximate Determinant-Household/Environmental factors |
| Place of delivery | M15 | 1=home<br>2=public facility<br>3=private medical facility | Proximate determinant - Health seeking behaviour |

| | | | |
|---|---|---|---|
| Status of breastfed | M4 | 1=child has been breastfed<br>2=child had been never breastfed | Proximate determinant - Health seeking behaviour |
| Region | V101 | 1= Caprivi<br>2=Erongo<br>3=Hardap<br>4=Karas<br>5=Kavango<br>6=Khomas<br>7=Kunene<br>8=Ohangwena<br>9=Omaheke<br>10=Omusati<br>11=Oshana<br>12=Oshikoto<br>13=Otjozondjupa | The region in which the household is situated, these will be used as a proxy of shared frailty |

**3.7. Ethical consideration**

Permission to use the NDHS data for the purpose of this study was granted by World Bank Group who are the administrators of the Demographic Health Survey website, where the data was downloaded. Furthermore, since the NDHS data is an already published (secondary) data for public use, ethical consideration from the Ministry of Health and Social Services is not warranted.

**3.8. Limitation of the study**

Women in the 2013 NDHS were enumerated at the household where they were listed during the enumeration period (de facto survey). Thus, some of the women interviewed in the survey may not have been staying in the same locality throughout the five-year period before the survey. Some of the women were also not counted at their usual place of residence, and thus the individual and contextual factors listed in the survey may not necessarily relate to their births in the last five years before the survey. Likewise, the interactions of some of the predictor variables on the dependent variable might also be affected because of the timing. For example, the marital status, household wealth index and maternal education reported in 2013 referred to current status, and may not necessarily have been the actual status of the mother at the time of birth or death of the child (Kaundjua, 2013).

### 3.9. Summary

Chapter 3 described the research methodology that was used to collect and analyze data. It explained the research design, population, sample for data collection, research instruments and procedures used to collect data, and the method for data analysis. The following Chapter 4 presents an analysis and results.

# CHAPTER FOUR

## ANALYSIS AND OUTPUTS

### 4.0. Introduction

This chapter is organized into four sections; section one deals with the distribution of the study population by different socio-economic, socio-demographic and environmental characteristics. The outcomes of the findings from the descriptive statistics through frequencies in tables are illustrated; the Chi-square associations test. While section two and three deals with the Kaplan Meier curves, Log rank test and the tests of the assumption of Proportional Hazard (PH) models of the various characteristics at national level, respectively, and the analysis of frailty models based on the AIC selection model in the fourth section.

### 4.1. Distribution of births and death by the study variables

Table 4.1 below summarizes the frequencies and percentages of the variables used in the study.
This section presents the results of the descriptive data analysis results before moving on to make further inferences based on models built. From table 4.1 below, a total of 4 897 children were included in this study. Of these children, 218 (4.5%) children died before the age of five and 4 679 (95.5%) children survived passed the age of five.

Kavango region had the highest birth frequency 512(10.5%) followed by Ohangwena and Kunene each at 446(9.1%) and 412(8.4%) births, respectively. Out of the 512(10.5%) births in Kavango regions, 32(6.2%) died before the age of five. As for Ohangwena regions, 27(6.1%) out of 446 births died before the age of five.

2226 (45.5%) of the children residence in Urban area and 2671 (54.5%) in rural areas. Of the 2 226 children who reside in urban area, 88(4.0%) children did not make it beyond five (5) years of age. Likewise, out of the 2 671 children whose residence was rural area, 130(4.9%) died before the age of five (5).

Of the total sampled for the survey 4 897 majority of children's mothers 3 099(63.3%) attained secondary education as their highest level of education compared to the other categories. Moreover, 3 973(81.4%) children were born in public health facilities of which 177(4.5%) died before their fifth birthday. Only a few 209(4.3%) were born at private facilities with one (0.5%) death. In addition, more than 95 percent 4 754(97%) of the children were single birth and only 143(3%) children were born either twins, triplets etc., and 4599(94.6%) were breastfeed while 262(5.4%) have never been breastfeed since birth. Of the 4 754(97%) single birthed children 189(4.0%) did not survive pass the age of five while 143(3%) children who were multiple birthed children, 29(20.3%) of them died before the age of five (5).

Additionally, half of the children 2 442(50%) were born by mothers who were currently married at the time of the survey and those born by mothers who were formerly married were the least 261(5%) in comparison with other categories for marital status, with majority of these children (above 95%) surviving past the age of five(5).

As for the age of respondent at first birth, preceding birth interval and household wealth index, majority of the under-five children during the period under review 2 485(51%) were born by mothers who were less than 20 years of age at first birth and only 26(1%) were born by mothers who were over 35 years at their first birth. About 2 799(84.7%) of children are long birth interval, 2 132(44%) are from poor households. It is worth noting that all children born by mothers who were over 35 years at their first birth, survived past the age of five (5) years, hence retaining a survival probability of 1 at the end of the reference period (59 moths).

Based on the chi-square statistical test results, at 5% significant level, four (4) out of the 12 variables (Maternal highest education level, place of delivery, type of birth and status of breastfeeding) are significantly associated with the risk of child dying before the age of five.

**Table 4. 1: Distribution of births and death by the study variables and the chi-square association test**

| Variable | Categories | Child dead | | Percentage dead (not relative to the entire country) | Percentage alive (not relative to the entire country) | Frequency total | Frequency percentage | Chi square test | p-value |
|---|---|---|---|---|---|---|---|---|---|
| | | No | Yes | | | | | | |
| **Child is dead** | | 4679 | 218 | 4.5 | 95.5 | 4897 | | - | - |
| | | | | | | | | | |
| **Region** | Caprivi | 379 | 24 | 6.0 | 94.0 | 403 | 8.2 | 17.4186 | 0.135 |
| | Erongo | 341 | 15 | 4.2 | 95.8 | 356 | 7.3 | | |
| | Hardap | 317 | 12 | 3.6 | 96.4 | 329 | 6.7 | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Karas | 346 | 12 | 3.4 | 96.6 | 358 | 7.3 | | |
| | Kavango | 480 | 32 | 6.2 | 93.8 | 512 | 10.5 | | |
| | Khomas | 375 | 12 | 3.1 | 96.9 | 387 | 7.9 | | |
| | Kunene | 391 | 21 | 5.1 | 94.9 | 412 | 8.4 | | |
| | Ohangwena | 419 | 27 | 6.1 | 93.9 | 446 | 9.1 | | |
| | Omaheke | 321 | 15 | 4.5 | 95.5 | 336 | 6.9 | | |
| | Omusati | 353 | 11 | 3.0 | 97.0 | 364 | 7.4 | | |
| | Oshana | 264 | 8 | 2.9 | 97.1 | 272 | 5.6 | | |
| | Oshikoto | 321 | 17 | 5.0 | 95.0 | 338 | 6.9 | | |
| | Otjozondjupa | 372 | 12 | 3.1 | 96.9 | 384 | 7.8 | | |
| | | | | | | | | | |
| **Type of place of residence** | Urban | 2 138 | 88 | 4.0 | 96.0 | 2226 | 45.0 | 2.3836 | 0.123 |
| | Rural | 2 541 | 130 | 4.9 | 95.1 | 2671 | 55.0 | | |
| | | | | | | | | | |
| **Maternal Highest educational level** | No education | 381 | 20 | 5.0 | 95.0 | 401 | 8.2 | 14.1367 | 0.003 |
| | Primary | 1 096 | 69 | 5.9 | 94.1 | 1165 | 23.8 | | |
| | Secondary | 2 972 | 127 | 4.1 | 95.9 | 3099 | 63.3 | | |
| | Higher | 230 | 2 | 0.9 | 99.1 | 232 | 4.7 | | |
| | | | | | | | | | |
| **Place of delivery** | home | 666 | 31 | 4.4 | 95.6 | 697 | 14.3 | 7.7111 | 0.021 |
| | public facility | 3,796 | 177 | 4.5 | 95.5 | 3,973 | 81.4 | | |
| | private medical facility | 208 | 1 | 0.5 | 99.5 | 209 | 4.3 | | |
| | | | | | | | | | |
| **Type of birth** | single | 4,565 | 189 | 4.0 | 96.0 | 4,754 | 97.0 | 86.7582 | 0 |
| | multiple | 114 | 29 | 20.3 | 79.7 | 143 | 3.0 | | |
| | | | | | | | | | |
| **Current marital status** | never married | 2,103 | 91 | 4.1 | 95.9 | 2,194 | 45.0 | 0.8707 | 0.647 |
| | currently married | 2,327 | 115 | 4.7 | 95.3 | 2,442 | 50.0 | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | formerly married | 249 | 12 | 4.6 | 95.4 | 261 | 5.0 | | |
| | | | | | | | | | |
| **Age of respondent at 1st birth** | less than 20 years | 2,364 | 121 | 4.9 | 95.1 | 2,485 | 51.0 | 3.0669 | 0.216 |
| | 20 to 34 years | 2,289 | 97 | 4.1 | 95.9 | 2,386 | 49.0 | | |
| | more than 34 years | 26 | 0 | 0.0 | 100.0 | 26 | 1.0 | | |
| | | | | | | | | | |
| **Preceding birth interval** | short birth interval | 477 | 29 | 5.7 | 94.3 | 506 | 15.3 | 1.1051 | 0.293 |
| | long birth interval | 2,669 | 130 | 4.6 | 95.4 | 2,799 | 84.7 | | |
| | | | | | | | | | |
| **household wealth index** | poor | 2,026 | 106 | 5.0 | 95.0 | 2,132 | 44.0 | 3.5348 | 0.171 |
| | rich | 1,045 | 50 | 4.6 | 95.4 | 1,095 | 22.0 | | |
| | richer | 1,608 | 62 | 3.7 | 96.3 | 1,670 | 34.0 | | |
| **Status of breastfed** | child has been breastfed | 4458 | 141 | 3.1 | 96.9 | 4599 | 94.6 | 280.0212 | 0 |
| | child had never been breastfed | 198 | 64 | 24.4 | 75.6 | 262 | 5.4 | | |

Among the children who were reported dead, 218 cases (4.5%), majority of them, 130 (59.6%) were from rural areas and 88 (40.4%) from urban areas (Table 4.2). Moreover, Kavango, Ohangwena and Caprivi regions accounted for the highest number of children who had died, each at 32 (14.7%), 27 (12.4%) and 24 (11.0%) children respectively. Furthermore, Hardap, Karas, Khomas and Otjozondjupa region share the same proportion/percentage of children who died from the 218 cases, each with 12(5.5%). Oshana region accounts for the least number of under-five children that are dead 8 cases (3.7%) out of the 218 cases nationally.

Furthermore, table 4.2 further shows that among the children who were reported dead, children born by mothers who attained secondary education accounts for majority of dead cases 127(58.3%), followed by mothers who had primary level 69(31.7%) and mothers with highest level of education had the least dead children 2(0.9%). Majority of the categories that accounts for most of the children that were reported dead are as follows: 177(84.7%) were children who were born at public facilities, 189(86.7%) were single birth, those from currently married mothers at 115(52.8%), those born by mothers who are less than 20 years at 121(55.5%) children, 130(81.8%) reported cases for long birth interval, 106(48.6%) believed to come from poor households and 141(68.78%) have been breastfeed.

**Table 4. 2: Proportion of the under-five children who died per each variable**

| Variable | Categories | Frequency | Proportion/share of dead (not relative to the entire country) |
|---|---|---|---|
| Region | Caprivi | 24 | 11 |
| | Erongo | 15 | 6.9 |
| | Hardap | 12 | 5.5 |
| | Karas | 12 | 5.5 |
| | Kavango | 32 | 14.7 |
| | Khomas | 12 | 5.5 |
| | Kunene | 21 | 9.6 |
| | Ohangwena | 27 | 12.4 |
| | Omaheke | 15 | 6.9 |
| | Omusati | 11 | 5 |
| | Oshana | 8 | 3.7 |
| | Oshikoto | 17 | 7.8 |
| | Otjozondjupa | 12 | 5.5 |
| Type of place of residence | Urban | 88 | 40.4 |

| | | | |
|---|---|---|---|
| | Rural | 130 | 59.6 |
| **Maternal Highest educational level** | No education | 20 | 9.2 |
| | Primary | 69 | 31.7 |
| | Secondary | 127 | 58.3 |
| | Higher | 2 | 0.9 |
| **Place of delivery** | home | 31 | 14.8 |
| | public facility | 177 | 84.7 |
| | private medical facility | 1 | 0.5 |
| **Type of birth** | single | 189 | 86.7 |
| | multiple | 29 | 13.3 |
| **Current marital status** | never married | 91 | 41.7 |
| | currently married | 115 | 52.8 |
| | formerly married | 12 | 5.5 |
| **Age of respondent at 1st birth** | less than 20 years | 121 | 55.5 |
| | 20 to 34 years | 97 | 44.5 |
| | more than 34 years | 0 | 0 |
| **Preceding birth interval** | short birth interval | 29 | 18.3 |
| | long birth interval | 130 | 81.8 |
| **Household wealth index** | poor | 106 | 48.6 |
| | rich | 50 | 22.9 |
| | richer | 62 | 28.4 |
| **Status of breastfed** | child has been breastfed | 141 | 68.78 |

| | | | |
|---|---|---|---|
| | child had never been breastfed | 64 | 31.22 |
| **Total** | | **218** | |

### 4.2. Kaplan Meier Curves of Under-Five Mortality in Namibia

Figure 4.1., below shows the survival function of under-five mortality in Namibia. It is evident from Figure 4.1 and Appendix 2., that there was a higher probability of children surviving past five years. About 95 percent of children in Namibia survived past five years (59 months).

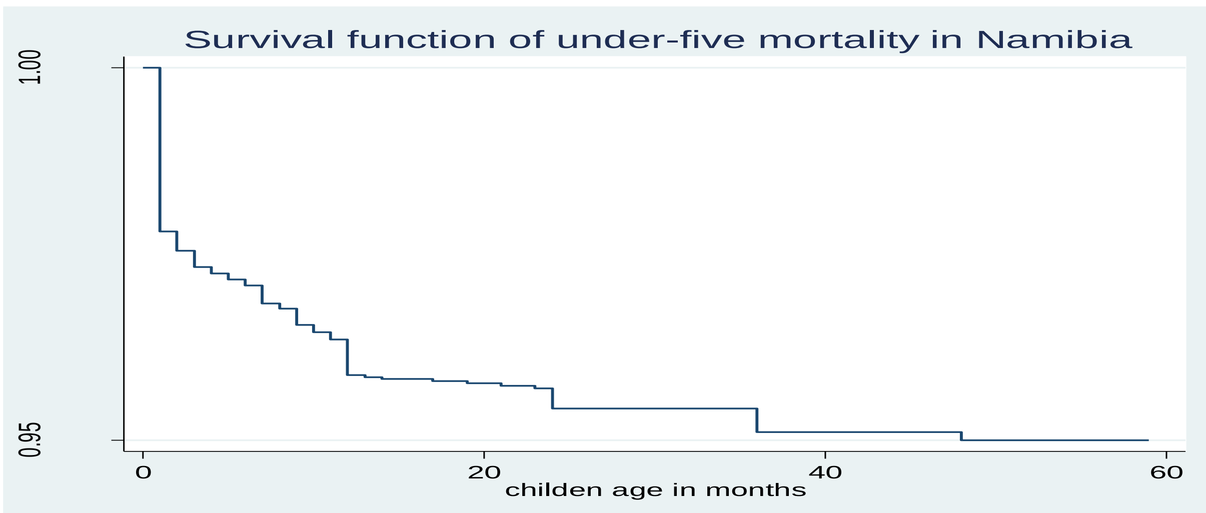



**Figure 4. 1: Survival function of under-five mortality in Namibia**

Figure 4.2 below shows survival estimates of under-five mortality in terms of type of place of residence. It shows that there was a slight difference in the probability of survival for under-five children that live in urban/rural areas. For example, the probability of survival for under-five children in urban area was slightly higher compared to those that are in rural areas. Furthermore, it was observed that the probability of survival for under-five children in urban areas remained constant at around 35 months and above compared to rural areas. About 97 percent of children in Namibia that lived in urban areas survived past five years (59 months) while only about 94 percent of children in Namibia that lived in rural areas survived past five years (59 months).

The log rank test (*Table 4.1*) shows that type of residence was not significantly associated with under-five mortality in Namibia. Thus, there were no significant disparities in the probability of survival for the under-five children's in terms of their type of place of residence.

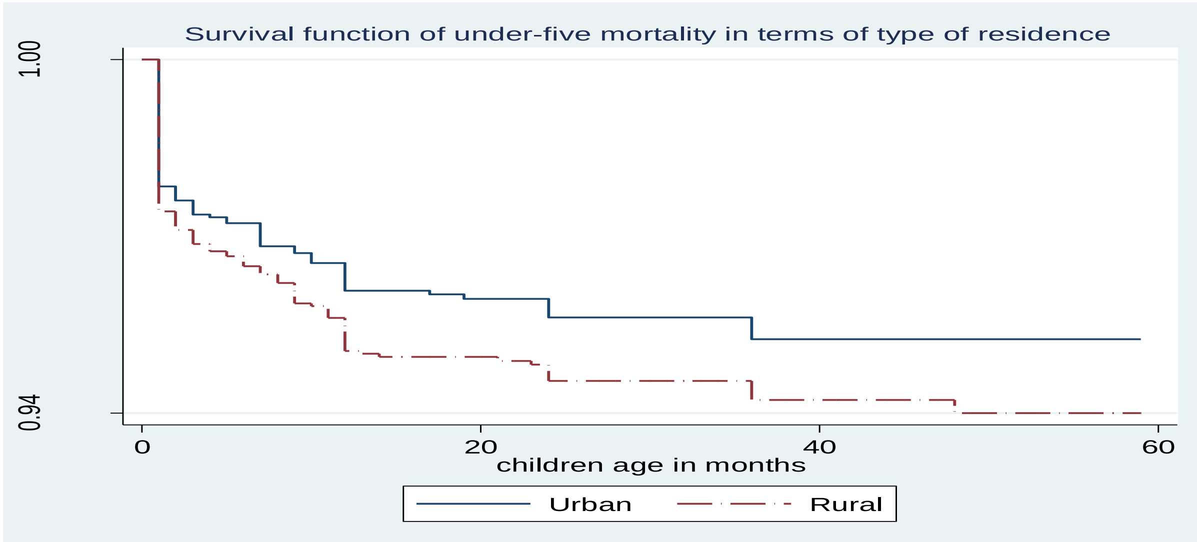



**Figure 4. 2: Survival function of under-five mortality in terms of type of place of residence**

Figure 4.3 shows that the probability of survival for under-five children born by mothers with higher educational level (those mothers that went up to tertiary level) was higher compared to those born by mothers with primary, secondary and no education.

Moreover, larger differences have been found to exist between the mortality of children of women who have attained secondary education and those that only ended up at primary education level compared to those with no level of education.

It can be observed that children born by mothers with primary as the highest education level have a lower survival probability compared to all the other three groups (higher, secondary and primary highest level of education).

The log rank test (*Table 4.2*) shows that the mother's highest education level was significantly associated with under-five mortality in Namibia.

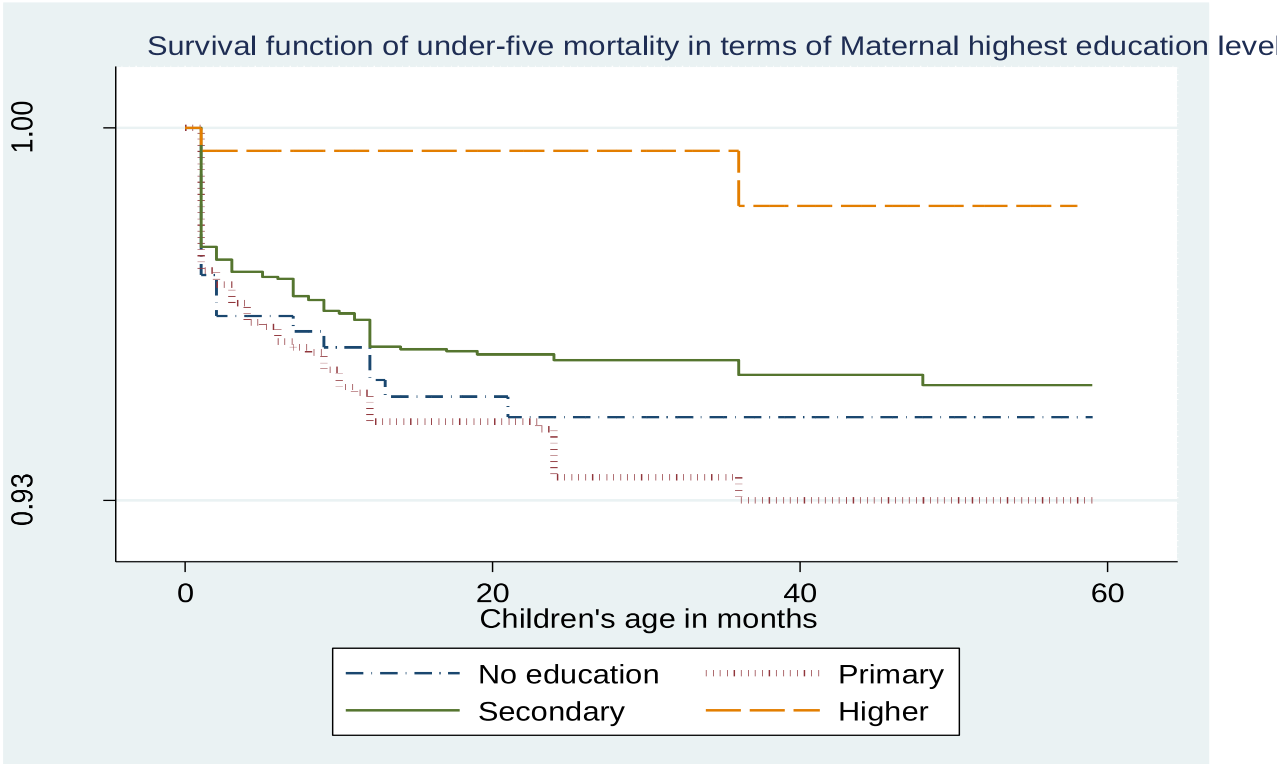



**Figure 4. 3: Survival function of under-five mortality in terms of maternal highest education level**

Figure 4.4., shows how under-five mortality varies with mother's age at first birth. It can be seen that all children born by first time mothers at the age of 35 upward, survived past 59 months. Furthermore, first time mothers' ages between 20-34 years and that the children born to such mothers were less likely to die than those whose mothers who were below 20 years of age.

The log rank test (*Table 4.2*) shows that mother's age at first birth was not significant. Thus, there were no significant disparities in the probability of survival for the under-five children's in terms of their mother's age at first birth.

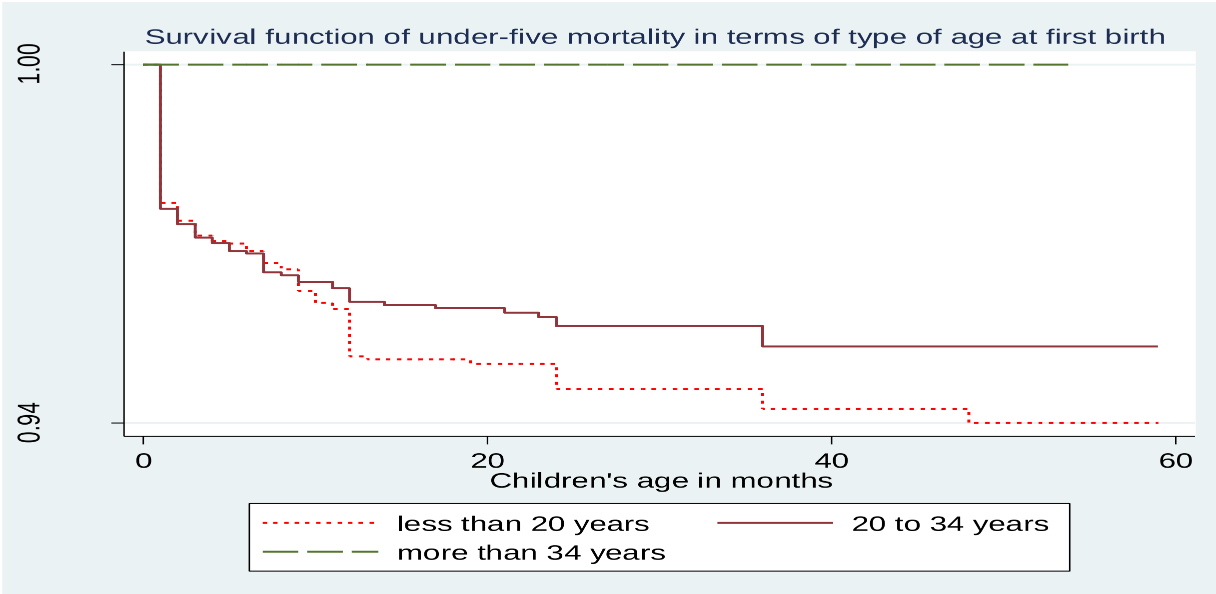



**Figure 4. 4: Survival function of under-five mortality in terms of mother's age at first birth**

Figure 4.5., shows how under-five mortality varies with mother's marital status. It was evident that children born from current married mothers have low probability of survival compared to children who are born by mothers that are not married or those that are formerly married.

The log rank test (*Table 4.2*) shows that marital status was not statistically significant. Thus, there were no significant disparities in the probability of survival for the under-five children's mothers in terms of their mothers' marital status.

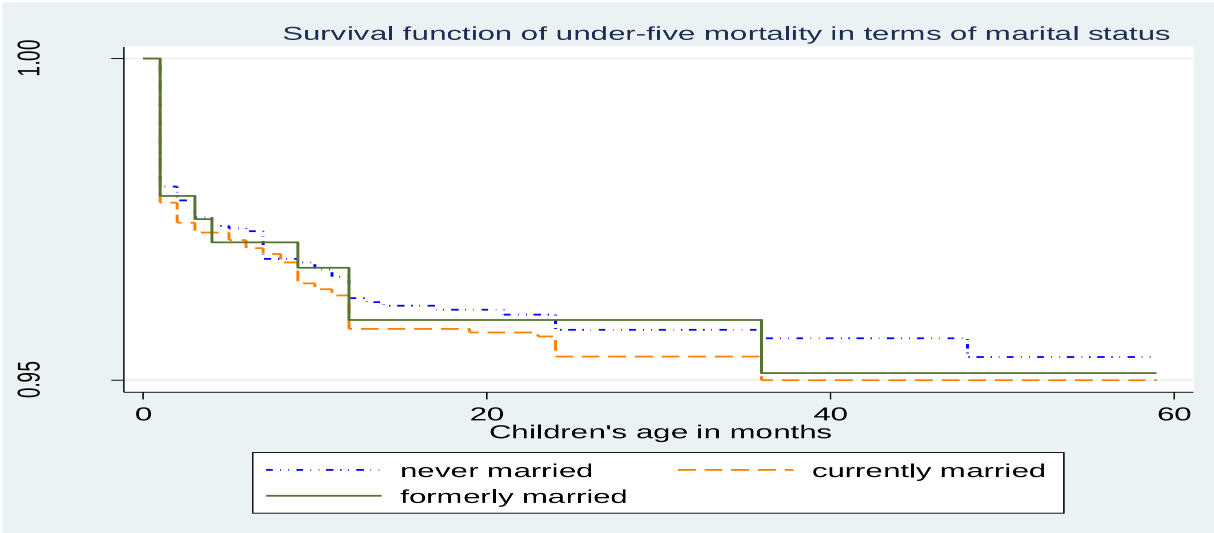



**Figure 4. 5: Survival function of under-five mortality in terms of current marital status**

Figure 4.6., shows how under-five mortality varies with type of birth. It was evident that single births have low mortality compared to multiple births (twins, quadrants, etc). More than 90 percent of single birth children survives past 59 months compared to multiple birth children, whose survival rate is around 78 percent.

The log rank test (*Table 4.2*) shows that the type of birth was statistically significant. Thus, there were significant disparities in the probability of survival for the under-five children's type of birth. The type of birth is a determinant of under-five mortality.

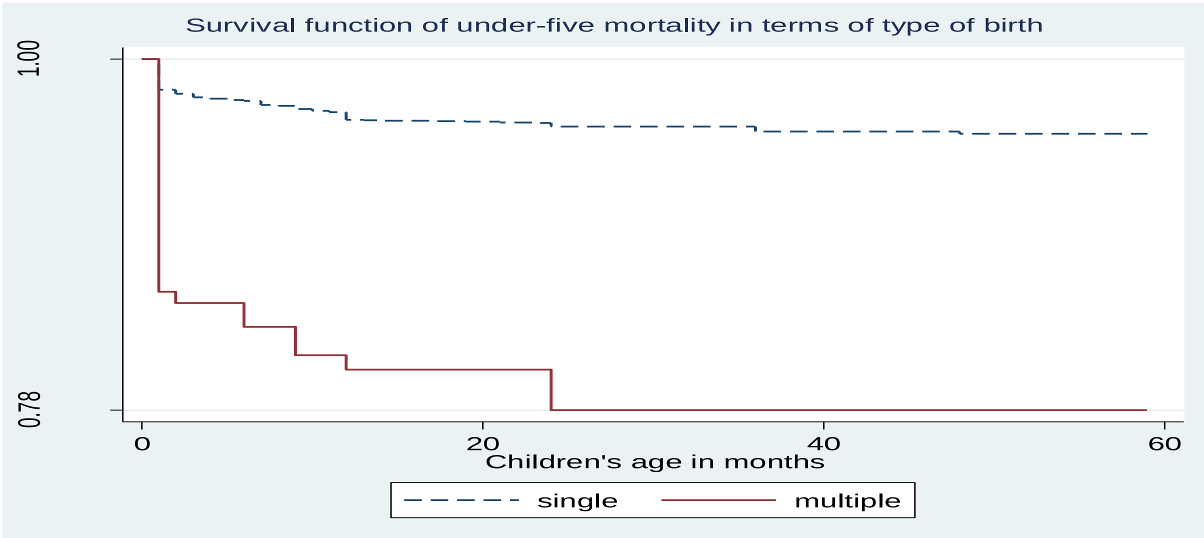



**Figure 4. 6: Survival function of under-five mortality in terms of type of birth**

Figure 4.7., shows how under-five mortality varies with preceding birth interval. It can be seen that preceding long interval (more than 24 months) have higher probability of survival compared to children born within a short interval periods (less than 24 months).

The log rank test (*Table 4.2*) shows that the preceding birth interval was not statistically significant. Thus, there were no significant disparities in the probability of survival for the under-five children's in term of their preceding birth interval.

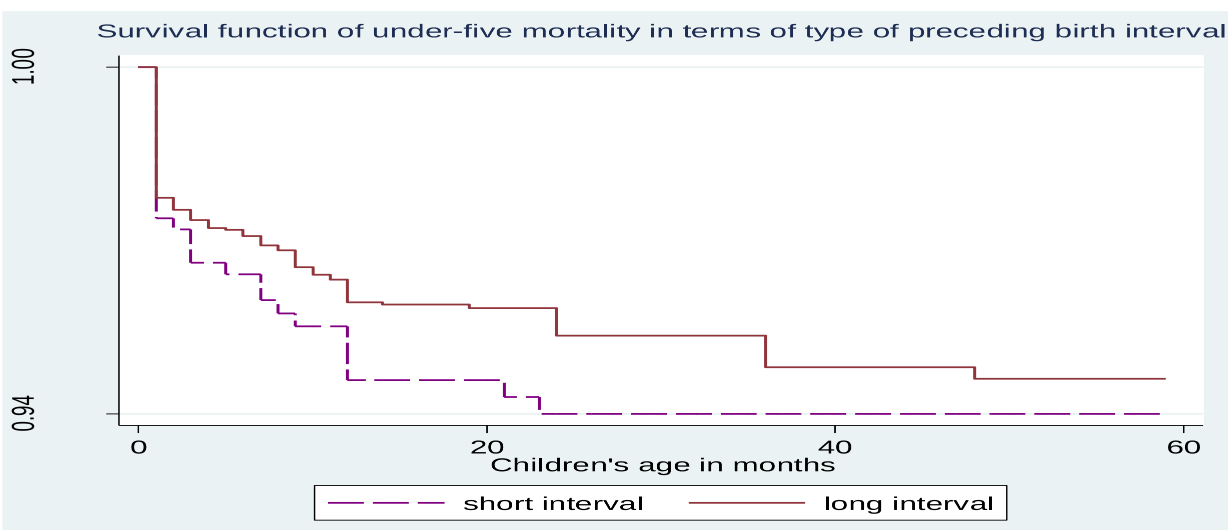



**Figure 4. 7: Survival function of under-five mortality in terms of preceding birth interval**

Figure 4.8 shows how under-five mortality varies with the wealth status for the household. It was evident that the probability of survival for under-five children increases as the wealth status of a household improves. Result shows that probability of survival was lowest among children from poor household while for richest households the probability of survival was very high.

The log rank test (*Table 4.2*) shows that the wealth status for the household was not statistically significant. Thus, there were no significant disparities in the probability of survival for the under-five children's in term of their household's wealth status.

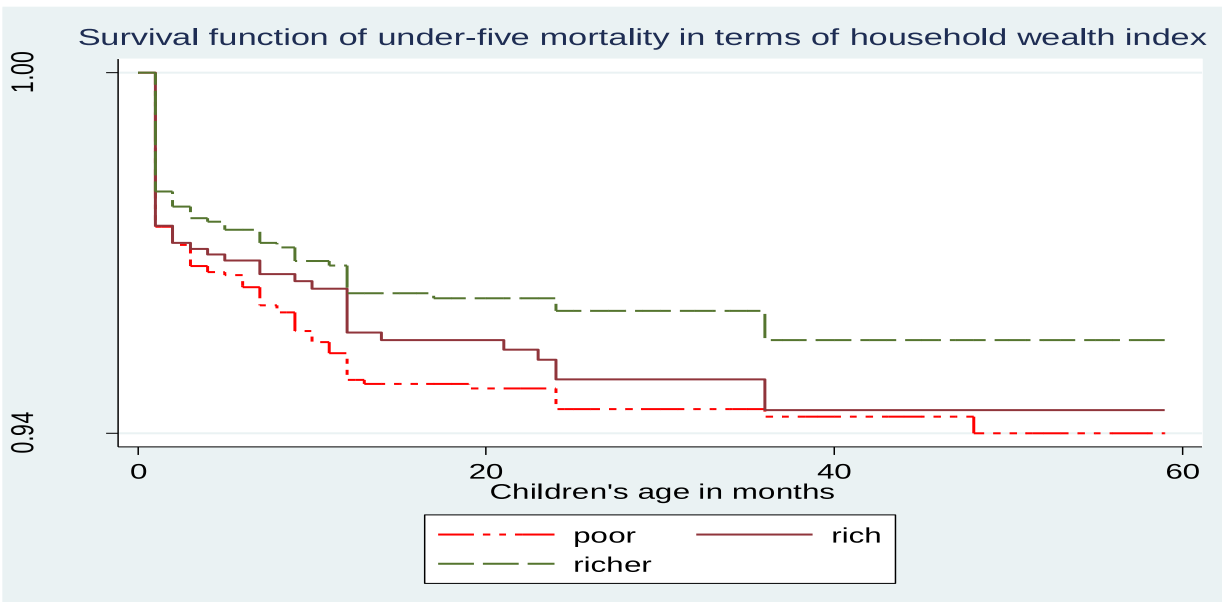



**Figure 4. 8: Survival function of under-five mortality in terms of household wealth index**

It can be seen from Figure 4.9 that children who were born in public facilities were likely to die before attaining the age of five than those who were born at home or private medical facility. Alternatively, those children who were born in private medical facilities showed a small risk of dying before age five (5) than those born at home. The probability of children born at private medical facility becomes constant at around 99 percent at about 2 months compared to those born in public facilities that keeps reducing until 95 percent at nearly 50 months.

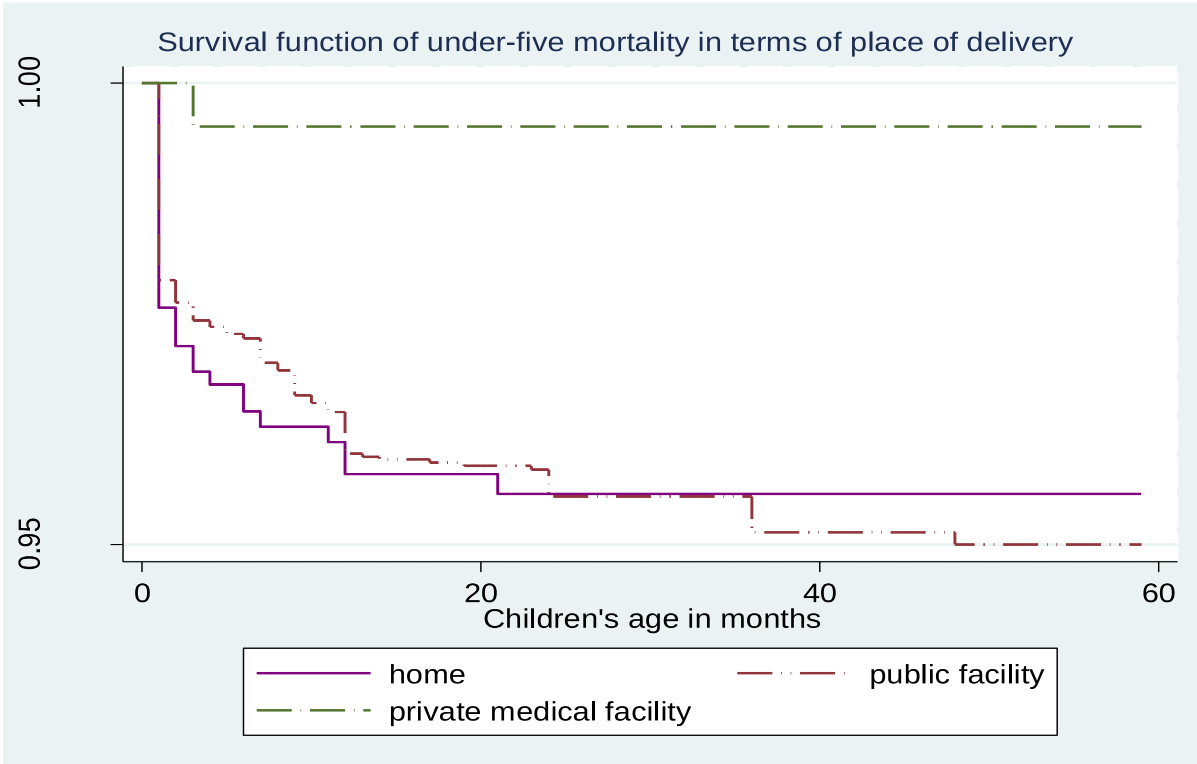



**Figure 4. 9: Survival function of under-five mortality in terms of place of delivery**

Figure 4.10 shows how under-five mortality varies with the children status of breastfed. It was evident that the probability of survival for under-five children that have been breastfed was higher compared to those children that were not breastfed.

The log rank test (*Table 4.2*) shows that the children status of breastfed was statistically significant. Thus, there were significant differences in the probability of survival for the under-five children's in terms of their status of breastfed.

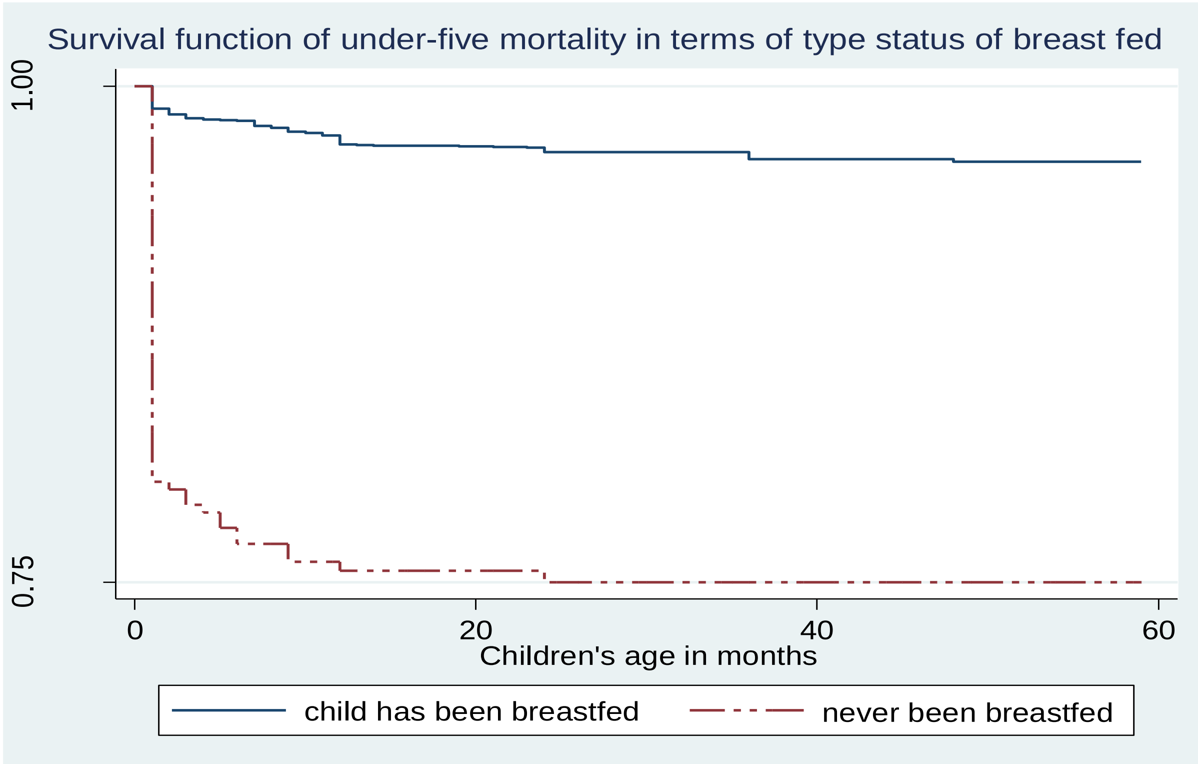



**Figure 4. 10: Survival function of under-five mortality in status of breastfed**

**Log-rank test for the independent variables**

In terms of the socio-economic factors, the Log-rank test (table 4.2) shows a significant difference in the probability of survival for under-five children with respect to maternal highest educational level, type of birth, place of delivery and the status of the child's breastfed.

**Table 4. 3: Log-rank test for the independent variables**

| Variable | Chi-square test | Log-rank test |
|---|---|---|
| | | |
| Child is alive | - | - |
| Region | 17.81 | 0.1217 |
| Type of place of residence | 2.69 | 0.1013 |
| Maternal Highest educational level | 13.84 | 0.0031 |
| Age of respondent at 1st birth | 3.04 | 0.2190 |
| Current marital status | 0.48 | 0.7856 |
| Type of birth | 95.36 | 0.0000 |
| Preceding birth interval | 0.95 | 0.3298 |
| household  wealth index | 3.88 | 0.1434 |
| Place of delivery | 7.76 | 0.0207 |
| Status of breastfeed | 298.50 | 0.0000 |

*Test carried out at $p<0.05$*

### 4.3. Testing for the assumption of the Proportional hazard models being developed

From the fitted/graphed Kaplan Meier curves below in section 4.2, the assumption of the proportionality in the groups was violated as it can be seen from the graphs such as the Kaplan Meier graphs of the categorical groups such as that for maternal highest education level, age of respondent at first birth, marital status and place of delivery. The categorical group's curves crossed each other.

This assumption can also be tested using the $-\ln(-\ln(S(t)) \, vs \ln(t)$ plot for the categorical variables we are interested in, for a better graphical illustration.

The following are the $-\ln(-\ln(S(t)) \, vs \ln(t)$ plots of all the variables used in the study.

From the Figure below, Figure 4.11, there is quite enough proof to show that the PH assumption (of parallel hazard functions) or proportionality has not been violated, since the curves (urban and rural) did not cross each other.

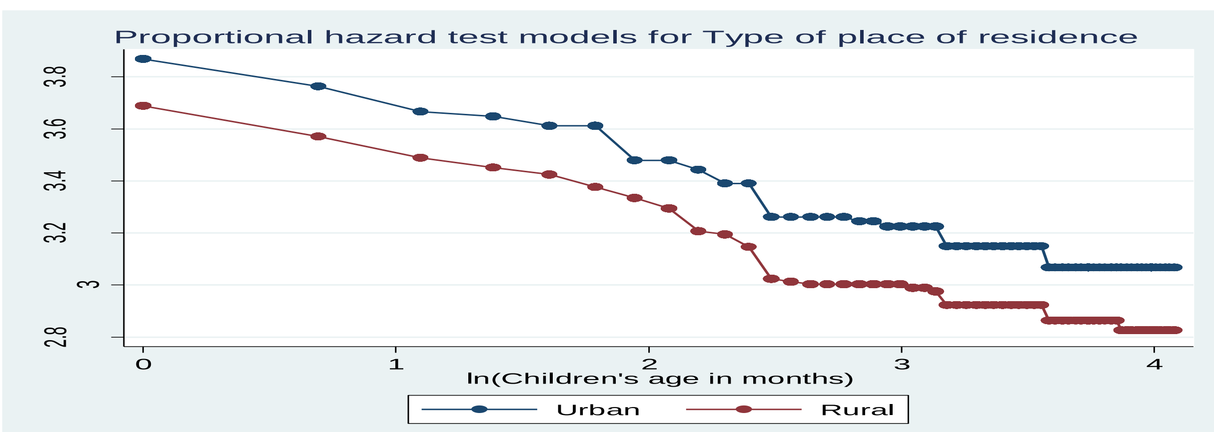



**Figure 4. 11: PH model test for the survival probability of under-five children in terms of type of place of residence**

From Figure 4.12, there is quite enough evidence to show that the PH assumption (of parallel hazard functions) or proportionality has been violated, since the curve crossed each other.

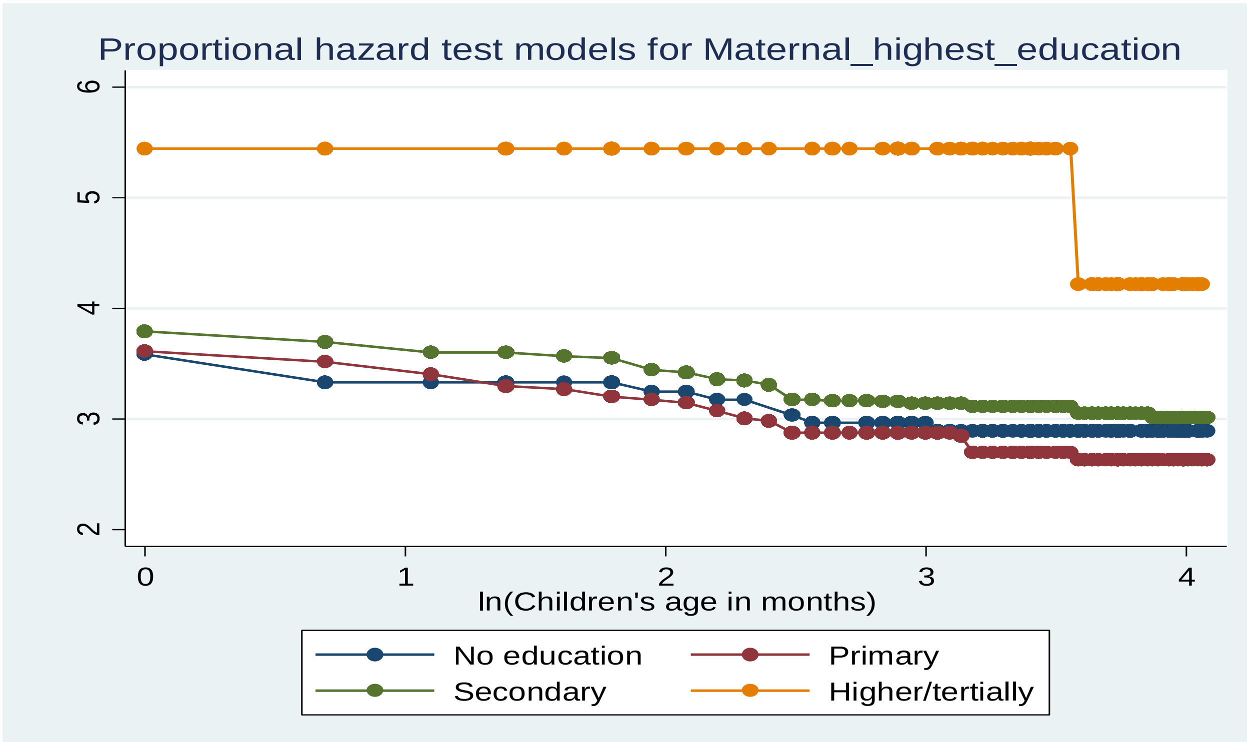



**Figure 4. 12: PH model test for the survival probability of under-five children in terms of maternal highest education level**

Figure 4.13, shows that, there is enough evidence to show that the PH assumption (of parallel hazard functions) or proportionality has been violated, since the curves for public facility and home crossed each other.

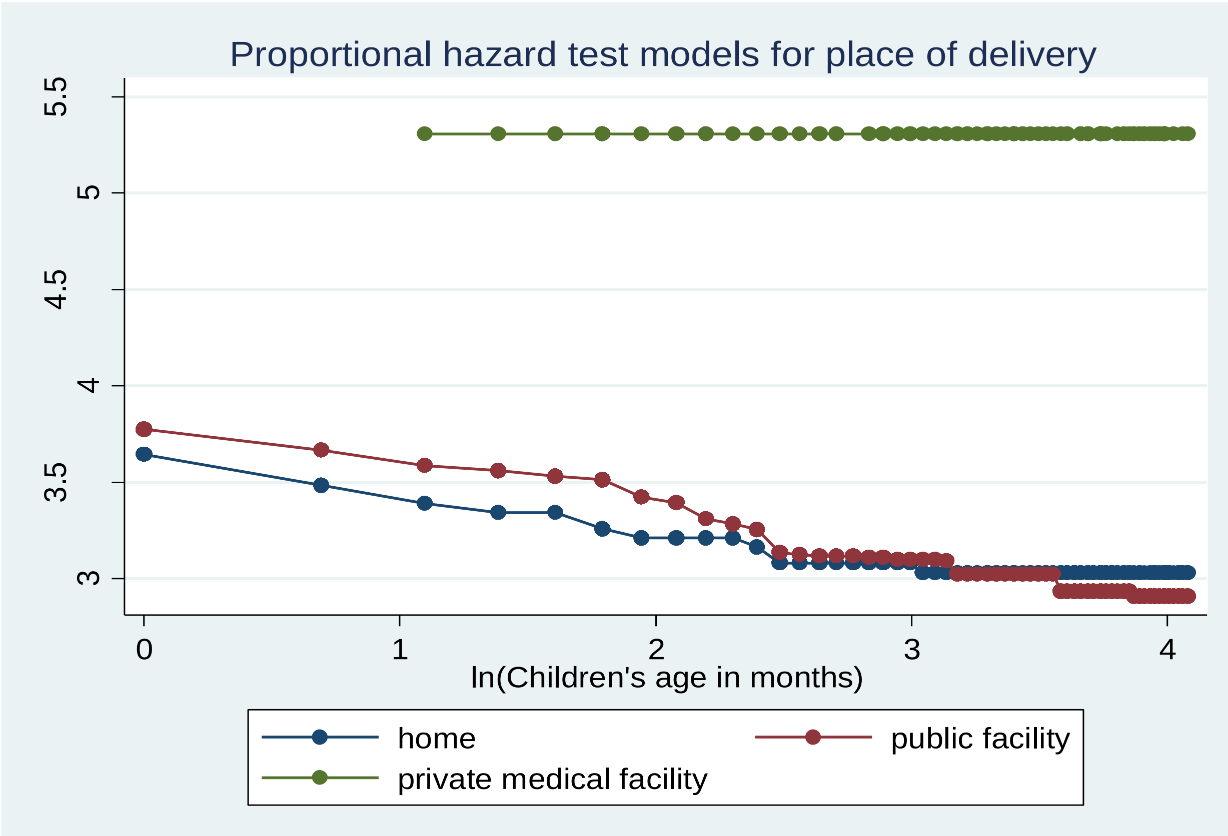



**Figure 4. 13: PH model test for the survival probability of under-five children in terms of place of delivery**

From Figure 4.14, similarly, there is enough evidence to show that the PH assumption (of parallel hazard functions) or proportionality has been violated, since all the curves crossed each other.

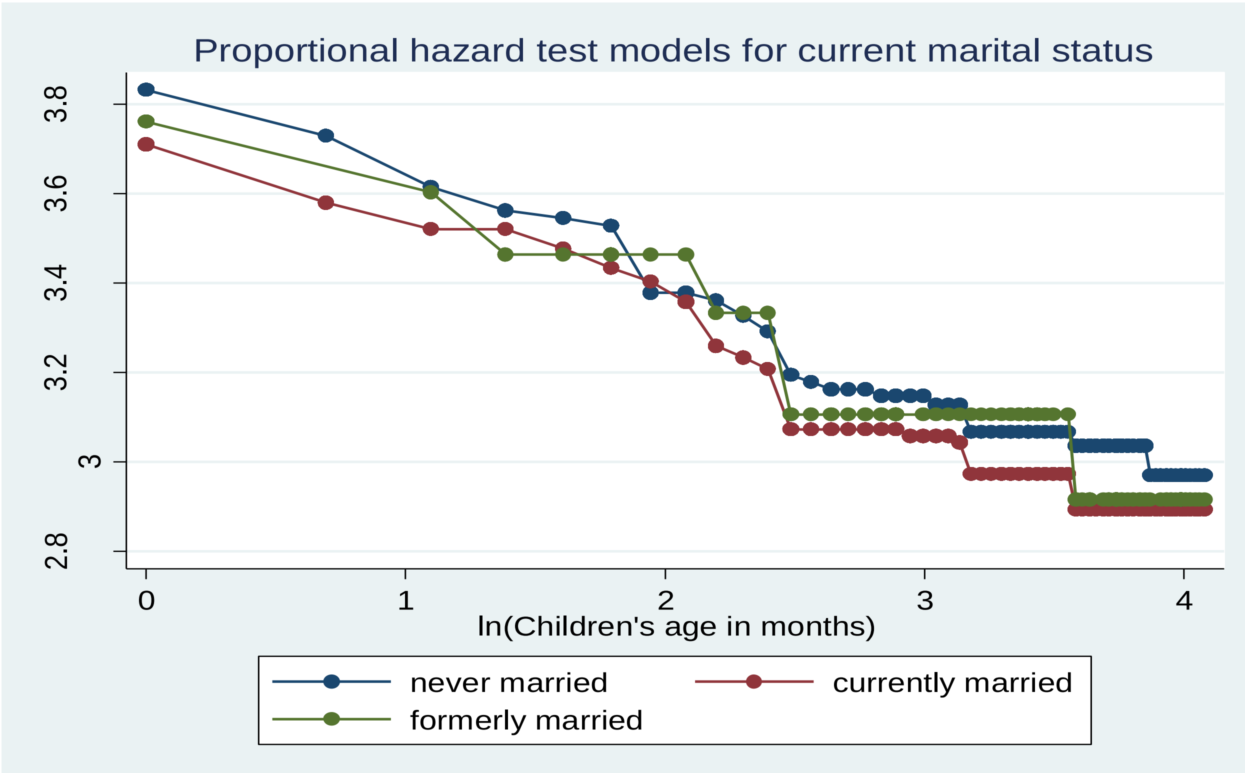



**Figure 4. 14: PH model test for the survival probability of under-five children in terms of marital status**

From Figure 4.15, there is enough evidence to show that the PH assumption (of parallel hazard functions) or proportionality has been violated, since the both the curves cross each other.

No death was recorded in the children born by mothers who were 34 years and above at the time of first birth (as it can be seen in table 4.1). The survival probability for this group was 1, the y-axis of Figure 4.15 is (–ln(-ln(survival probability))), (-ln(-ln(1))) is undefined, hence the curve for this age at first birth group was not plotted on the graph.

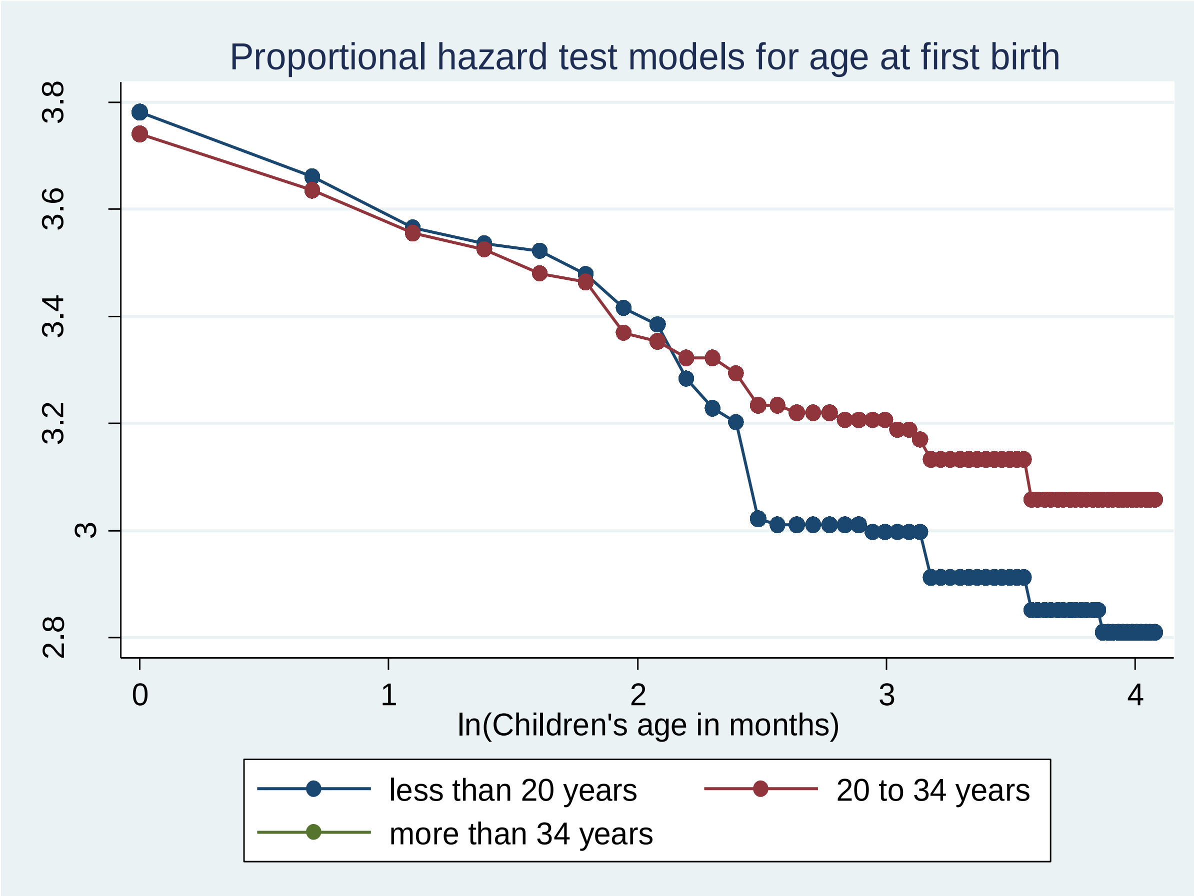



**Figure 4. 15: PH model test for the survival probability of under-five children in terms of age of respondent at first birth**

From Figure 4.16, it can be seen that the PH assumption (of parallel hazard functions) or proportionality has not been violated, since the both the curves (short birth and long birth interval) did not cross each other and are far apart from each other.

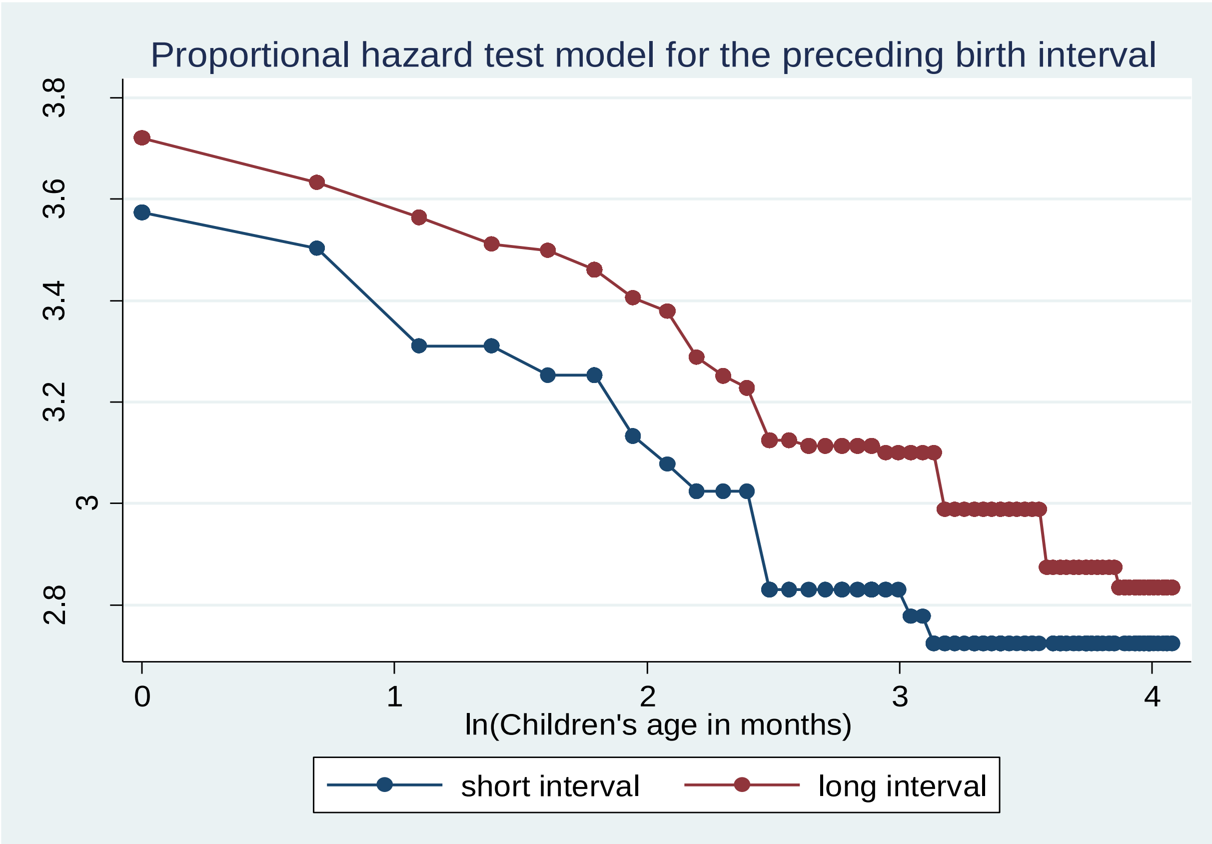



**Figure 4. 16: PH model test for the survival probability of under-five children in terms of the preceding birth interval**

From Figure 4.17, it can be seen that the PH assumption (of parallel hazard functions) or proportionality has not been violated, although the curves for poor and rich touched each other at a point or more points, the curves did not cross each other.

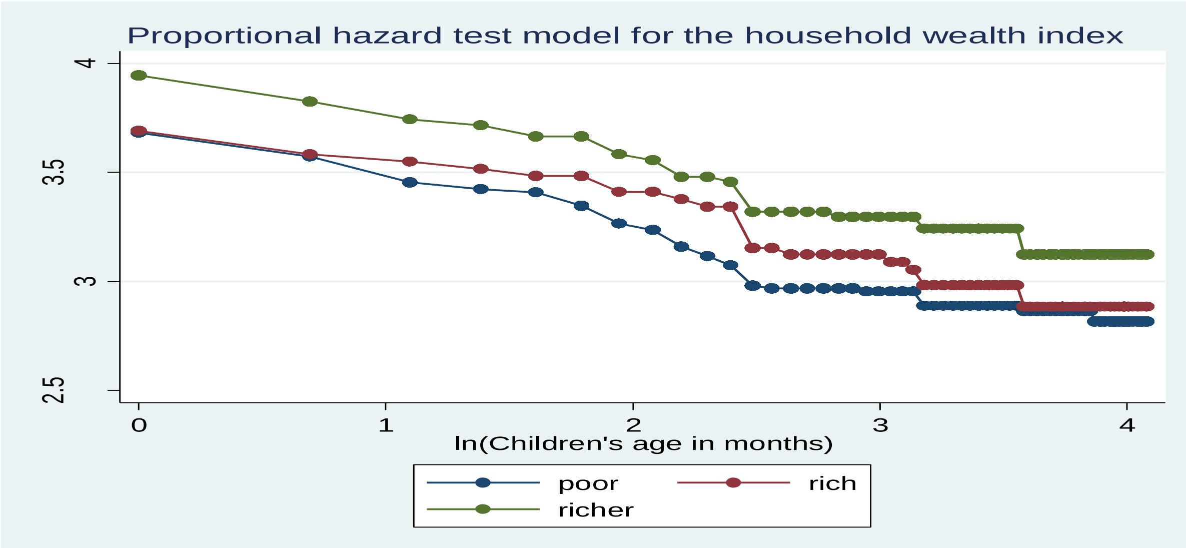



**Figure 4. 17: PH model test for the survival probability of under-five children in terms of household wealth index**

Likewise, Figure 4.18, it can be seen that the PH assumption (of parallel hazard functions) or proportionality has not been violated, since both the curves (single and multiple birth) did not cross each other and run far apart from each other.

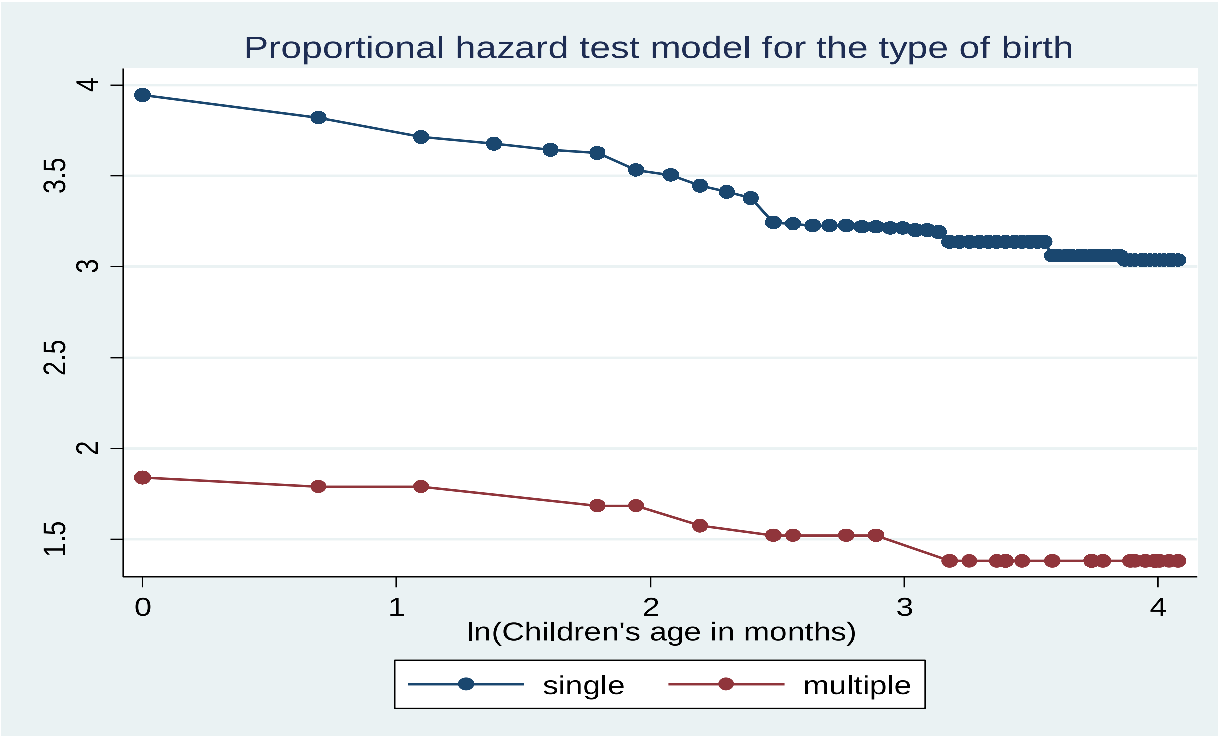



**Figure 4. 18: PH model test for the survival probability of under-five children in terms of type of birth**

For Figure 4.19, it can be seen that the PH assumption (of parallel hazard functions) or proportionality has not been violated, since both the curves did not cross each other and run far apart from each other.

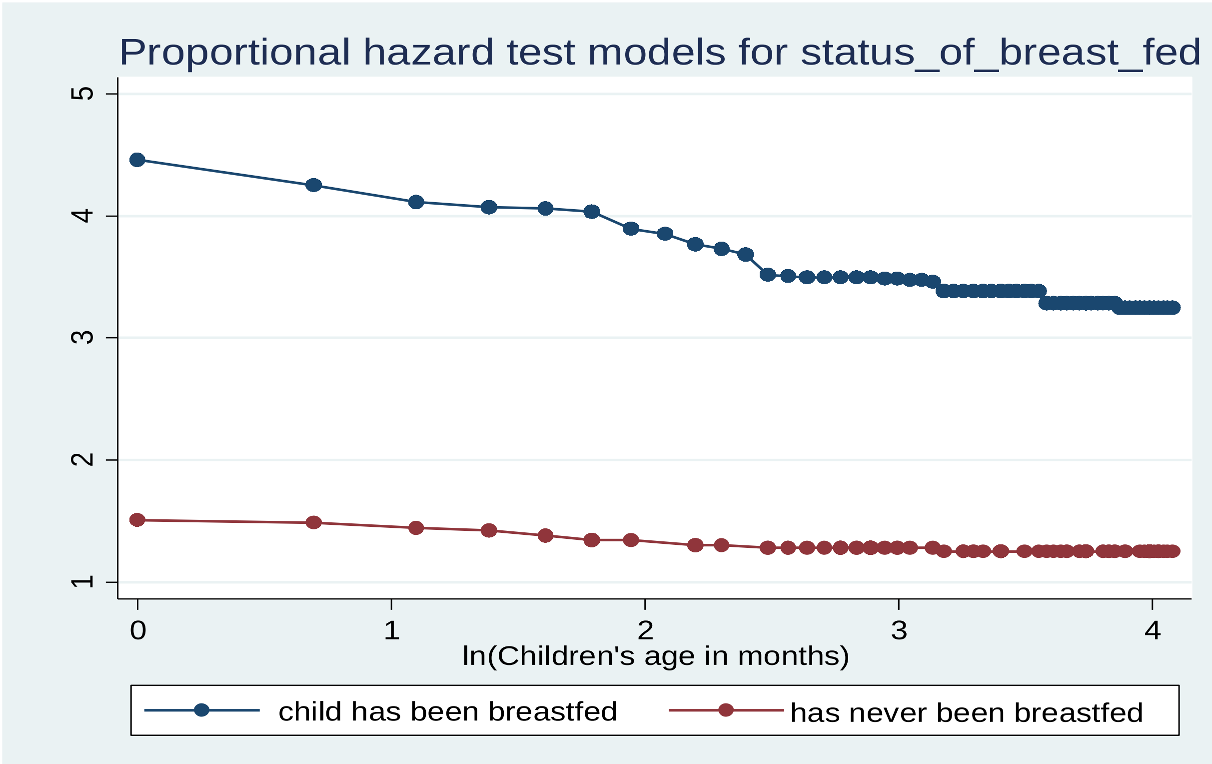



**Figure 4. 19: PH model test for the survival probability of under-five children in terms status of breastfeed**

**4.4. Kaplan Meier graphs showing the survival pattern per region by type of place of residence**

Figure 4.20 shows survival estimates of under-five mortality in Caprivi region by the type of place of residence. It shows that there was a slight difference in the probability of survival for under-five children that live in urban/rural areas. For example, the probability of survival for under-five children in urban area was slightly higher compared to those that are in rural areas. Only 94 percent of children in Caprivi that lived in rural areas survived past five years (59 months) in comparison with more than 94 percent of children that lived in urban areas survived past five years (59 months).

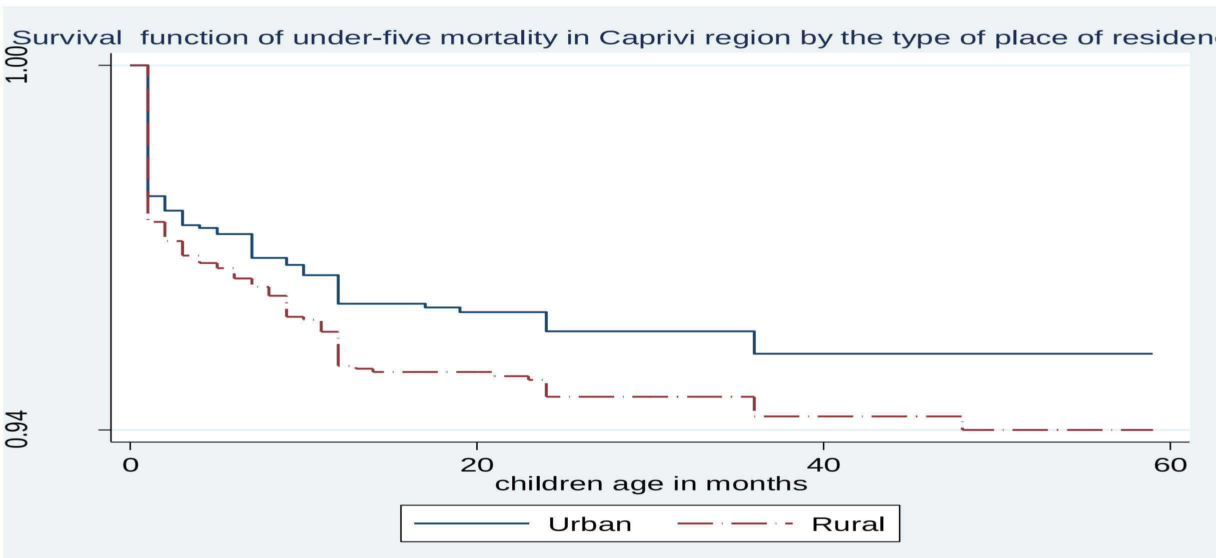



**Figure 4. 20: Kaplan Meier graphs showing the survival pattern in Caprivi region by type of place of residence**

Figure 4.21 shows survival estimates of under-five mortality in Erongo region by the type of place of residence. It shows that there was a great difference in the probability of survival for under-five children that live in urban/rural areas. For instance, all children than lived in rural areas survived past five (5) years of age while only 5 percent of children that lived in urban areas did not survive beyond five years (59 months) of age.

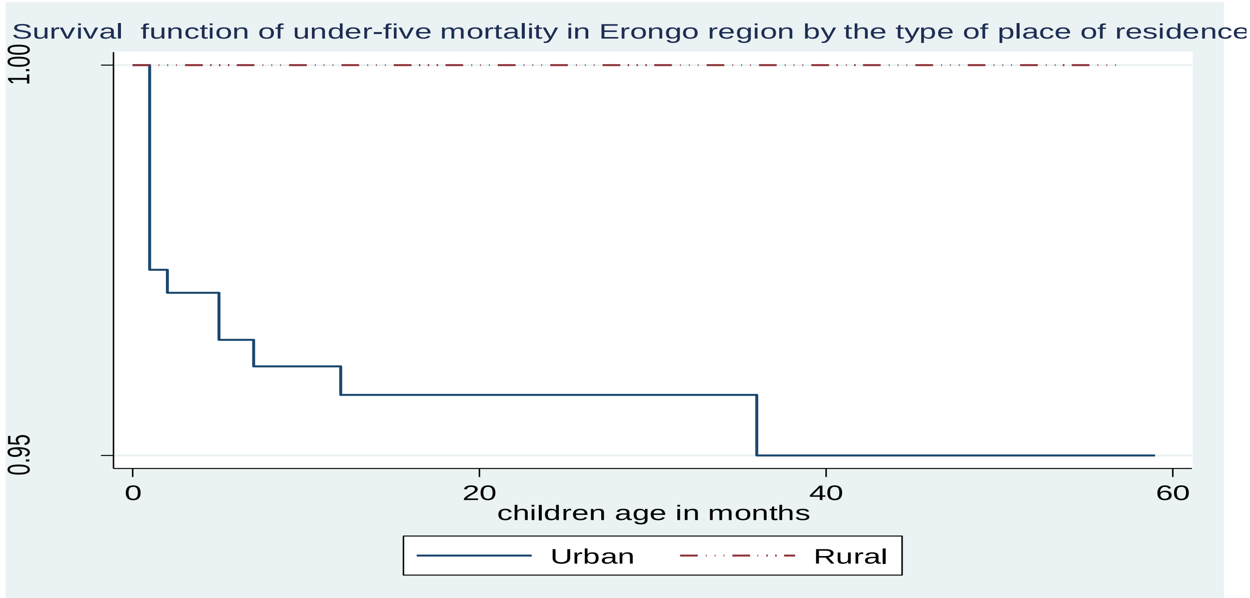



**Figure 4. 21: Kaplan Meier graphs showing the survival pattern in Erongo region by type of place of residence**

Figure 4.22 shows survival estimates of under-five mortality in Hardap region by the type of place of residence. It can be seen that the survival pattern of under-five children in Hardap between rural and urban follows a similar pattern. The survival pattern of children in Hardap region, so as Erongo region, in terms of the type of place of residence behaves differently from most of the regions under study, here children who live in rural areas are the ones with higher probability of survival compared to those in urban areas.

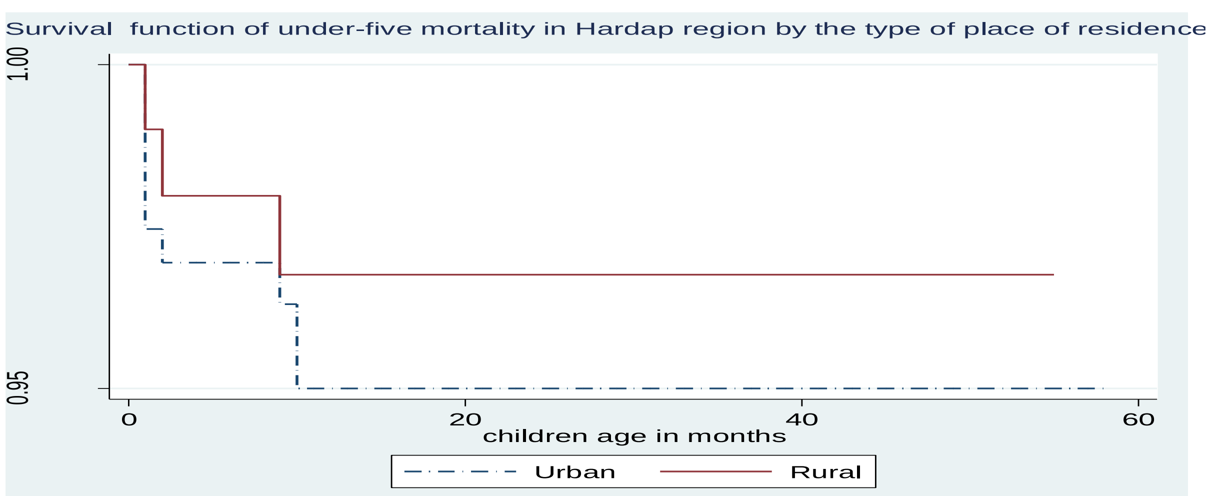



**Figure 4. 22: Kaplan Meier graphs showing the survival pattern in Hardap region by type of place of residence**

Figure 4.23 shows survival estimates of under-five mortality in Karas region by the type of place of residence. It shows that there was a great difference in the probability of survival for under-five children that live in urban/rural areas. Like most of the regions under study, children than lived in urban areas has got a higher probability of survival past 5 years of age compared to those that live in rural areas. Seven (7) percent of children in rural areas of Karas did not live to see their fifth (5) birthday.

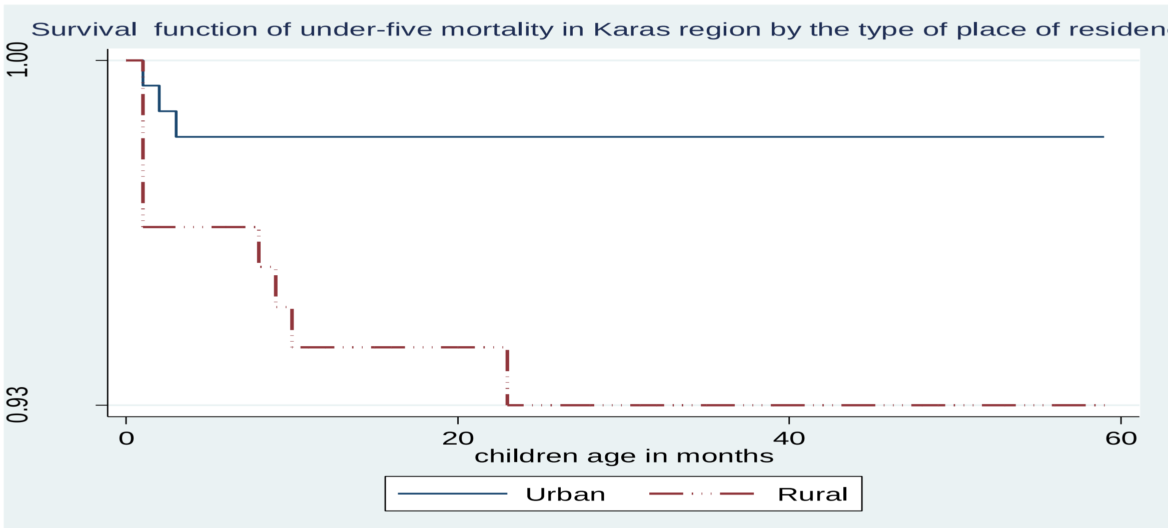



**Figure 4. 23: Kaplan Meier graphs showing the survival pattern in Karas region by type of place of residence**

Figure 4.24 shows survival estimates of under-five mortality in Kavango region by the type of place of residence. It shows that there was a great difference in the probability of survival for under-five children that live in urban/rural areas. Like in Erongo, Hardap and Kavango region, children who live in rural areas have a higher probability of survival compared to those that resides on urban areas.

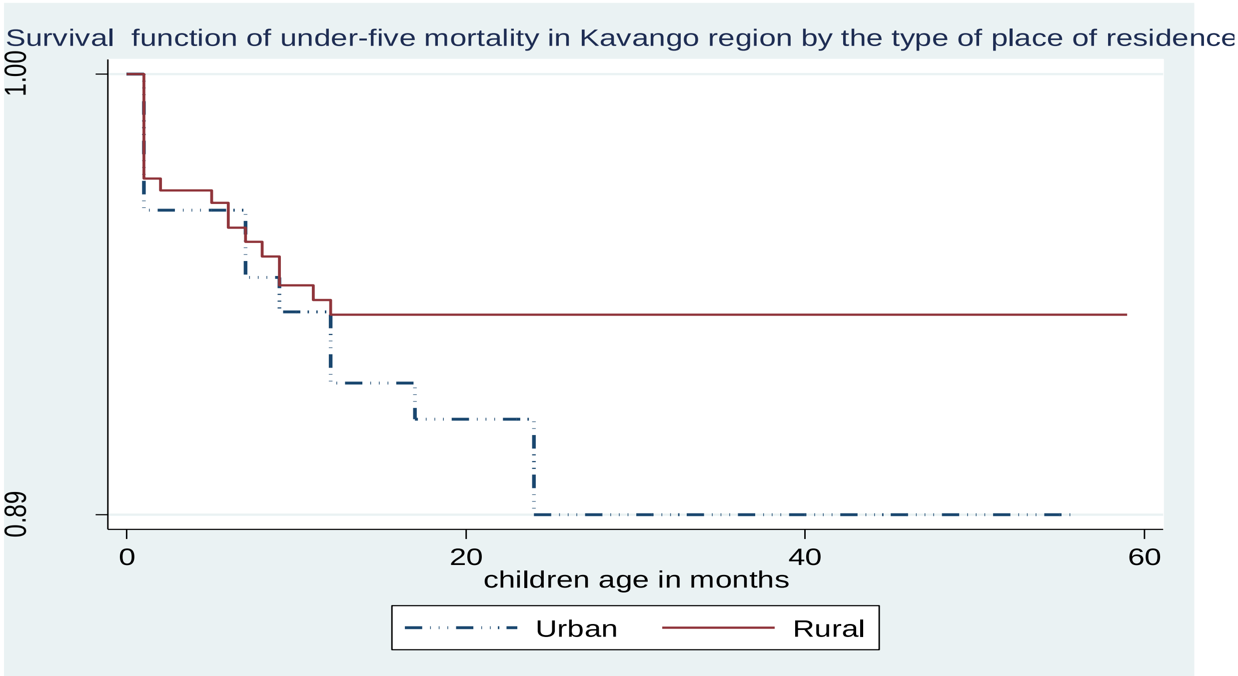



**Figure 4. 24: Kaplan Meier graphs showing the survival pattern in Kavango region by type of place of residence**

Figure 4.25 shows survival estimates of under-five mortality in Khomas region by the type of place of residence. It shows that there was a slight difference in the probability of survival for under-five children that live in urban/rural areas. All children that resides in rural areas during the period under study survived to see their fifth (5) birthday, whereas only 96 percent of those that resides in urban areas survived until five years.

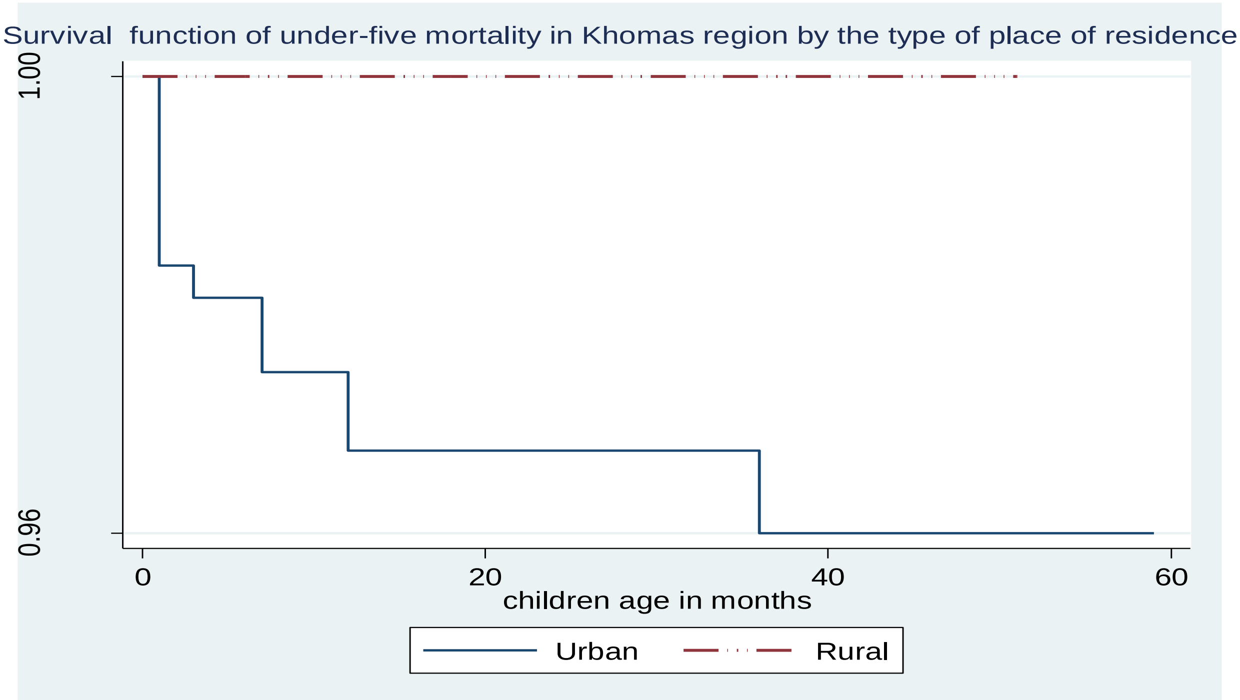



**Figure 4. 25: Kaplan Meier graphs showing the survival pattern in Khomas region by type of place of residence**

Figure 4.26 shows survival estimates of under-five mortality in Kunene region by the type of place of residence. It shows that there was a slight difference in the probability of survival for under-five children that live in urban/rural areas. The probability of survival for under-five children in urban area was slightly higher compared to those that are in rural areas. Only 94 percent of children in Kunene who lived in rural areas survived past five years (59 months) in comparison with more than 94 percent of children that lived in urban areas survived past five years (59 months).

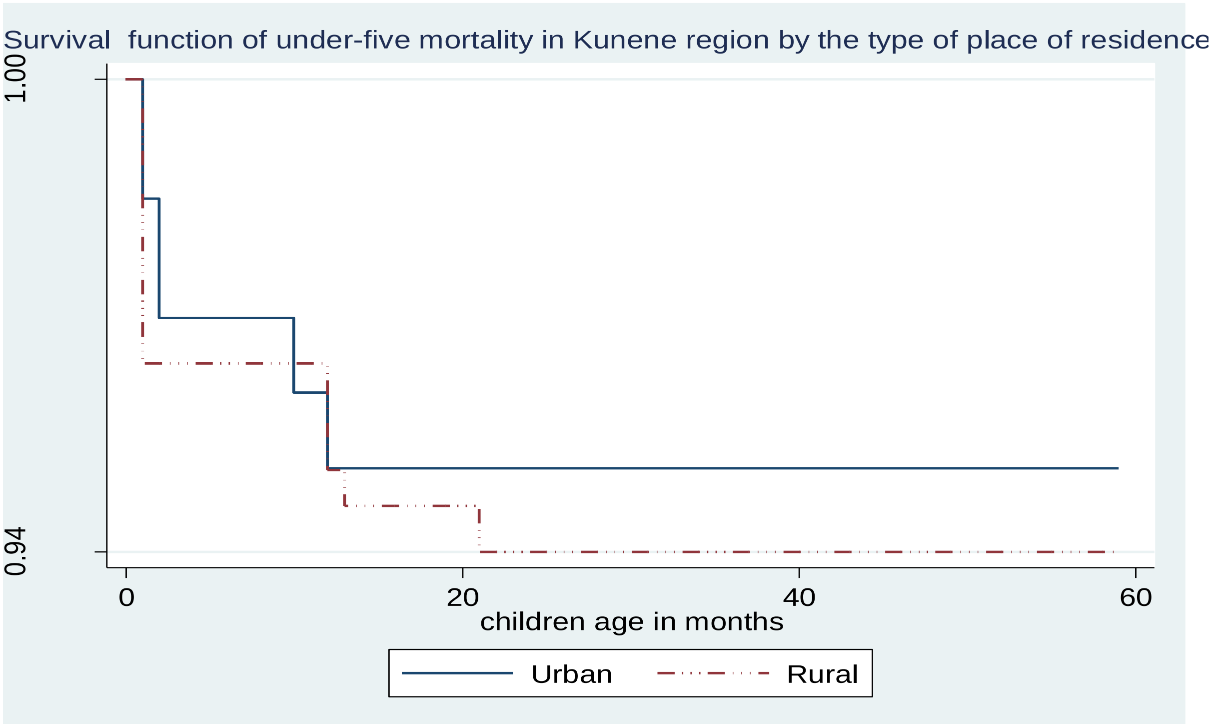



**Figure 4. 26: Kaplan Meier graphs showing the survival pattern in Kunene region by type of place of residence**

Figure 4.27 shows survival estimates of under-five mortality in Ohangwena region by the type of place of residence. It shows that there was a slight difference in the probability of survival for under-five children that live in urban/rural areas. It can be seen that from the first 30 months, children in urban areas have a higher probability of survival compared to those in rural areas, while from 30 months and above, children in rural areas are well off compared to those in urban areas.

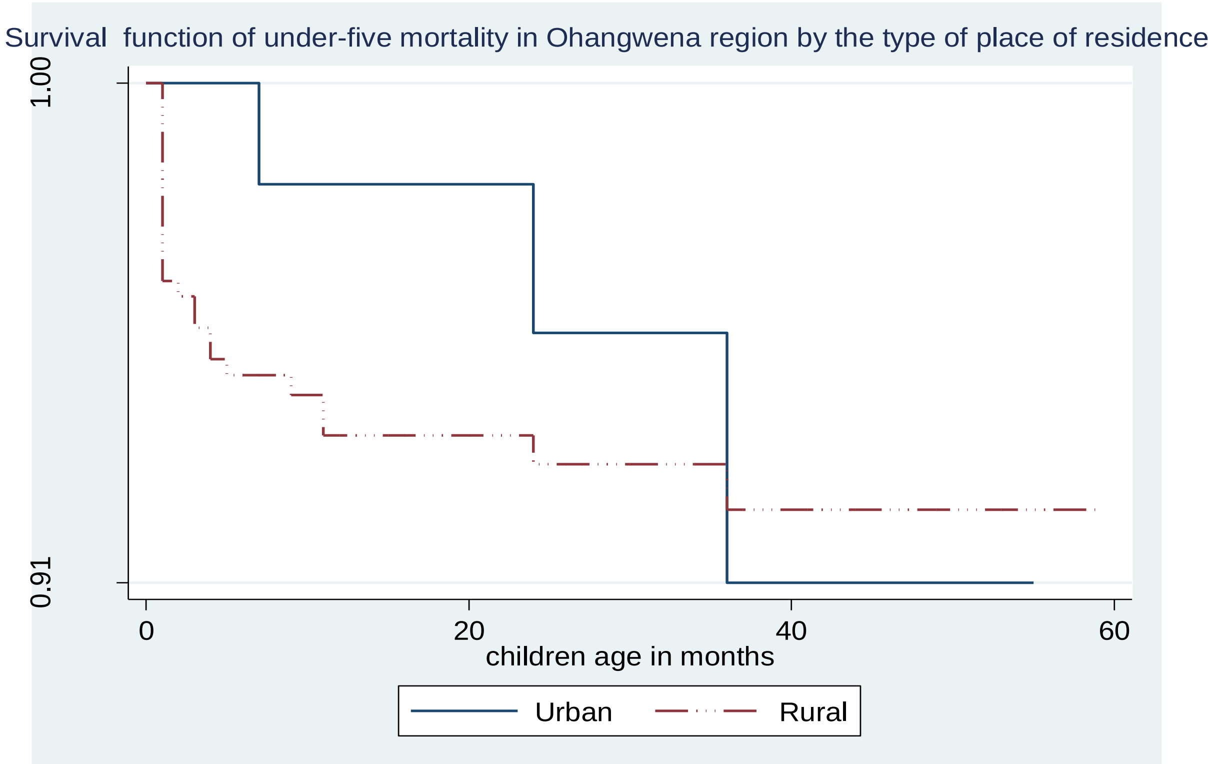



**Figure 4. 27: Kaplan Meier graphs showing the survival pattern in Ohangwena region by type of place of residence**

Figure 4.28 shows survival estimates of under-five mortality in Omaheke region by the type of place of residence. It shows that there was a slight difference in the probability of survival for under-five children that live in urban/rural areas. For example, the probability of survival for under-five children in urban area was high compared to those that resides in rural areas. Only 94 percent of children in Omaheke region that lived in rural areas survived past five years (59 months) in comparison with more than 94 percent of children that lived in urban areas survived past five years (59 months).

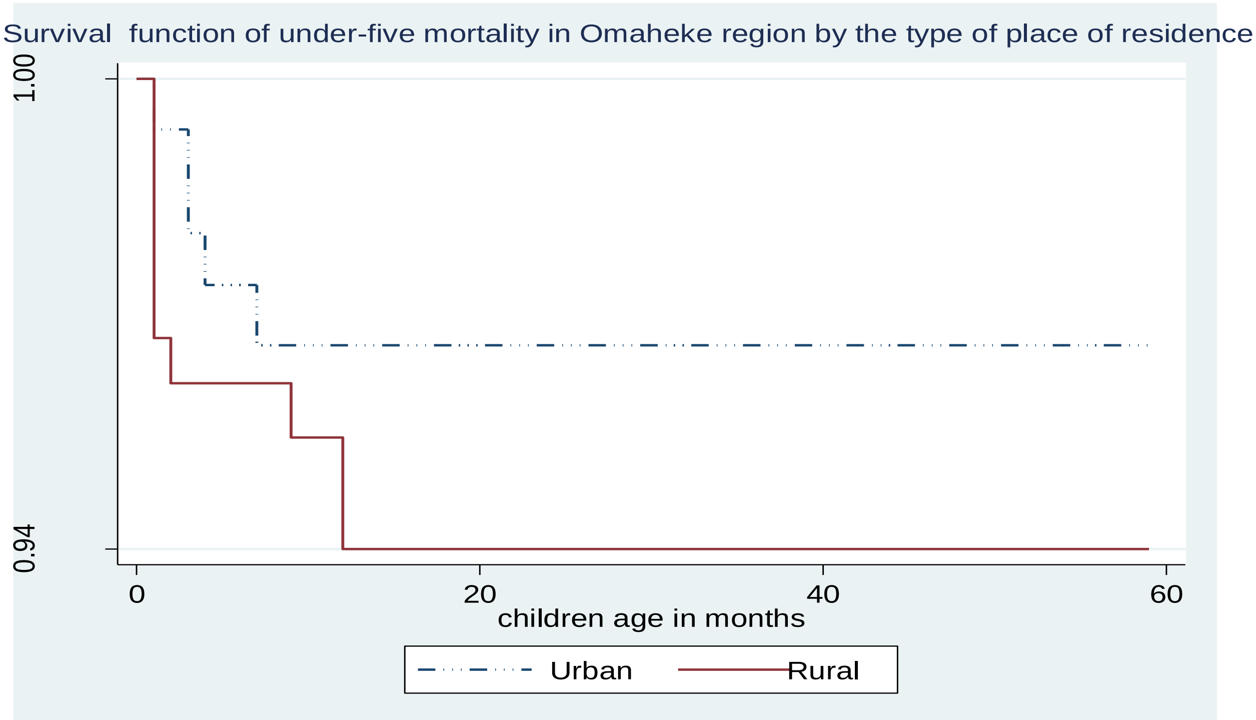



**Figure 4. 28: Kaplan Meier graphs showing the survival pattern in Omaheke region by type of place of residence**

Figure 4.29 shows survival estimates of under-five mortality in Omusati region by the type of place of residence. It shows that there was a slight difference in the probability of survival for under-five children that live in urban/rural areas. The probability of survival in urban areas becomes constant at about 95 percent at 1 month while for rural area keeps falling until at about 50 months of age. The probability of survival for the under-five children in urban areas is higher compared to those that are in rural areas.

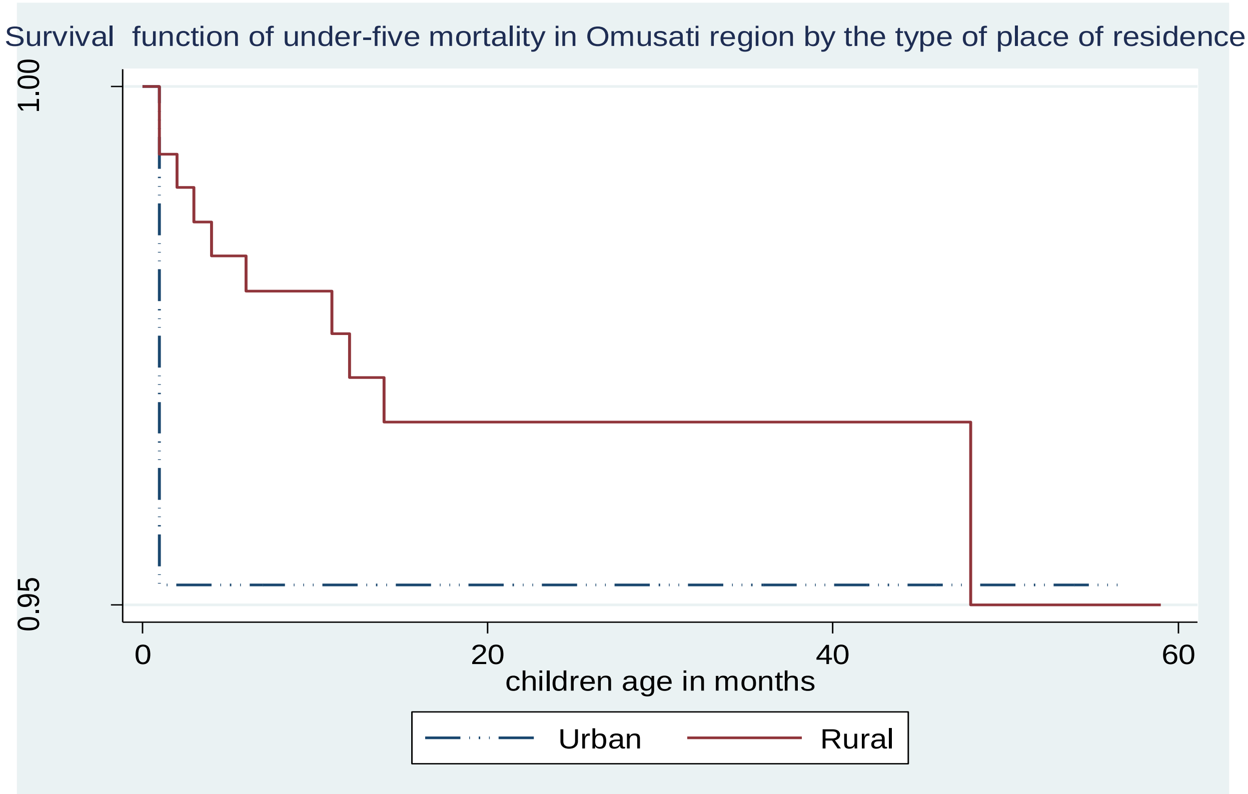



**Figure 4. 29: Kaplan Meier graphs showing the survival pattern in Omusati region by type of place of residence**

Figure 4.30 shows survival estimates of under-five mortality in Oshana region by the type of place of residence. It shows that there was a slight difference in the probability of survival for under-five children that live in urban/rural areas. For example, the probability of survival for under-five children in urban area was slightly higher compared to those that are in rural areas. Only 96 percent of children in Oshana region that lived in rural areas survived past five years (59 months) in comparison with more than 96 percent of children that lived in urban areas survived past five years (59 months).

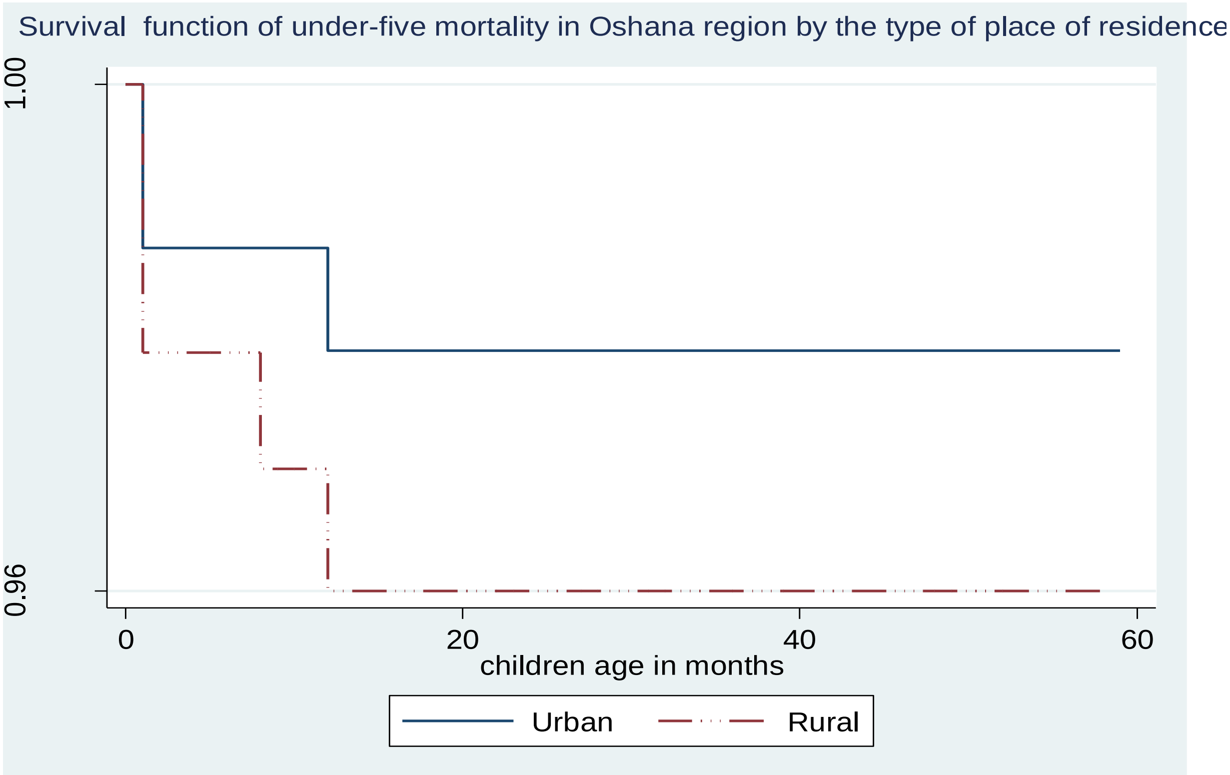



**Figure 4. 30: Kaplan Meier graphs showing the survival pattern in Oshana region by type of place of residence**

Figure 4.31 shows survival estimates of under-five mortality in Oshikoto region by the type of place of residence. It shows that there was a slight difference in the probability of survival for under-five children that live in urban/rural areas. It can be seen that, probability of survival for under-five children in rural area was higher compared to those that are in rural areas. Only 94 percent of children in Oshikoto that lived in urban areas survived past five years (59 months) in comparison with more than 94 percent of children that lived in rural areas survived past five years (59 months).

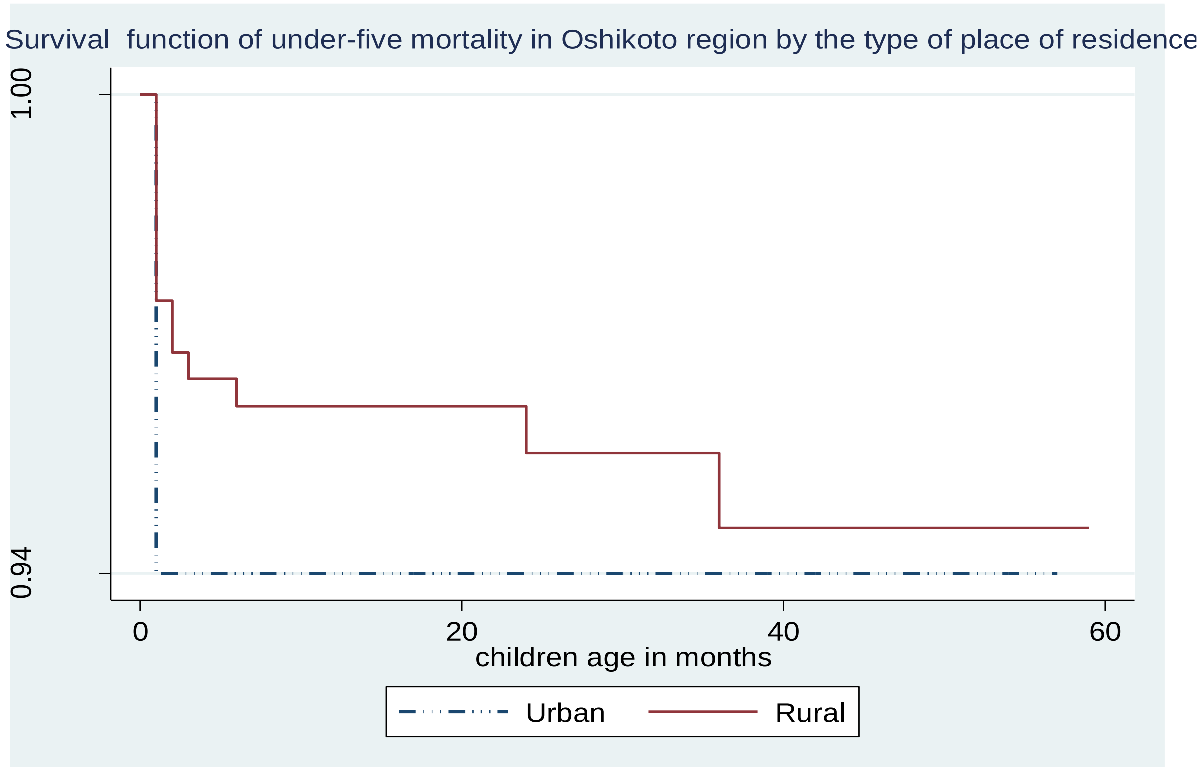



**Figure 4. 31: Kaplan Meier graphs showing the survival pattern in Oshikoto region by type of place of residence**

Figure 4.32 shows survival estimates of under-five mortality in Otjozondjupa region by the type of place of residence. It shows that there was a slight difference in the probability of survival for under-five children that live in urban/rural areas. It is evident that probability of survival for under-five children in urban area was a little higher compared to those that are in rural areas. Only 93 percent of children in Otjozondjupa that lived in rural areas survived past five years (59 months) in comparison with more than 93 percent of children that lived in urban areas survived past five years (59 months).

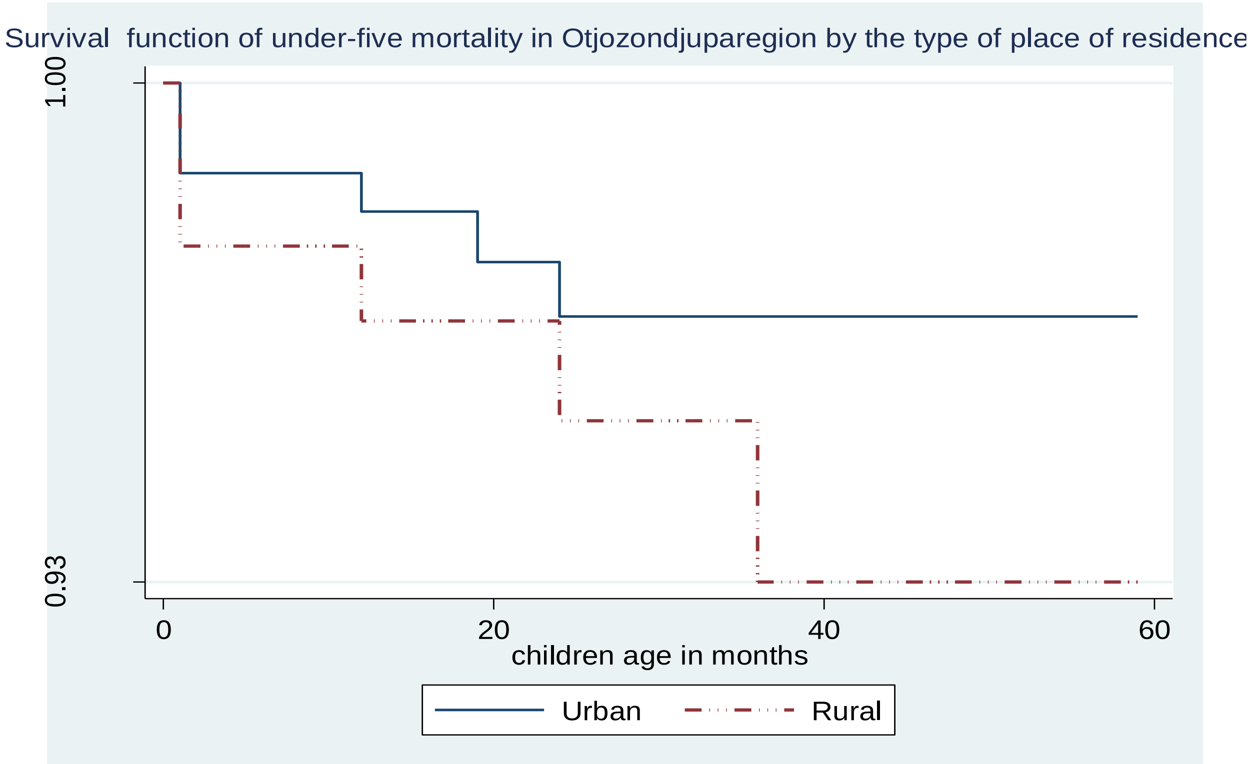



**Figure 4. 32: Kaplan Meier graphs showing the survival pattern in Otjozondjupa region by type of place of residence**

### 4.5. Results of the Cox Proportional Hazard Models

Three models were fitted using Stata 14 and Akaike Information Criterion (AIC was used to assess the best model where references will be made from. The model with the lower AIC value was chosen to make reference from. Mode 1 assumes that there is no frailty; this is the normal Cox proportional Hazard Model.

The second model assumes that frailties are acting at the individual level, which follows a Gamma distribution with mean 1 and variance 0.

The third model assumes that shared frailties acting at the community level using region as the frailty variable.

However, from the model selection, only the best model will be reported and interpreted. The best model was model 2 with individual frailties, as follows:

**Below are the results of the cox proportional fitted models**

**Table 4. 4: Cox proportional Hazard rate model with individual frailty for the effect of the predictor variables on the risk of dying before the age of five**

LR chi2(7) = 123.53

Log likelihood = -1109.6803 Prob > chi2 = 0.0000

| Covariates | Hazard Ratio | p-value | 95% Confidence interval | | Significance |
|---|---|---|---|---|---|
| | | | lower | upper | |
| | | | | | |
| Maternal highest education | | | | | |
| No education(ref) | 1.00 | | | | |
| Primary | 1.1513 | 0.7950 | 0.3977 | 3.3324 | Not Significant |
| Secondary | 0.8978 | 0.8370 | 0.3206 | 2.5142 | Not Significant |
| Higher | 0.0922 | 0.0210 | 0.0121 | 0.7000 | Significant |
| | | | | | |
| Place of delivery | | | | | |
| Home(ref) | 1.00 | | | | |

| | | | | | |
|---|---|---|---|---|---|
| public facility | 1.0587 | 0.8900 | 0.4703 | 2.3835 | Not Significant |
| private medical facility | 0.0361 | 0.0130 | 0.0026 | 0.4992 | Significant |
| | | | | | |
| Type of birth | | | | | |
| Single(ref) | 1.00 | | | | |
| multiple | 12.4615 | 0.0000 | 3.6503 | 42.5413 | Significant |
| | | | | | |
| Status of breastfeed | | | | | |
| child has been breastfed(ref) | 1.00 | | | | |
| child has never been breastfed | 55.7700 | 0.0000 | 23.5511 | 132.0655 | Significant |
| Constant | 0.0031 | 0.0000 | 0.0011 | 0.0091 | |

*S=significant at p-value< 0.05,* Note: Ref refers to Reference category

**4.5.1. AIC selection criterions/results for model selections**

**Table 4. 5: results of the AIC selection for the best model comparison**

| Model | Obs | Log likelihood (null model) | Log likelihood (model) | Degree of freedom | AIC |
|---|---|---|---|---|---|
| | | | | | |
| **1- no frailty** | 4859.00 | -1328.59 | -1222.56 | 8.00 | 2461.13 |
| | | | | | |
| **2- individual frailty** | 4859.00 | -1171.45 | -1109.68 | 9.00 | 2237.36 |
| | | | | | |
| **3- shared frailty** | 4859.00 | -1327.80 | -1221.53 | 9.00 | 2461.06 |

The Cox proportional hazard model results (Table 4.4) show the association between the predictor variables (stratified in categories) and the hazard ratio (HR) of dying before the age of five. The results are presented in the form of hazard ratios that indicate the direction (i.e., decrease, increase or no change) of change in the outcome variable associated with a one level change of a predictor variable compared to the reference level. A HR of 1.00 implies no difference in the risk of a child dying before the age of five between the categories, while a HR greater than 1.00 indicates an increase in the risk of a child dying. Lastly, a HR below 1.00 indicates a decrease in the risk of a child dying relative to the reference category.

The results from the Cox model **(table 4.5) with individual frailty above**, the model with **minimum AIC value of 2237.36** on the risk of dying before the of age five show that all four (4) covariates are statistically significantly associated with the risk of a child dying before the age of five, at p-value<0.05. These are the dummy catergory for place of residence (those children born in private medical facilities), dummy catergory for maternal highest level of education (higher education level) the type of birth and the status of the child being breastfeed or not.

**i. Overall model**

The goodness of fit (LR chi2 (7) = 123.53) and its corresponding p-value (Prob > chi2 = 0.0000) indicates that the covariates in the model have an overall significant effect on the risk of child dying before the age of five.

**ii. Individually covariates**

After controlling for other variables such as; type of birth, place of delivery and the status of breastfeed, the covariate maternal highest education level (higher category) was found to be significantly associated with the risk of a child dying before the age of five (p-value = 0.021) at 5% significant level. It can be seen that children born by mothers with primary education are 15% more at risk of dying (HR= 1.153, C.I (0.3977, 3.3324)) than those with no education. While, children born by mothers with secondary as their highest level of education are 10% lower at the risk of dying with (HR=0.8978 CI: 0.3206, 2.5142) compared to those born by mother with no level of education. For those children born by mothers with higher level of education (tertiary), it can be seen that their risk of dying before the age of five is reduced with 91% (HR=0.0922, C.I (0.0121, 0.7000)) compared to those children born by mothers with no education.

Likewise, after controlling for other variables, type of birth, maternal highest education, and the status of breastfeed, the covariate place of delivery (the private medical facility category) was significantly associated with the risk of a child dying before the age of five (p-value = 0.013) at 5% significant level.

From the hazard ratio, it can be seen that children born at private hospitals are less likely to die compared to children born at home (HR = 0.036, C.I (0.0026,0.4992)), while children born in public hospitals are 5% higher (HR = 1.0587, C.I (0.4703,2.3835)) at risk of dying compared to those born at home.

Moreover the covariate type of birth was significantly associated with the risk of a child dying before the age of five (p-value = 0.00) at 5% significance level. It is noticeable that, multiple births are 12 times (HR = 12.4615, C.I (3.6503, 42.5413)) higher at the risk of dying compared to single birth children.

Lastly, the covariate status of breastfeed was significantly associated (p=0.000) with the risk of the children dying before the age of five at 5% significance level. The results indicate that children who have not been breastfeed were 55.7700 times more at risk of dying compared to children who were breastfed (HR = 55.7700, C.I (23.5511,132.0655)).

### 4.6. Discussion of the findings

#### 4.6.1. Socio-economic factors and under-five mortality

The study found some results which were consistent with what has been reported previously by other researchers, while others contradict some investigators.

The findings revealed that the type of place of residence was not associated with under-five mortality in Namibia. This contradicts the findings of Ogada (2014), the author stated that depending on the place of residence where a child is born and to the family it is born, the environment influences their survival rates. The children born in good and well taken care of environments survive more than those born in terrible environments such as slum areas of urban areas and rural areas with contaminated environment, lack of quality water for domestic use and limited toilet facilities.

Furthermore, Wambugu (2014) also stated that children in urban areas where proper sanitation and water are available, and where modern treatment is more frequent will have lower incidences of under-five mortality compared to those that are in rural area where access to health services is limited.

Results further revealed that the children's place of delivery was statistically associated with under-five mortality in Namibia. Children born in private medical facilities have a reduced probability of dying compared to children born at home. This finding agrees with previous studies such as ( Adedini et al, 2012; Oganda, 2014). Mostly, for children born in private hospitals, mothers receive the best medical services. These mothers maybe well-educated or from richer families that will be able to take good care of them, compared to children born at homes where the risk of death during giving birth is higher, as the mother might not be able to receive proper medical attention.

Under-five children who were born to mothers who experienced multiple births were more likely to experience mortality during their first five years of life than those born to mothers who had single births. This finding opposes that of Ogada (2014) but confirm findings with other researchers such as Kaundjua (2013) who stated that there is no difference between the type of birth of the child.

In addition, the covariate status of breastfeed was significantly associated to the risk of the children dying before the age of five. The results support that of Kaundjua (2013) for NDHS 2006, which illustrates that the status of breastfeed is a crucial determinant of under-five mortality (table 4.6). Breast milk contains antibodies that help babies fight off viruses and bacteria, as well as, lowers the baby's risk of having asthma or allergies and diarrhea (Mosley & Chen, 1984).

Results further revealed that household wealth status was not statistically associated with children mortality. However, from the hazard ratios, children from wealthier households have a reduced risk of death compared to children from poor households. This finding differs from other researchers such as Wambugu (2014), Ogada (2014) and Kaundjua (2013) which determined that household wealth level is associated with under-five mortality. "For poor families, a mother 's outside work may result in child neglect or care by a less skilled sibling/worker, while a wealthy family may hire a skilled and attentive nursemaid thus reducing the chances of under-five mortality"( Ogada, 2014). Moreover, children from wealthier (rich/richer) households mostly have access to clean toilet facilities, clean water sources and their mothers are employed with sources of income. This enhances these children's chances of survival when compared to children from poor households which sometimes have little or no assess to clean water, limited or no safe/clean toilets or little or no source of income.

Moreover, findings revealed that mother's education was significantly associated with the risk of the children dying before the age of five. Similar results were obtained from (Ogada, 2014; Kaundjua ,2013; Mosley & Chen 1984), who indicated that higher levels of educational attainment are generally associated with lower mortality rates, since education exposes mothers to information about better nutrition, use of contraceptives to space births, and knowledge about childhood illnesses and treatment. This finding is confirmed by the hazard rates that suggest that children born to mothers with higher education have a higher probability of survival compared to the rest of the children.

While findings from this study reveal that mother's education is a determinant to child mortality, Wambugu (2014) and Root (2001) findings differs. Their studies found out that education is not a determinant to child mortality. Root (2001), claims that some socio-economic factors such as education alone may not have a greater effect on children mortality. Well-educated mothers may be unable to reduce risk of exposure due to factors beyond their control, these can be a contaminated community environment, lack of water and lack of access to toilet facility. Root (2001), further claims that effect of the combination of these factors which are beyond mothers' control might expose their children to diseases and accelerate their death, but not necessary education alone.

Age at first birth was also not statistically significant on under-five mortality for NDHS 2013. This study contradicts Oganda (2014) and Kaundjua (2013) findings, who argue that age at first birth was a risk factor for under-five mortality. However the results of the Kaplan Meier curve confirm literature that asserts that under-five mortality is more likely to occur among mothers whose ages are below 20 years than it is in elder women. Younger mothers being inexperienced may not be able to take proper care of the infants, this can reduce the probability of survival for those children compared to older mothers. Furthermore, the more matured a mother is, the more they can be able to take care of the children in terms of financial stability, health and good balance diet (Ogada ,2014; Wambugu, 2014; Mosley & Chen ,1984).

Additionally, the results show that marital status is not significantly associated with child mortality. This finding is different to and contradicts Kaundjua (2013) findings for NDHS 2006 which found that marital status was associated with under-five mortality in Namibia. Furthermore, Kaplan Meier shows how under-five mortality varies with mother's marital status. It was evident that children born from current married mothers have low probability of survival compared to children who are born by mothers that are not married or those that are formerly married. This finding shows an unexpected results unlike in most studies findings. It was expected that the children born by married mothers tends to have a higher probability of survival compared to those born by single or divorced mothers because of the support they get from their husband compared to single mothers who sometimes do not have support from their partners (Ogada, 2014).

Results further revealed that preceding birth intervals was not significantly associated with the risk of under-five mortality, this is in support with the findings from (Wambugu, 2014; Oganda, 2014). The authors obtained that socioeconomic determinants alone such as preceding birth interval have rather small and insignificant effect on infant and child mortality, instead they operate through other determinants to accelerate death as it can be seen from Mosley and Chen framework used in the study.

Results from the Kaplan Meier indicates that children born within a longer birth interval have a reduced chance of dying compared to short birth interval. This can be attributed by the fact that; shorter birth intervals are mostly associated with short period of breastfeeding compared to long birth intervals (Kaundjua, 2013). Children born within a shorter birth interval have a shortened duration of breastfeed which causes the child to receive inadequate antibodies from breast milk that help babies fight off viruses and bacteria, as well as, lowers the baby's risk of having asthma or allergies and diarrhea (Mosley & Chen, 1984).

# CHAPTER FIVE

## CONCLUSIONS, RECOMMENDATIONS AND FUTURE RESEARCH SUGGESTIONS

### 5.0. Introduction

This section outlines the findings, draws the conclusions that could be made on the findings of this study and recommendations, both for policy and future research suggestions.

### 5.1. Summary and conclusions of the findings

The aim of the study was to apply survival analysis in order to explain effects of socio-economic factors on under-five mortality in Namibia. Survival analysis techniques (Kaplan-Meier to construct the survival curves, Log Rank Test to determine differences in survival between groups and Cox Proportional Hazards to investigate the association between the survival time of the children below the age of five and their socio-demographic characteristics) were used to estimate the children under the age of five's survival pattern. Furthermore, individual and shared frailty models were fitted to determine the random effect of heterogeneity on under-five mortality.

The study employed a quantitative method, where retrospective cohort study was applied since the study data were a secondary data obtained from NDHS on 4897 children aged 0 months to 59 months who had been given birth to in the five years preceding the survey. The key objective was to find out the influence of socio-economic factors on under-five mortality in Namibia. Sub-objectives used to achieve this main objective were the determination of the survival patterns of under-five children between rural and urban areas per region in Namibia, examining the extent to which socio-economic factors influence under-five mortality in Namibia and to model the influence of unobserved risk factors on under-five mortality. For individual frailty, parametric frailty model with gamma frailty with mean 0 and variance of 1 was fitted. While, for the shared frailty model an additional frailty model with region as a random effect was added to the individual frailty parametric model. This showed whether there is heterogeneity in the under-five mortality across the country.

The demographic characteristics considered were the maternal education, mother's marital status, the age of the mother at first birth, preceding birth interval, type of birth, place of residence, household wealth index, status of breastfed and the place of delivery.

Results revealed that maternal education, place of delivery, type of birth and the child's status of breastfeed were significantly associated with the risk of dying before the age of five.

It was discovered that regions do not account for heterogeneity in the under-five mortality across the country. This can be seen from the third fitted frailty model with region as a random effect variable which was not concluded to be the best fitted model that describes the data from the AIC model selection.

Furthermore, on average, children born in rural areas have a lower survival pattern compared to those that resides on urban areas. This can be supported by the fitted Kaplan Meier Curves, both at national level and at regional level. However, regions such as Erongo, Hardap, Kavango, Khomas, Ohangwena and Oshikoto show that the survival pattern from under five children in rural areas is slightly higher, averaged at around 4 to 5 percentages higher in rural areas compared to urban areas. These unexpected results can be attributed to the fact that the sample size might not be adequately powered to do relevant exclusive subgroup analysis (disaggregation at lower community levels than that at the National level), but still crucial to report on as it answers to one of the study's specific objective.

Regions such as Erongo and Khomas are more urban (town) based- majority of the population resides in the urban area compared to those that resides in rural areas (Ministry of Health and Social Services & Namibia Statistics Agency, 2014). A smaller number of children who lives in rural areas (which can be less than 5%) compared to majority that resides in urban areas, not many deaths are expected in the rural areas for this two regions hence the explanation of the unexpected results. The researcher therefore conclude that the results at national level will be the most powerful conclusions to conclude on compared to survival patterns between urban and rural areas in each region.

It can be seen that there was a higher probability of children surviving past five years. About 95 percent of children in Namibia survived past five years (59 months).

### 5.2. Recommendations

#### 5.2.1. Recommendations for policy

The results suggest urgent policy issues that need to be addressed to safeguard child survival in Namibia. The key issues to be addressed are the child's status of breastfeeding and more focuses on programs that empower women such as free education to all, especially tertiary education.

To start with, maternal education was found to be associated with the risk of a child death, the study recommends more enthuses be put in policies that empower women through education which will reduce the child mortality in Namibia. These policies should aim at making tertiary education free of charge and accessible to all, this will encourage all women to attend school and better their life to enable them to take good care of their children. From the descriptive analysis, of the dead children, only less than 1% (0.9%) have attained higher education. Educated mothers tend to immunize their children, feed on balance diet and seek for medical attention when their children are sick, which will result in the reduction of child mortality.

Moreover, breastfeeding should be encouraged as children who were breastfed are 54 times less likely to die at age five (5) compared to those who were not breastfed.

#### 5.2.2. Recommendation for Future Research Suggestions

There is need to find out the underlying reasons explaining the likelihood of lower under-five mortality in private health facilities because the study revealed that children born from private facilities are less likely to experience death before age five than those born at home and at public facilities.

Furthermore, missing values were deleted in the study, hence the study recommends new studies that look into ways of dealing with missing values without removing them.

## 6.0. REFERENCES


Adedini, A. S., Odimegwu, O.C., Ibisomi, D.O.L., Elwange, C.B. & Imasiku, E. (2012). *Regional Inequalities in Under-five Mortality in Nigeria: A Multilevel Analysis.* Retrieved 06th March 2017, from http://paa2012.princeton.edu/papers/120262

Adeniyi, O., Abiodum, A., & Oyejola, B.A. (2014). *Nested Frailty Model for Infant Mortality Data.* Department of Statistics, University of Ilorin, Ilorin, Nigeria. Retrieved 09th January 2017, from https://www.researchgate.net/publication/319209243_Nested_Frailty_Model_for_Infant_Mortality_Data

Analytics University, (2014). *Survival Models Introduction to Survival Analysis Data Science.mp4.* Published on 31 August 2014. Retrieved May 10th, 2017, from https://www.youtube.com/watch?v=Cg0Gl-_6TwM

Antai, D., & Moradi, T. (2010). Urban Area Disadvantages and Under 5 Mortality in Nigeria: The Effect of Rapid Urbanization. *Environment Health Perspect*, 118(6). Retrieved; May 10th, 2017, from http://openaccess.city.ac.uk/3371/

Baker, R. (1999). *Differential in Child Mortality in Malawi, Social Networks Project Working Papers, No. 3,* University of Pennsylvania. Retrieved; January 20th, 2017, from http://malawi.pop.upenn.edu/sites/www.pop.upenn.edu/files/SNP-WP3-baker-1999.pdf

Box-Steffensmeier, J., & Jones, S. B. (2004). *Event History Modelling: A Guide for Social Scientists.* United Kingdom: Cambridge University. Retrieved; May 10th, 2017, from https://zodml.org/sites/default/files/Event_History_Modeling_A_Guide_for_Social_Scientists_%28Analytical_Methods_for_Social_Research%29.pdf

Kandjimbi, A. (2014). *An Event History Analysis of Socio-Economic Determinants of Adult Mortality in Namibia*. A Thesis Submitted in Partial Fulfilment of the Requirements for The Degree of Master of Science in Applied Statistics and Demography, University of Namibia, Windhoek, Namibia. Retrieved 09th January 2017, from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.935.3065&rep=rep1&type=pdf

Kaundjua, M.B. (2013). *The Determinants of the Child Mortality Rate in Rural Namibia.* University of Namibia, Windhoek, Namibia. Retrieved 09th January 2017, from https://www.researchgate.net/publication/280564864_The_determinants_of_the_child_mortality_rate_ in_ rural_Namibia

Mamum, M.A.A. (2014). *Zero-Inflated Regression Models for Count Data: An Application to Under-5 Deaths*. Master's thesis, Ball State University, Muncie, Indiana. Retrieved 09th January 2017, from http://cardinalscholar.bsu.edu/bitstream/handle/123456789/198134/MamunM_2014-2_BODY.pdf;jsessionid=8661264F6F28037FF088BFEF5EB89BAD?sequence=1

Maposa, I. (2017). *Survival Analysis and Modelling Class notes*. Masters of Science in Biostatistics, University of Namibia, Windhoek, Namibia.

Ministry of Health and Social Services & Namibia Statistics Agency. (2014). *2013 Namibia's Demographic and Health Survey Main Report.* Windhoek, Namibia. Retrieved 09th January 2017, from https://dhsprogram.com/pubs/pdf/FR298/FR298.pdf

Ministry of Health and Social Services. (2008). *2006-2007 Namibia's Demographic and Health Survey Main Report.* Windhoek, Namibia. Retrieved 09th January 2017, from http://www.who.int/fctc/reporting/party_reports/namibia_annex1_demographichealthsurvey_2006.pdf

Ministry of Health and Social Services. (2014*). Namibia Child Survival Strategy 2014-2018* .Retrieved 10th February 2017, from https://www.unicef.org/namibia/na.Child_Survival_Strategy_2014_small.pdf

Ministry of National Planning Commission. (2017). *Fifth Namibia Development Plan 2017-2022.* Windhoek, Namibia. Retrieved 10th February 2017, from https://www.npc.gov.na/?wpfb_dl=294

Ministry of National Planning Commission. (2017). *Official Proposed Sustainable Development Goals Indicators.* Windhoek, Namibia. Retrieved 10th February 2017, from https://sustainabledevelopment.un.org/content/documents/11803Official-List-of-Proposed-SDG-Indicators.pdf

Takane, Y. (1987). *Akaike Information Criterion (AIC)-Introduction*. McGrill University. Retrieved 08th October 2018, from https://www.researchgate.net/profile/Yoshio_Takane/publication/278928698_AKAIKE_INFORMATION_CRITERION_AIC_-_INTRODUCTION/links/56606d2a08aebae678aa123b/AKAIKE-INFORMATION-CRITERION-AIC-INTRODUCTION.pdf?origin=publication_detail

Mosley, W. H., & Chen, L. (1984). An analytical framework for the study of child survival in developing countries. *In child survival: Strategies for Research, Population and Development Review, 10.* N.Y. Retrieved May 20, 2017, from https://core.ac.uk/download/pdf/33996115.pdf

Petersen, J.H., Andersen, P.K. & Gill, R.G. (2001). *Variance Components for Survival Data.* Department of Biostatistics, University of Copenhagen, Copenhagen, Denmark. Retrieved 09th January 2017, from https://dspace.library.uu.nl/bitstream/handle/1874/1644/frailty95.pdf?sequence=1

Root, G. P. M. (2001). Sanitation, community environment and childhood diarrhoea in rural Zimbabwe. *Journal of Health Population and Nutrition, 19,* 73-82. Retrieved, 10th February 2019, from http://www.jhpn.net/index.php/jhpn/article/download/79/68

Vaupel, J.W., Manton, K.G., & Stallard, E. (1979). Demography. *The Impact of Heterogeneity in Individual Frailty on the Dynamics of Mortality, 16(*3). Retrieved 15th January 2017, from http://www.ressources-actuarielles.net/EXT/ISFA/1226.nsf/0/2d6493f9f0d93b50c125774b0045c00b/$FILE/Vaupel-Demography-16-1979-3.pdf

Wambugu, M.R. (2014*). Determinants of Under-5 Mortality in Kenya during Upsurge and Declining Trend Period.* Master's thesis, University of Nairobi, Nairobi. Retrieved 09th January 2017, from http://psri.uonbi.ac.ke/sites/default/files/chss/psri/psri/Mwangi%20Reuben%20Wambugu_Research%20Project%202014_0.pdf

Wienke, A. (2011). *Frailty Models in Survival Analysis*. Institute of Medical Epidemiology, Biostatistics, and Informatics Martin-Luther-University, Halle-Wittenberg, Germany. Retrieved 09th January 2017, from https://www.crcpress.com/Frailty-Models-in-Survival-Analysis/Wienke/p/book/9781420073881

Namibia Statistics Agency. (2011). *Namibia 2011 Population and Housing Census Main Report.* Windhoek, Namibia. Retrieved May 20, 2017, from https://nsa.org.na/page/publications

Namibia Statistics Agency. (2014). *Namibia 2011 Population and Households Census Mortality Report.* Windhoek, Namibia. Retrieved May 20, 2017, from https://nsa.org.na/page/publications

Ogada, S.O. (2014). *Socioeconomic Determinants of Under-Five Mortality in Principal Cities of East Africa Community: A Case Study of Nairobi, Dar-Es-Salaam and Kigali*. A Research Project Submitted in Partial Fulfilment for The Award of a Master of Arts Degree in Population Studies. Population Studies and Research Institute, University of Nairobi, Nairobi. Retrieved May 20, 2017, from http://psri.uonbi.ac.ke/sites/default/files/chss/psri/psri/STEPHEN%20OMOLO%20OGADA%20PROJECT_0.pdf

Pact Namibia. (2016). *Measuring Child Well-being in Namibia: Recommendations for Child Well-being Indicators for the Child Care and Protection Act*. Publication submitted to Ministry of Gender & Child Welfare and to Namibia Statistics Agency in June 2016, Windhoek, Namibia.

Persson, I. (2002). Essays on the Assumption of Proportional Hazards in Cox Regression. Dissertation for the Degree of Doctor of Philosophy in Statistics presented at Uppsala University in 2002. *Comprehensive Summaries of Uppsala Dissertations from the Faculty of Social Sciences, 110*. Acta Universitatis Upsaliensis, Uppsala. ISBN 91-554-5208-6. Retrieved May 20, 2017, from https://pdfs.semanticscholar.org/6494/f12b1ff2e4a301b78cb5aa55827232caaaae.pdf

Pourhoseingholi, M. A., Hajizadeh, E., Moghimi, B., Safaee, A., Abadi, A., & Zali, R. M. (2007). Comparing Cox Regression and Parametric Models for Survival of Patients with Gastric Carcinoma. Asian Pacific *Journal of Cancer Prevention, 8,* 412-415. Retrieved May 25, 2018, from http://journal.waocp.org/article_24627_ebe3312e5286863e0b3f2b84277d66fb.pdf

United Nations Children's Fund. (2015). *Committing to Child Survival: A Promise Renewed, Progress report 2014* .Retrieved 10th January 2017, from http://files.unicef.org/publications/files/APR_2014_web_15Sept14.pdf

United Nations Children's Fund. (2019). *The state of the World's Children 2019 Children, Food and Nutrition Growing Well in a Changing World.* Retrieved October 2019, from https://www.unicef.org/media/60806/file/SOWC-2019.pdf

United Nation Development Programme. (2011). *2030 Agenda for Sustainable Goals*. Retrieved May 20, 2017, from http://www.undp.org/content/dam/undp/library/corporate/brochure/SDGs_Booklet_Web_En.pdf

United Nations Economic Commission for Africa. (2015). *Namibia's 2015 Country Profile*. Retrieved May 20, 2017, from http://www.un.org/esa/agenda21/natlinfo/wssd/namibia.pdf

World Health Organization. (2018). Children: Reducing *Mortality*. Retrieved 10th January 2017, from http://www.who.int/mediacentre/factsheets/fs178/en/

Valencia, M.K. (2014). *The Determinants of Under-Five Mortality in Malawi: Evidence Based On Demographic and Health Survey 2010*. A Mini-Dissertation Submitted to The Faculty of Human and Social Sciences in Partial Fulfilment of the Requirements for The Degree of Master of Social Sciences in Population Studies and Sustainable Development. North-West University, Mafikeng Campus, South Africa. Retrieved January 30, 2019 from https://repository.nwu.ac.za/bitstream/handle/10394/15082/Maiwashe_KV.pdf?sequence=1

## 7.0. APPENDICES

**Appendix 1 = STATA do file for the codes used for the models**

***create a variable for the outcome variable (child alive/dead) interchanging the response**

**generate child_dead = .**

**replace child_dead = 1 if Outcome_variable==0 //event**

**replace child_dead = 0 if Outcome_variable==1 //censored**

**#delimit ;**

**lab def child_dead_lab**

**1 "Yes"**

**0 "No";**

**#delimit cr**

**Label values child_dead child_dead_lab**

**Label variables child_dead "child_dead"**

**-----------------------------------------------------------------------------------------------------------------------------**

**//creating a time to death variable that transforms all the 0 months entries (117) in to 1 month, so they will be included in the analysis**

**gen current_age_months = Age_in_months**

**replace current_age_months = 1 if Age_in_months == 0**

**//-----------------------------------------------------------------------------------------------------------------------------**

***Running the Kaplan meier curves**

**global time current_age_months**

**global event child_dead**

**global xlist Maternal_highest_education marital_status age_at_first_birth preceding_birth_interval type_of_birth Type_of_place_of_residence household_wealth_index place_of_delivery status_of_breast_fed**

**global group Type_of_place_of_residence**

**describe $time $event $xlist**

**summarize $time $event $xlist**

***set data at survival time**

**stset $time, failure($event)**

**stdescribe**

**stsum**

***Graph of survival function (Kaplan-Meier Survival Curve)**

**sts graph, survival**

***list of survival function**

**sts list, survival**

**///-----------------------------------------------------------------------------------------------------------------------------------**

***Kaplan_Meier survival curves for two groups**

**sts graph, by($group)**

***Kaplan_Meier survival curves for other categorical variables**

**sts graph, by(household_wealth_index) ytitle(Probability of survival) xtitle(Children's age in months) title(Survival function of under-five mortality in terms of type of place of residence)**

**sts graph, by(place_of_delivery) ytitle(Probability of survival) xtitle(Children's age in months) title(Survival function of under-five mortality in terms of type of place of residence)**

**sts graph, by(type_of_birth) ytitle(Probability of survival) xtitle(Children's age in months) title(Survival function of under-five mortality in terms of type of place of residence)**

**sts graph, by(marital_status) ytitle(Probability of survival) xtitle(Children's age in months) title(Survival function of under-five mortality in terms of type of place of residence)**

**sts graph, by(age_at_first_birth) ytitle(Probability of survival) xtitle(Children's age in months) title(Survival function of under-five mortality in terms of type of place of residence)**

**sts graph, by(preceding_birth_interval) ytitle(Probability of survival) xtitle(Children's age in months) title(Survival function of under-five mortality in terms of type of place of residence)**

**sts graph, by(household_wealth_index) ytitle(Probability of survival) xtitle(Children's age in months) title(Survival function of under-five mortality in terms of type of place of residence)**

**sts graph, by(Maternal_highest_education) ytitle(Probability of survival) xtitle(Children's age in months) title(Survival function of under-five mortality in terms of type of place of residence)**

**sts graph, by(status_of_breast_fed) ytitle(Probability of survival) xtitle(Children's age in months) title(Survival function of under-five mortality in terms of type status_of_breast_fed)**

**//-----------------------------------------------------------------------------------------------------------------------------**

**//Objective or research question number one. Survival paten per region by type of place of residence**

**//stset current_age_months, failure (child_dead==1)**

**//failure event:  child_dead == 1**

**use "D:\Region data sets October\caprivi.dta", clear //use this file because it is the Caprivi region file**

**sts graph, by(Type_of_place_of_residence) ytitle(Probability of survival) xtitle(children age in months) title(Survival  function of under-five mortality in Caprivi region by the type of place of residence)**

**use "D:\Region data sets October\erongo.dta", clear //use this file because it is the Erongo region file**

**sts graph, by(Type_of_place_of_residence) ytitle(Probability of surviva) xtitle(children age in months) title(Survival  function of under-five mortality in Erongo region by the type of place of residence)**

**use "D:\Region data sets October\hardap.dta", clear //use this file because it is the Hardap region file**

**sts graph, by(Type_of_place_of_residence) ytitle(Probability of surviva) xtitle(children age in months) title(Survival function of under-five mortality in Hardap region by the type of place of residence)**

**use "D:\Region data sets October\karas.dta", clear //use this file because it is the Karas region file**

**sts graph, by(Type_of_place_of_residence) ytitle(Probability of surviva) xtitle(children age in months) title(Survival function of under-five mortality in Karas region by the type of place of residence)**

**use "D:\Region data sets October\kavango.dta", clear // use this file because it is the Kavango region file**

**sts graph, by(Type_of_place_of_residence) ytitle(Probability of survival) xtitle(children age in months) title(Survival function of under-five mortality in Kavango region by the type of place of residence)**

**use "D:\Region data sets October\khomas.dta", clear //use this file because it is the Karas region file**

**sts graph, by(Type_of_place_of_residence) ytitle(Probability of survival) xtitle(children age in months) title(Survival function of under-five mortality in Khomas region by the type of place of residence)**

**use "D:\Region data sets October\kunene.dta", clear //use this file because it is the Kunene region file**

**sts graph, by(Type_of_place_of_residence) ytitle(Probability of survival) xtitle(children age in months) title(Survival function of under-five mortality in Kunene region by the type of place of residence)**

**use "D:\Region data sets October\ohangwena.dta", clear //use this file because it is the Ohangwena region file**

**sts graph, by(Type_of_place_of_residence) ytitle(Probability of survival) xtitle(children age in months) title(Survival  function of under-five mortality in Ohangwena region by the type of place of residence)**

**use "D:\Region data sets October\omaheke.dta", clear //use this file because it is the Omaheke region file**

**sts graph, by(Type_of_place_of_residence) ytitle(Probability of survival) xtitle(children age in months) title(Survival  function of under-five mortality in Omaheke region by the type of place of residence)**

**use "D:\Region data sets October\omusati.dta", clear //use this file because it is the Omusati region file**

**sts graph, by(Type_of_place_of_residence) ytitle(Probability of survival) xtitle(children age in months) title(Survival  function of under-five mortality in Omusati region by the type of place of residence)**

**use "D:\Region data sets October\oshana.dta", clear //use this file because it is the Oshana region file**

**sts graph, by(Type_of_place_of_residence) ytitle(Probability of survival) xtitle(children age in months) title(Survival  function of under-five mortality in Oshana region by the type of place of residence)**

**use "D:\Region data sets October\oshikoto.dta", clear //use this file because it is the Oshikoto region file**

**sts graph, by(Type_of_place_of_residence) ytitle(Probability of survival) xtitle(children age in months) title(Survival  function of under-five mortality in Oshikoto region by the type of place of residence)**

**use "D:\Region data sets October\otjozondjupa.dta", clear //use this file because it is the Otjozondjupa region file**

**sts graph, by(Type_of_place_of_residence) ytitle(Probability of survival) xtitle(children age in months) title(Survival  function of under-five mortality in Otjozondjuparegion by the type of place of residence)**

**//-----------------------------------------------------------------------------------------------------------------------------**

**// Testing for the log rank tests between groups**

**sts test Region, logrank**

**sts test Type_of_place_of_residence, logrank**

```
sts test place_of_delivery, logrank

sts test child_dead, logrank

sts test type_of_birth, logrank

sts test marital_status, logrank

sts test age_at_first_birth, logrank

sts test preceding_birth_interval, logrank

sts test household_wealth_index, logrank

sts test Maternal_highest_education, logrank

sts test status_of_breast_fed, logrank

//------------------------------------------------------------------------------------------------------------------------------------

// PH model assumption testing the ln or log plots for the proportionality of the model / curves

stphplot, by(Region) xtitle(ln(Children's age in months)) title(Proportional hazard test models for Regions)

stphplot, by(Maternal_highest_education) xtitle(ln(Children's age in months)) title(Proportional hazard test models for Maternal_highest_education)

stphplot, by(place_of_delivery) xtitle(ln(Children's age in months)) title(Proportional hazard test models for place of delivery)

stphplot, by(marital_status) xtitle(ln(Children's age in months)) title(Proportional hazard test models for current marital status)

stphplot, by(age_at_first_birth) xtitle(ln(Children's age in months)) title(Proportional hazard test models for age at first birth)

stphplot, by(Type_of_place_of_residence) xtitle(ln(Children's age in months)) title(Proportional hazard test models for Type of place of residence)
```

**stphplot, by(preceding_birth_interval) xtitle(ln(Children's age in months)) title(Proportional hazard test model for the preceding birth interval )**

**stphplot, by(household_wealth_index) xtitle(ln(Children's age in months)) title(Proportional hazard test model for the household wealth index)**

**stphplot, by(type_of_birth) xtitle(ln(Children's age in months)) title(Proportional hazard test model for the type of birth )**

**stphplot, by(status_of_breast_fed) xtitle(ln(Children's age in months)) title(Proportional hazard test models for status_of_breast_fed)**

**//-------------------------------------------------------------------------------------------------------------------------------**

**// COX PROPORTIONAL HAZARD MODELS**

**// THE next models are the 3 models to be fitted**

**//stset current_age_months, failure (child_dead==1)**

**//failure event: child_dead == 1**

**//----------------------------------------------------------------------------------------------------------------------------**

**//MODEL 1, NO FRAULITY, Assuming no unobserved heterogeneity**

**streg i.Maternal_highest_education i.place_of_delivery i.type_of_birth i.status_of_breast_fed, dist(exponential) level(95)**

**estat ic // the command for running the AIC for the best model selection//**

**//MODEL 2, Individual frailty----individual heterogeneity**

**streg i.Maternal_highest_education i.place_of_delivery i.type_of_birth i.status_of_breast_fed, dist(exponential) frailty(gamma) level(95)**

**estat ic // the command for running the AIC for the best model selection//**

**//MODEL 3, Shared frailty---using region**

**streg i.Maternal_highest_education i.place_of_delivery i.type_of_birth i.status_of_breast_fed, dist(exponential) frailty(gamma) shared(Region) level(95)**

**estat ic // the command for running the AIC for the best model selection//**

**Appendix 2 = Survival function or Figures for under 5 children in Namibia**

| Time | Beginning. Total | Fail | Net Lost | Survivor Function | [95% Confidence interval] lower | upper |
|---|---|---|---|---|---|---|
| 1 | 4897 | 112 | 73 | 0.9771 | 0.9725 | 0.9810 |
| 2 | 4712 | 13 | 50 | 0.9744 | 0.9696 | 0.9785 |
| 3 | 4649 | 11 | 38 | 0.9721 | 0.9671 | 0.9764 |
| 4 | 4600 | 4 | 56 | 0.9713 | 0.9662 | 0.9756 |
| 5 | 4540 | 4 | 46 | 0.9704 | 0.9653 | 0.9748 |
| 6 | 4490 | 4 | 566 | 0.9696 | 0.9643 | 0.9740 |
| 7 | 3920 | 10 | 44 | 0.9671 | 0.9616 | 0.9718 |
| 8 | 3866 | 3 | 41 | 0.9663 | 0.9608 | 0.9711 |
| 9 | 3822 | 9 | 40 | 0.9641 | 0.9583 | 0.9690 |
| 10 | 3773 | 4 | 42 | 0.9630 | 0.9572 | 0.9681 |
| 11 | 3727 | 4 | 33 | 0.9620 | 0.9561 | 0.9671 |
| 12 | 3690 | 19 | 33 | 0.9571 | 0.9507 | 0.9626 |
| 13 | 3638 | 1 | 51 | 0.9568 | 0.9505 | 0.9623 |
| 14 | 3586 | 1 | 30 | 0.9565 | 0.9502 | 0.9621 |
| 15 | 3555 | 0 | 31 | 0.9565 | 0.9502 | 0.9621 |
| 16 | 3524 | 0 | 44 | 0.9565 | 0.9502 | 0.9621 |
| 17 | 3480 | 1 | 41 | 0.9562 | 0.9499 | 0.9618 |
| 18 | 3438 | 0 | 581 | 0.9562 | 0.9499 | 0.9618 |
| 19 | 2857 | 1 | 27 | 0.9559 | 0.9495 | 0.9615 |
| 20 | 2829 | 0 | 32 | 0.9559 | 0.9495 | 0.9615 |
| 21 | 2797 | 1 | 40 | 0.9556 | 0.9491 | 0.9612 |
| 22 | 2756 | 0 | 25 | 0.9556 | 0.9491 | 0.9612 |
| 23 | 2731 | 1 | 35 | 0.9552 | 0.9487 | 0.9609 |
| 24 | 2695 | 8 | 30 | 0.9524 | 0.9456 | 0.9584 |
| 25 | 2657 | 0 | 40 | 0.9524 | 0.9456 | 0.9584 |
| 26 | 2617 | 0 | 24 | 0.9524 | 0.9456 | 0.9584 |
| 27 | 2593 | 0 | 32 | 0.9524 | 0.9456 | 0.9584 |
| 28 | 2561 | 0 | 34 | 0.9524 | 0.9456 | 0.9584 |
| 29 | 2527 | 0 | 33 | 0.9524 | 0.9456 | 0.9584 |
| 30 | 2494 | 0 | 615 | 0.9524 | 0.9456 | 0.9584 |
| 31 | 1879 | 0 | 35 | 0.9524 | 0.9456 | 0.9584 |
| 32 | 1844 | 0 | 32 | 0.9524 | 0.9456 | 0.9584 |
| 33 | 1812 | 0 | 27 | 0.9524 | 0.9456 | 0.9584 |
| 34 | 1785 | 0 | 27 | 0.9524 | 0.9456 | 0.9584 |
| 35 | 1758 | 0 | 16 | 0.9524 | 0.9456 | 0.9584 |
| 36 | 1742 | 6 | 31 | 0.9491 | 0.9418 | 0.9555 |
| 37 | 1705 | 0 | 30 | 0.9491 | 0.9418 | 0.9555 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 38 | 1675 | 0 | 39 | 0.9491 | 0.9418 | 0.9555 |
| 39 | 1636 | 0 | 28 | 0.9491 | 0.9418 | 0.9555 |
| 40 | 1608 | 0 | 22 | 0.9491 | 0.9418 | 0.9555 |
| 41 | 1586 | 0 | 26 | 0.9491 | 0.9418 | 0.9555 |
| 42 | 1560 | 0 | 603 | 0.9491 | 0.9418 | 0.9555 |
| 43 | 957 | 0 | 25 | 0.9491 | 0.9418 | 0.9555 |
| 44 | 932 | 0 | 25 | 0.9491 | 0.9418 | 0.9555 |
| 45 | 907 | 0 | 14 | 0.9491 | 0.9418 | 0.9555 |
| 46 | 893 | 0 | 34 | 0.9491 | 0.9418 | 0.9555 |
| 47 | 859 | 0 | 25 | 0.9491 | 0.9418 | 0.9555 |
| 48 | 834 | 1 | 30 | 0.9480 | 0.9403 | 0.9547 |
| 49 | 803 | 0 | 26 | 0.9480 | 0.9403 | 0.9547 |
| 50 | 777 | 0 | 19 | 0.9480 | 0.9403 | 0.9547 |
| 51 | 758 | 0 | 32 | 0.9480 | 0.9403 | 0.9547 |
| 52 | 726 | 0 | 32 | 0.9480 | 0.9403 | 0.9547 |
| 53 | 694 | 0 | 22 | 0.9480 | 0.9403 | 0.9547 |
| 54 | 672 | 0 | 564 | 0.9480 | 0.9403 | 0.9547 |
| 55 | 108 | 0 | 26 | 0.9480 | 0.9403 | 0.9547 |
| 56 | 82 | 0 | 17 | 0.9480 | 0.9403 | 0.9547 |
| 57 | 65 | 0 | 19 | 0.9480 | 0.9403 | 0.9547 |
| 58 | 46 | 0 | 21 | 0.9480 | 0.9403 | 0.9547 |
| 59 | 25 | 0 | 25 | 0.9480 | 0.9403 | 0.9547 |