

**SURVIVAL PROBABILITY AND PREDICTORS OF UNDER-FIVE MORTALITY IN SIAYA  
COUNTY, WESTERN KENYA**

**HARUN ODHIAMBO OWUOR**

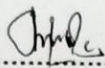
**H153/4269/2018**

**A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE  
AWARD OF MASTER OF SCIENCE DEGREE IN EPIDEMIOLOGY AND BIostatISTICS  
OF JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY.**

**© Feb, 2024**

### DECLARATION

I hereby declare that this is my original work and has not been presented for the award of a degree in any other university.

Signature:  ..... Date: 14/03/2024

**Harun Odhiambo Owuor**

**H153/4269/2018**

**Jaramogi Oginga Odinga University of Science and Technology**

### APPROVAL BY SUPERVISORS

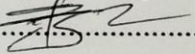
This thesis was submitted with our approval as university supervisors.

1. Dr. Asito Amollo, Ph.D

Department of Biological Sciences

School of Biological, Physical, Mathematics and Actuarial Sciences

Jaramogi Oginga Odinga University of Science and Technology

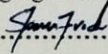
Signature:  ..... Date: 14/03/2024

2. Dr. Dickens Omondi, Ph.D

Department of Public Health and Community Development

School of Health Sciences

Jaramogi Oginga Odinga University of Science and Technology

Signature:  ..... Date: 14/03/2024

## **DEDICATION**

I dedicate this work to my late mother, Pamela Anyango Owuor, who advised me to pursue a master's degree during my undergraduate graduation.

## **ACKNOWLEDGEMENT**

I thank my supervisors, Dr. Amollo Asito, and Dr. Dickens Omondi for their continuous support and guidance. Special thanks to KEMRI, FHU department, and HDSS staff to name a few: Sammy Khagayi, David Obor, Joyce Were, Fred Onduru, and Bernard Asuke for their continued support and unconditional help in data collection and analysis.

Furthermore, special thanks to my wife Kezia Onyango, son Harun Williams, Denver Hart and Renny Roux, father William Owuor, and the entire family for their continued prayers, encouragement, and moral and spiritual support. Thanks also to my classmates, friends, and colleagues for their support. In addition, thanks to families who consented to participate in the study and voluntarily gave their demographic and health information.

Finally, special thanks to Dr. Victor Akelo, Dr. Richard Omore, and Dr. Steve Wandiga for advice, encouragement, and exceptional support throughout the process.

## **ABSTRACT**

Approximately 1 in 26 children worldwide die before the age of five, with more than 50% of these deaths occurring in sub-Saharan Africa. In Kenya, despite gains in reducing under-five mortality from 52 to 41.9 deaths per 1000 live births between 2015 and 2022, this rate remains notably higher than the Sustainable Development Goal (SDG) 3 target of 25 deaths per 1000 by 2030. The impact of interventions on risk factors and socio-structural inequities have varied across regions, indicating potential effects of unaddressed issues. There is a need to further understand the key drivers of under-5 mortality in given contexts to help improve intervention effectiveness. Siaya County is one of the regions with high under-five mortality, 63 deaths per 1,000 live births as compared with the national rate of 41 deaths per 1000 live births. The broad objective of this study was to estimate the survival probability and determine predictors of under-five mortality in Siaya County. Specifically, it estimated the survival probability; and determined the socioeconomic, maternal healthcare-seeking, and environmental predictors of under-five mortality in Siaya County. The study utilized secondary data from the Siaya Health Demographic Surveillance System from 2015 to 2020 data set. This is an annual population-based longitudinal surveillance. The data on predictors and child survival of children born within the six years of the study were retrieved. The total number of observations was 24452, representing the number of live births born within the study period. The male-to-female ratio was 1:1, with 1,540 (6.3%) children dying before celebrating their fifth birthday. The cumulative survival probability among children under five was approximately 90% with children of younger age being at increased risk of death. In Cox multivariable analysis, the risk of death among females was 18 times (HR 0.82 CI=0.74, 0.91  $p < 0.001$ ) lower than male children. Under-five mortality decreased with increasing educational attainment of the mother (HR 0.40 CI 0.23, 0.70  $p < 0.001$ ) and number of ANC visits (HR 0.48 CI 0.26, 0.88  $p = 0.018$ ). Delivery in the hospital ( $p = 0.001$ ); birth over age 18 years ( $p = 0.034$ ) and use of a modern or pit latrine ( $p = 0.03$ ) improved survival. In conclusion, the hazard of death among children under the age of five years was higher at an early age. Female gender, low maternal education attainment, fewer number of ANC visits, maternal age, delivery in hospital, and toilet use were associated with higher under-five mortality. These observations reinforce the need to target multiple components at the community and institutional levels.

## TABLE OF CONTENTS

DECLARATION.....	i
DEDICATION .....	ii
ACKNOWLEDGEMENT.....	iii
ABSTRACT .....	iv
LIST OF TABLES .....	viii
LIST OF FIGURES .....	viii
LIST OF ACRONYMS AND ABBREVIATIONS .....	ix
CHAPTER ONE.....	1
INTRODUCTION.....	1
1.1 Background information.....	1
1.2 Statement of the Problem .....	2
1.3 Research Objective.....	3
Main objective.....	3
Specific Objectives.....	3
1.4 Research Questions .....	3
1.5 Study Justification .....	3
1.6 Significance of Study .....	4
1.7 Scope and Limitations of this study .....	4
CHAPTER TWO.....	6
LITERATURE REVIEW .....	6
2.1 Introduction .....	6
Overview of Under-five Mortality .....	6
2.3 Socioeconomic factors and under-five mortality.....	7
2.3.1 Maternal Education .....	7
2.3.2 Wealth Index .....	7
2.4 Demographic factors and under-five mortality .....	8
2.4.1 Maternal age at birth and under-five mortality.....	8
2.4.2 Maternal marital status and under-five mortality .....	9
2.5 Cultural factors .....	9
2.5.1 Religion Affiliation .....	9
2.5.2 Family size.....	10
2.6 Maternal Health Seeking Behavior.....	11
2.6.1 Events around antenatal care .....	11

6.2 Events around delivery .....	12
2.7 Environmental Factors.....	13
2.7.1 Source of drinking water and toilet facility .....	13
2.7.2 Cooking fuel .....	14
2.8.1 Conceptual Framework.....	15
CHAPTER THREE.....	17
RESEARCH METHODOLOGY .....	17
3.1 Study Area: .....	17
3.2 Study Design .....	17
3.3 Study population and duration.....	17
3.4 Sampling and Sample Size Determination .....	18
3.6 Exclusion Criteria.....	18
In complete data at the time of abstraction.....	18
3.7 Research Instrument .....	18
3.8 Description of Variables.....	19
3.8.1 Dependent variable .....	19
3.8.2 Independent Variables .....	19
3.9.0 Data Management and Statistical Analysis .....	21
3.9.1 Data Source .....	21
3.9.2 Data collection.....	21
3.9.3 Data storage .....	21
3.9.4 Data security and confidentiality .....	21
3.9.5 Statistical Analysis .....	21
How to fit the model.....	22
3.10 Ethical Considerations.....	22
4.1 Descriptive statistic of the study population.....	24
4.1.1 Socioeconomic, sociocultural, and sociodemographic characteristics of the study population .....	25
4.1.2 Environmental and maternal health care-seeking behavior characteristics of the study population. ....	26
4.2 Survival Probability of children under five years in Siaya County .....	28
4.4 Kaplan Meier curve estimate.....	28
4.5 Results of the multivariate analysis .....	32
CHAPTER FIVE.....	35
DISCUSSION .....	35
CHAPTER 6.....	38

CONCLUSIONS AND RECOMMENDATIONS .....	38
6.1 Conclusion.....	38
6.2 Recommendation.....	38
6.2.1 Recommendations for Programs .....	38
6.2.1 Recommendations for further research.....	39
References .....	40
APPENDICES .....	49
Appendix 1: Map of Study Area .....	49
Appendix 2: Data Confidentiality Form.....	50
Appendix 3: Data abstraction retrieval form .....	51
Appendix 4: Approval letter from JOOUST PBS .....	53
Appendix 4: Additional graphs and tables for data analysis .....	54

## LIST OF TABLES

Table 4.1 Selected socioeconomic, sociodemographic, and sociocultural characteristics of the study population in Siaya County using 2015 – 2020 HDSS data .....	25
Table 4.2 Environmental, Child, and Maternal health-seeking characteristics of the study population in Siaya County using HDSS data (2015 – 2020) .....	27
Table 4.1 Table 4.2 The final fitting Cox proportional hazard model among under-five children in Siaya County using 2015 – 2020 HDSS data .....	33

## LIST OF FIGURES

Fig 2.1: Conceptual framework of childhood survival by Mosley and Chen (1984) .....	15
Fig 2.2: Conceptual framework modeled from Mosley and Chen (1984) .....	16
Fig 4.1a: Distribution of under-five children by ages in Siaya.....	24
Fig 4.1b: Distribution of under-five mortality by ages in Siaya.....	25
Figure 4.2a Survival probability of children under-five in Siaya County.....	29
Figure 4.2b Kaplan Meier estimates in Gender.....	29
Figure 4.2c Kaplan Meier estimates in Education .....	30
Figure 4.2d Kaplan Meier estimates in Maternal age .....	30
Figure 4.2e Kaplan Meier estimates in Place in delivery.....	31
Figure 4.2f Kaplan Meier estimates in Family size.....	31
Figure 6.1 The map of Siaya County Health Demographic Surveillance System .....	49
Figure 6.1 Distribution of time to events of under-five mortality .....	54
Figure 6.2 Plot of variable completeness .....	54

## **LIST OF ACRONYMS AND ABBREVIATIONS**

**ANC** – Antenatal Care

**HDSS** – Health Demographic Surveillance System

**HIV** – Human Immunodeficiency Virus

**ITN** – Insecticide Treated Nets

**KDHS** – Kenya Health Demographic Surveillance

**KEMRI** – Kenya Medical Research Institute

**MOH** – Ministry of Health

**NCDs** – Non-Communicable Diseases

**PMTCT** – Prevention of Mother to Child Transmission

**SCRH** – Siaya County Referral Hospital

**SDGS** – Sustainable Development Goals

**U5M** – Under-five mortality

**UN** – United Nations

**UN&IGME** – United Nations Inter-Global Agency Mortality Estimation

**WHO** – World Health Organization

**WASH** – Water, Sanitation and Hygiene

**ODF** – Open Defecation Free

## **CHAPTER ONE**

### **INTRODUCTION**

#### **1.1 Background information**

Under-five mortality is death between the age of birth and the fifth birthday (Ely & Driscoll, 2020; UN - IGME, 2022). It remains a prominent public health concern with most early child mortality due to conditions that could be prevented or treated with access to simple, affordable interventions (UN - IGME, 2018). Globally, an estimated 5 million children died in 2021, with 2.3 million deaths occurring in the first month of life, making it the most vulnerable period (UN - IGME, 2022). The United Nations Inter-Agency Group estimated that 1 in 26 children in the world died before reaching the age of five in 2020, with more than 57% of those deaths occurring in sub-Saharan Africa (UN & IGME), 2021). In Kenya, the under-five mortality rate is estimated at 41.9 deaths per 1000 live births, with Siaya having an under-five mortality rate of 63 deaths per 1000 live births (UN & IGME, 2021; KNBS, 2022). Kenya has had a remarkable decline in child mortality since the United Nation (UN) Millennium Declaration was signed in 2000. The under-five mortality rate has declined by more than 50% from 90 deaths per 1000 live births in 2003 to 41.9 deaths per 1000 live births in 2022(UN - IGME, 2022). The spontaneous improvement in child survival may be attributed to strengthening community health services, improving immunization coverage levels across the country, and enhancing the use of mosquito nets (MOH Kenya, 2020). Piloting universal health care and accessible maternal and child health at all level facilities to increase utilization of antenatal care, skilled attendance at childbirth, postnatal care, and integrated management of childhood illnesses have significantly improved child health care (UNFPA, 2020). Despite the progress Kenya is still short of the target for Sustainable Development Goals (SDG) 3 which aims to reduce the newborn mortality rate to at least 12 per 1000 live births and under-five mortality to at least 25 per 1000 live births in every country by 2030 (UNFPA, 2020).

Although the under-five mortality indicator has declined significantly, there are still differences in the mortality rate between counties in the country. Siaya County has a higher under-five mortality of 63 deaths per 1000 live births compared to Laikipia County which has the lowest under-five mortality rate of 27 deaths per 1000 live births (KNBS, 2022). Therefore, the risk of dying is almost three times higher in Siaya County compared to Laikipia County. In addition, various studies have shown the survival rate among under-five to be more than 70%, with high mortality experienced during the early neonatal

period (Egbon *et al.*, 2022; Oduse *et al.*, 2021). However, there is scanty literature on the survival probability among those under the age of five years in Siaya County. Hence the study aimed to estimate the survival probability among children under the age of 5 years.

Risk factors associated with under-five mortality are unevenly distributed across the world between developed and developing countries. Various studies have reported mixed findings on demographic, socio-economic, cultural, environmental, and maternal behaviors. Macharia (2019) argued that most deaths are attributed to preventable causes, primarily associated with inequalities across various socioeconomic such as wealth, education, and rampant poverty across the country (Macharia *et al.*, 2019). Moreover, Ettarh & Kimani (2012) attributed higher under-five mortality to widespread household poverty in rural areas than urban areas but, differing across counties, with the Western Kenya region being more vulnerable than the Central region. However, they used data from cross-sectional studies such as surveys. This study used continuous longitudinal data collected within a geographically defined population and collected semi-annually. This close follow-up provided more information on various demographic and health factors. Since a high mortality rate cannot be attributed to a single factor, there is a need to examine various predictors associated with under-five mortality and determine the one that requires urgent intervention to fast-track progress in achieving SDG 3.2 by 2030.

## **1.2 Statement of the Problem**

Despite global progress in reducing child mortality in recent decades, under-five mortality in Kenya remains relatively high, irrespective of several national policies, strategies, and interventions, which include universal health coverage, free maternal childbirth, and free treatment for children under the age of five (Keats *et al.*, 2018). While various determinants such as socioeconomic status, maternal education, healthcare accessibility, and environmental factors influence child survival (Kisiangani *et al.*, 2020), there exists a gap in understanding the specific predictors of under-five mortality within the local context. Existing literature often fails to capture the intricate relationships among these predictors and their collective impact on survival probability, thereby hindering targeted intervention strategies (Awiti *et al.*, 2018; Kaguthi *et al.*, 2012). Therefore, understanding annual changes in child survival and predictors of under-five mortality in Siaya County can provide insight into healthcare performance and provide evidence to inform intervention planning aimed at mitigating child mortality rates and advancing the health outcomes of children in the region.

### **1.3 Research Objective**

#### **Main objective**

To investigate the survival probability and predictors of under-five mortality in Siaya County between 2015 and 2020.

#### **Specific Objectives**

1. To estimate the survival probability among under five living in Siaya County between 2015 and 2020
2. To establish socioeconomic predictors of under-five mortality in Siaya County between 2015 and 2020.
3. To determine the child and maternal health care-seeking behaviors predictors of under-five mortality in Siaya County between 2015 and 2020.
4. To determine the environmental predictors of under-five mortality in Siaya County between 2015 and 2020.

### **1.4 Research Questions**

1. What is the survival probability of under-five children living in Siaya County over time?
2. What are the socioeconomic predictors of under-five mortality in Siaya County between 2015 and 2020?
3. What are the child and maternal health care-seeking behaviors predictors of under-five mortality in Siaya County between 2015 and 2020?
4. What are the environmental predictors of under-five mortality in Siaya County between 2015 and 2020?

### **1.5 Study justification**

The under-five mortality rate is a key indicator of a nation's level of child health and gross development (UNICEF, 2018). Despite the interventions done by the Ministry of Health (MOH) in collaboration with Non-governmental institutions in Siaya County like free maternity services, expansion of immunization coverage in every health facility, integration of Prevention of Mother to Child Transmissions (PMTCT) services, improving HIV treatment and testing in lower facilities, free medication among under five, training and empowering community health volunteers in the detection of danger signs and real-time referral and management of acute or severe illness (MOH, 2018). Siaya has a persistently high number of under-five mortality rates, underscoring ongoing challenges in child health and survival.

Unlike other counties, it has other poor public health indicators that may be associated with under-five mortality, such as high HIV prevalence at 14.2%, high teenage pregnancies, and poor health-seeking behavior (NASCO, 2020; KNBS, 2023). Given this context, a focused examination within Siaya County is essential, considering its unique sociodemographic and maternal factors that may influence U5MR differently compared to other regions. By utilizing HDSS data from 2015 to 2020, the study aims to assess intervention effectiveness and identify areas necessitating targeted efforts for improvement. Through the exploration of predictors such as maternal health care-seeking behaviors, socioeconomic, and environmental conditions, the study seeks to pinpoint key predictors that can be addressed through policy interventions and public health programs. In addition, by identifying the most important factors, this study aimed to contribute to the growing evidence-based understanding of why the under-five mortality rate is high in Siaya County, Western Kenya Region. The findings are valuable for policymakers and for adopting cost-effective methods in our resource-limited country.

### **1.6 Significance of the Study**

Understanding survival probabilities, and the predictors of under-five mortality in Siaya County holds enormous significance in addressing public health challenges and guiding targeted interventions in Western Kenya. The study results clarified the higher risk of death among children at an early age and key predictors of under-five mortality such as maternal age, number of ANC visits, place of delivery gender, educational attainment, and toilet type. This knowledge will inform the planning of improvement interventions targeting health promotion and service delivery strengthening in the county. It also contributes to the development of tailored strategies aimed at reducing under-five mortality rates and improving child health outcomes in Siaya County and similar regions across the globe.

### **1.7 Scope and Limitations of this study**

The study ought to investigate the survival probability, and predictors of under-five mortality, including socioeconomic, environmental, and healthcare-related determinants, and assess the effectiveness of existing interventions in reducing child mortality rates in Siaya County. It utilized data from the Siaya HDSS dataset collected between 2015 to 2020. Since the data used are secondary, they might not include additional variables that were highlighted in the literature review. In addition, limitations may arise due to potential data inconsistencies, incomplete records, and the complexity of accurately identifying all contributing factors to under-five mortality, particularly within a specific geographical context.

## 1.8 Definition of terms

**Under-five mortality rate:** The probability per 1,000 that a newborn baby will die before reaching age five, if subject to age-specific mortality rates of the specified year

**Out-migration:** People moving from the HDSS to other areas outside the HDSS without moving back within the study period.

**Wealth quintile:** A measure of an individual's or household's economic and social position within a society, often determined by factors such as income, education, occupation, and access to resources. Wealth quintiles group households into five equal parts, ranked from lowest to highest, each representing 20% of the total number of households in the economy.

**Survival Probability:** The likelihood or chance that an individual, particularly a child under the age of five in this context, will survive a certain period of time, usually expressed as a percentage or a ratio.

**Predictors:** Factors or variables that are used to forecast or estimate a future outcome. In the context of under-five mortality, predictors could include socioeconomic status, access to healthcare, maternal education, prevalence of diseases, and other relevant factors.

**2015-2020:** The time frame under study, representing a five-year period during which data on under-five mortality and predictors of survival probability in Siaya County, Western Kenya, are analyzed and evaluated. This time frame allows for the assessment of trends and patterns over a significant period.

**Social determinants:** Refer to the various social, economic, and cultural factors that influence the health, well-being, and life opportunities of individuals and communities.

**Maternal and Child Health Services:** Programs and interventions aimed at promoting the health and well-being of mothers and children, including prenatal care, maternal nutrition, skilled birth attendance, postnatal care, and child immunization. Access to and utilization of these services can impact under-five mortality rates.

**Livestock ownership:** Refers to the legal and/or rightful possession of animals raised or kept for various purposes such as food production, agriculture, labor, or companionship.

**Index child:** Refers to a specific child within a family or a study population that serves as the focal point of observation or analysis.

## CHAPTER TWO

### LITERATURE REVIEW

#### 2.1 Introduction

This chapter focused on the literature associated with under-five mortality among children under five years. It involved views of scholars, conceptual review, and empirical research from other studies that provided research work with an opportunity to contrast and compare results. It helps to guide the analytic framework adopted in this work.

#### 2.2 Overview of under-five Mortality

Under-five mortality in Kenya has been declining from 98 deaths per 1000 live births in 1990 (Foster, 2014) to 41.9 deaths per 1000 live births in 2021 (UN - IGME, 2022), with the prevalence varying from region to region. Nyanza, Northeastern, and Coastal regions recorded higher under-five mortality of more than 70% while the Central region has the lowest mortality of less than 30% (KNBS, 2022).

Most under-5 child deaths in Kenya are due to conditions that are preventable and treatable through interventions that are widely accessible, straightforward, simple, and low price such as the use of antibiotics used for treating pneumonia, oral rehydration remedy for managing diarrheal diseases, and the availability of insecticide-treated nets (ITNs) to prevent malaria (Kebede *et al.*, 2023). Pneumonia, diarrheal diseases, and malaria are the major causes of death during the post-neonatal period while birth asphyxia, prematurity, and neonatal sepsis remain the major causes of death in the neonatal period (WHO, 2018). HIV-related deaths have significantly contributed to under-five mortality, and the incidence of mother-to-child transmission has decreased to less than 5% in 2018 (MOH, 2018). In addition, the undernutrition of children in Kenya is the same as the global one with 26% of children being stunted before the age of 5 years. 11% are underweight and 6% are malnourished though the severity of malnutrition varies across different socio-demographic and geographical regions (UN & IGME, 2021). Finally, if significant advancements are not made in the African region, there is a chance that mortality figures could either remain stagnant or possibly rise. Despite the relatively high under-five mortality rates in Sub-Saharan Africa, there are indications of improvement within the region between 2015 – 2021 (UN-IGME, 2022). However, childhood mortality continues to pose a significant challenge for these developing nations, particularly as researchers strive to identify the contributing factors to these elevated levels (WHO, 2018)

## **2.3 Socioeconomic factors and under-five mortality**

### **2.3.1 Maternal education**

Previous literature has shown that more maternal education increases mothers' personal, social, and cultural capital, which is associated with higher child survival (Raghunathan *et al.*, 2019; Kiross *et al.*, 2019). Better-educated mothers have better access to health care and thus greater awareness of children's health and sanitation (Bado & Susuman, 2016). They are also good at maintaining universally accessible health information and infrastructure (Patel & Olickal, 2021). Therefore, making a prompt decision in case of any danger sign that may result in under-five mortality.

Raghupathi & Raghupathi (2020) also found that mothers with a high level of education are associated with better physical and decision-making interdependence within their home, thus improving child health results. However, Grpin & Bharadwaj (2015) argued that higher levels of education lead to delayed marrying age, sexual debut, and first childbirth, leading to better economic opportunities for women. Furthermore, a study conducted in Uganda and Malawi suggests that each additional year and educational level reduces the likelihood of dying (Andriano & S Monden, 2017). However, another study revealed that education has no impact on infant mortality. He further explained that under-five mortality is higher among highly educated mothers, possibly due to the lower number of educated women in the region. This may be due to the small sample size used (Monden & Smits, 2013).

In Siaya County, Kaguthi *et al.*, (2018) found no association between maternal education and under-five mortality, possibly due to a small sample size of mothers attending sick visits or hospital stays.

Conversely, another study by Awiti *et al.*, (2018) demonstrated that children born to mothers with a high level of education are less likely to die under the age of five compared to children with a low level of education. However, the geographic area and sample size used were small, necessitating a study with a larger population and geographic area.

### **2.3.2 Wealth index**

The Wealth Index is a total indicator of a household's standard of living through time. It is determined using the respondents' household assets, furnishings, and services (Rutstein, 2004). In HDSS, this variable is defined as information about the possession of economic goods such as television, radio, lantern, mobile phone, bicycle, sofa, land ownership, livestock ownership, and dwelling characteristics like the source of drinking water and toilets. Household financial status significantly impacts child survival rates, with children from higher economic classes demonstrating greater chances of survival

(Lartey *et al.*, 2016). Stahl & Alexander (2012) identified socioeconomic status as one of the main predictors of survival, noting a 44% higher likelihood of survival to the fifth birthday among children from higher backgrounds compared to those from lower classes. In addition, their research highlights that wealthier families are three times more likely than poorer families to access crucial child survival treatments being covered across the continuum of care (Stahl & Alexander, 2012).

Lu *et al.*, (2019) found that the likelihood of death in the post-neonatal period in the wealthiest households was 85% lower than in the poorest households in the bivariate analysis. However, the association between wealth and newborn death was not statistically significant in the multivariate analysis. In addition, Wu, (2022), found that compared to children from high-class households, the mortality rate for both girls and boys living in low-class households was 40% higher. In Siaya County, most households are considered poor, with more than 56.4% of mothers farming on a small scale or being housewives, so they depend on their husband's little resources (Odhiambo *et al.*, 2012). However, there is limited data on the current scientifically documented evidence of the relationship between wealth index and under-five mortality within Siaya County.

## **2.4 Demographic factors and under-five mortality**

### **2.4.1 Maternal age at birth and under-five mortality**

According to previous studies, a mother's age at birth affects her child's chance of survival, and children born to younger and older women are more likely to die before age five (Tesfa *et al.*, 2021; Ahinkorah, 2021). Moreover, maternal age at birth strongly influences the physiological risk of under-five mortality, socio-economic profile, education, nutrition, and maternal morbidity that cause under-five mortality (Neal *et al.*, 2018). According to Sinha *et al.*, (2016), mothers at a young age have an increased risk of delivering through cesarean section, low birth weight and low gestational age, and utilization of health service delivery. The authors further argued that offspring born to mothers below 19 years and over 35 years have a greater risk of under-five mortality, due to the mother's advanced socio-economic profile. On the other hand, Bhusal & Khanal (2022) assert that mothers at a younger age have low levels of education which influences their health-seeking behavior hence high under-five mortality.

Selemani *et al.*, (2016) also ascertain that children born to mothers of extreme ages experience a greater risk of dying. They further explained that mothers of younger ages experience financial and social challenges that result in less health care being provided. In addition, mothers of young

maternal age have higher odds of developing complications during pregnancy such as preterm delivery, chorioamnionitis, endometritis, and mild preeclampsia which are the major contributing factors to neonatal mortality (Cavazos-rehg *et al.*, 2016). In Siaya County, most mothers are younger than 10 – 19 years. A report by the Office of the High Commissioner for Human Rights (OHCHR) revealed that teenage pregnancy in the county is still high despite a significant reduction from 35% in 2016 to 20% in 2020 (OHCHR, 2020). Moreover, a study by Paul Awiti (2018) revealed that mothers with extreme ages have higher odds of under-five mortality in Karemo Sub County. However, the study recommended future research with data from a more extensive geographical area with a broader population.

#### **2.4.2 Maternal marital status and under-five mortality**

Studies have shown that continuity and frequency in marriage play important roles in child survival (Lindström & Rosvall, 2019). Discontinuity often leads to reduced resources for raising children and inequalities in child survival, particularly in a region like Sub-Saharan Africa, where divorce or family separation is rare (Smith-Greenaway & Clark, 2017). Children of married mothers have higher chances of survival than those born from single parents (separated, widowed, divorced, single) (Shifa, Ahmed, & Yalew, 2018; Takele, Zewotir, & Ndanguza, 2019), because of the financial and emotional support or input received from their father at every stage of life (Francisco, 2013).

Ntoimo & Odimegwu, (2014) revealed that single mothers face various challenges such as low economic resources, poor parental resources, and poor health-seeking behavior which directly influence child growth and survival. Furthermore, a study conducted in Chad, Mali, Niger, DRC, and Zimbabwe has shown that unmarried mothers have higher chances of child mortality than their married counterparts due to a lack of spouse support (Yaya *et al.*, 2018). In Siaya County, there are few pieces of literature on the association between marital status and under-five mortality. A study by Paul Awiti (2018) found that children born to married mothers experienced less under-five mortality as compared with their counterparts who are not married. The study reported that the sample size was small, necessitating a study in Siaya County with a more extensive geographical region and broader population.

### **2.5 Cultural factors**

#### **2.5.1 Religion affiliation**

Religion affiliation significantly affects the outcome of child survival. A study conducted in Mozambique argued that mothers aligned to Catholic or Protestant religions have less under-five

mortality due to churches' more grounded association with the medical sector (Ede *et al.*, 2017). The authors further argued that Apostolic mothers have solid social ties and support in their communities. Catholic religion has also been associated with higher levels of autonomy due to its connection in international research on religion and the empowerment of women compared to those who attended traditional churches or are not affiliated with religion due to its connection in transnational religious studies and women's empowerment (Wroblewska *et al.*, 2016). Church intervention has influenced women's decision-making about marriage and family due to their comprehensive educational support. This, in turn, has helped them improve their attitudes and knowledge regarding marriage and health-seeking behavior leading to increased child survival (Hallfors *et al.*, 2016).

In contrast, several references have shown that religious affiliation has no significant association with under-five mortality. Richards *et al.*, (2022) found that different religions increased child mortality in the district in Mozambique in bivariate analysis, but there was no association between under-five mortality and household religious affiliation in multivariate analysis. The authors further argued that the greater risk of death in religious minorities was due to poor health systems and quality. No study has been conducted in Siaya County to show the relationship between religion and under-five mortality.

### **2.5.2 Family size**

The likelihood that a child will survive is greatly influenced by the number of children in a family. Children born into families with sizes of 4-6 have a 71% higher risk of dying than children born into families with sizes of 1-3, according to studies done in Ethiopia (Gebretsadik & Gabreyohannes, 2016; Dendup *et al.*, 2018). Additionally, another study found that children from polygamous families experience higher mortality, arguing that the elevated mortality rates may result from domestic violence and neglect from the household head of the polygamous family (Titilayo *et al.*, 2017). Wambugu (2014) asserts that children born in bigger families have a higher probability of dying than those with smaller families. The author further explained that this may be due to poor health-seeking behavior experienced in large families. In Siaya County, a study that examines the association between family size and under-five mortality has not been conducted. Therefore, there is a need to show the extent family size can influence under-five mortality.

## **2.6 Maternal Health seeking behavior**

The effectiveness of health-seeking behavior is crucial in influencing the likelihood that children will survive. According to a study done in rural Rwanda, children whose parents seek formal treatment have reduced under-five mortality (Kagabo *et al.*, 2018). In addition, factors such as increasing use of antenatal care, high rates of birth in a medical facility or with trained providers, increased knowledge of life-threatening complications during pregnancy, uptake of treatments, and a reduction in waiting times for medical attention improve child survival (Bhusal & Khanal, 2022).

### **2.6.1 Events around antenatal care**

Antenatal care is crucial for the mother's health and the growth of the unborn child (Larrañaga *et al.*, 2009). According to World Health Organization (WHO) guidelines, a pregnant woman should visit the hospital at least four times, with the first visit in the first trimester (WHO, 2018). The utilization of antenatal services offered at every level of a health facility has led to the early detection of complications and danger signs of pregnancy leading to a reduction in under-five mortality and morbidity (Machio, 2018). According to a study conducted in India mothers attending antenatal care more than 4 visits and those who received care from the first trimester have been observed to have reduced newborn mortality (Gupta & Talukdar, 2017).

Ochieng & Odhiambo, (2019) showed that multiple factors influence behavior when seeking formal health care during pregnancy, childbirth, and after childbirth in Siaya County. The study further argued that some of the well-known factors include proximity to the health facility, lack of transportation, and finances. Factors such as knowledge of the importance of ANC beyond the treatment of normal conditions, the relationship between the healthcare provider and the patient, the negative attitude of the healthcare provider, and the woman's negative experience in the healthcare setting emerged as factors influencing her decision-making (Ochieng & Odhiambo, 2019).

Studies have also revealed that low ANC attendances are associated with adverse pregnancy outcomes. According to a study conducted in Uganda, high ANC attendance of more than 4 times reduces the likelihood of developing pregnancy outcomes such as preterm delivery and low birth weight (Pervin *et al.*, 2020). This may be due to the high number of hospital deliveries with the assistance of skilled birth attendants seen among mothers who have attended ANC more than 4 times. However, no study has been conducted to show how antenatal health-seeking behavior affects under-five mortality in Siaya County.

## 6.2 Events around delivery

Quality of delivery determines the maternal outcome, improving child morbidity and mortality (Appiah *et al.*, 2020). Numerous studies have discovered a considerable correlation between child survival and certain fertility behaviors. Hospital delivery, perinatal care, qualified birth attendants, and information about complications of pregnancy have improved infant survival during labor and delivery. In addition, children born below average birth weight are much more likely to die in early childhood than those born below average. In addition, another study has shown that private hospitals perform better than public hospitals (Singh & Tripathi, 2013).

The amount of time spent between pregnancy and delivery has an impact on determining the newborn's survival outcome (Vogel, & Chawanpaiboon, 2018). Preterm delivery has been linked with negative birth outcomes and is the primary cause of death during the neonatal period (Thanh *et al.*, 2019). In their study, Khan *et al.*, (2014) observed that preterm delivery was common among women with lower socioeconomic activities and low education. Maternal factors such as diseases of the urinary tract, hypertension or hypertensive disorders in pregnancy, bleeding during pregnancy, and rupture of membranes before labor are also the major causes of preterm delivery (Wagura *et al.*, 2018).

The mode of delivery has a greater impact on child mortality. Various literature has revealed that children born through cesarean section are subjected to more complications during delivery (Thanh *et al.*, 2019). Women with previous cesarean delivery have a higher risk of developing fetal distress during induction of labor. Many injuries during delivery have been observed to be commonest among children born by instrumental vaginal delivery, leading to higher infant mortality (Kiwani R, 2018). Skilled assistance during delivery is referred to as care given to the mother during labor and early postpartum period performed by a skilled birth attendant with midwifery skills to manage normal deliveries and refer complicated deliveries (WHO, 2018). Despite 96% of women aged between 15 – 49 received at least one ANC visit from a skilled provider (KNBS, 2016), only about 82% in urban areas and 50.2% in rural areas in Kenya delivered in hospitals (UNICEF, 2016). Mwangi *et al.*, (2018) observed that mothers who seek care of skilled health attendants experience lower rates of maternal and neonatal mortality. Similarly, another study found a considerably higher risk of neonatal deaths among mothers delivered by unskilled birth attendants compared with skilled birth attendants. The study further argued that the low proportion of newborn deaths delivered by midwives is due to better neonatal care provided by skilled birth attendants in contrast with unskilled birth assistants (Badriah *et al.*, 2014). Furthermore,

Pal (2015) argued that hospital delivery endures advanced medicine, timely medical attention, and modern diagnostics, benefiting both mother and child and thereby helping improve their health hence reducing child mortality and morbidities.

Umutesi *et al.*, (2021) observed that home births are still high in Siaya County and may be due to causes affecting maternal decision-making that are not medical or cultural but more contextual. The authors furthermore argued that culture, economic influences, and the healthcare system are the three most important factors influencing maternal birthplace decisions. In addition, the study explained that proximity to the facility, medical conditions such as HIV infection, and past birth experience are factors in home birth (Umutesi *et al.*, 2021). However, there are no studies conducted in Siaya that have shown the link between place of birth and under-five mortality.

## **2.7 Environmental factors**

### **2.7.1 Source of drinking water and toilet facility**

Freshwater quality and quantity are essential for every development, maintaining healthy ecosystems and supporting economic growth in agriculture, manufacturing, and energy production (UN, 2018). Access to unimproved water and sanitation among children under five years old has remained a global public health concern (Ogbo *et al.*, 2017). It is the major cause of diarrhea, which has accounted for many deaths among under five in developing countries (UNICEF, 2019). Therefore, the risk of infant mortality has risen considerably because of inadequate water and sanitation (Gaffan *et al.*, 2023).

The source of water has also affected the quality and contamination level of water at the source, reducing the transmission level of water-related diseases (Singh & Gupta, 2017). Construction of wells and boreholes as an alternative source of water is highly recommended especially in rural areas (Sharma Waddington and Cairncross, 2021). Hence, World Health Organization has come up with various safety measures to ensure the quality and quantity of water for drinking to all (WHO, 2018).

In their study, Bereka & Habtewold (2017) argued that a child born in a family without access to protected drinking water had an 80.5% higher risk of dying than a child born in a home with such access. Another study found a correlation between the source of drinking water and under-five mortality, positing a significant link between water source and diarrheal diseases (Gaffan *et al.*, 2023).

Studies have shown that water from unprotected wells is highly populated by *fecal coliform* and *schistosoma* during both rainy seasons and off-rainy seasons. This was due to the contamination of fecal

matter from animals and humans and the widespread use of communal laundry facilities close to the wells (Lin *et al.*, 2022; Musuva *et al.*, 2021)

### **2.7.2 Cooking fuel**

Cooking fuel is one of the environmental variables influenced by socioeconomic status characteristics and household wealth index (Mosley & Chen, 2003). Various studies have associated the type of cooking fuel with under five mortalities (Alam *et al.*, 2022; Samuel *et al.*, 2016). Children from poor families in rural homes whose parents have no formal education and engage in farming activities majorly use firewood, cow dung charcoal, and biomass as a source of fuel and have higher mortality (Owili *et al.*, 2017).

Air pollution from solid waste in homes during cooking significantly contributes to respiratory illness and death due to the continuous emission of health-harming pollutants such as fine particles, greenhouse gases, and other chemicals (Naz *et al.*, 2016). A study done in Pakistan has strongly linked the source of cooking fuel and mortality among children from households without separate kitchens and women who never breastfeed at all (Naz *et al.*, 2017). Children in the kitchen with their mother at all times during cooking (Chakraborty *et al.*, 2014) and proximity to smoke have increased risk of health problems (Naz *et al.*, 2016)

## **2.8 Theoretical framework**

This study will utilize Mosley and Chen's theoretical framework for child survival (Mosley and Chen, 1984). It was developed to study the risk factors of child mortality in expanding nations and its major objective was to integrate research methodology used by social and medical scientists.

Mosley and Chen distinguished between variables considered to be socio-economic variables and biomedical variables. To have an effect on child mortality, socioeconomic factors work through a similar set of five proximate determinants: maternal, household environmental factors, nutrient deficiencies, injury, and personal sickness control. These proximate determinants affect the state of health of the child, determine whether the child is sick or healthy, and once the child is sick, they go on to establish whether the child gets well or dies (**Mosley & Chen, 1984**).

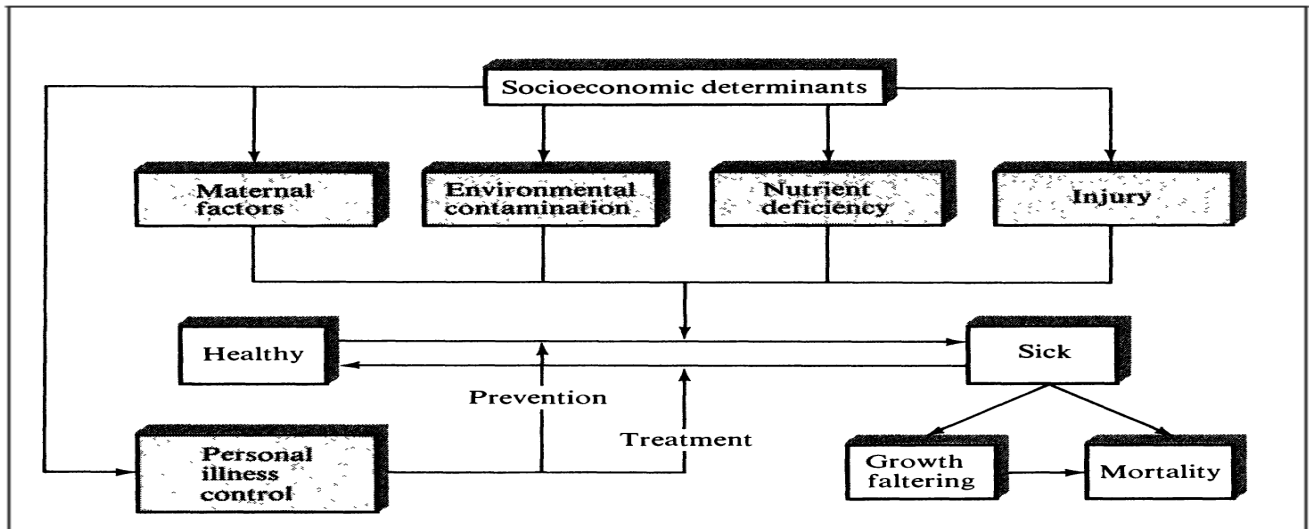
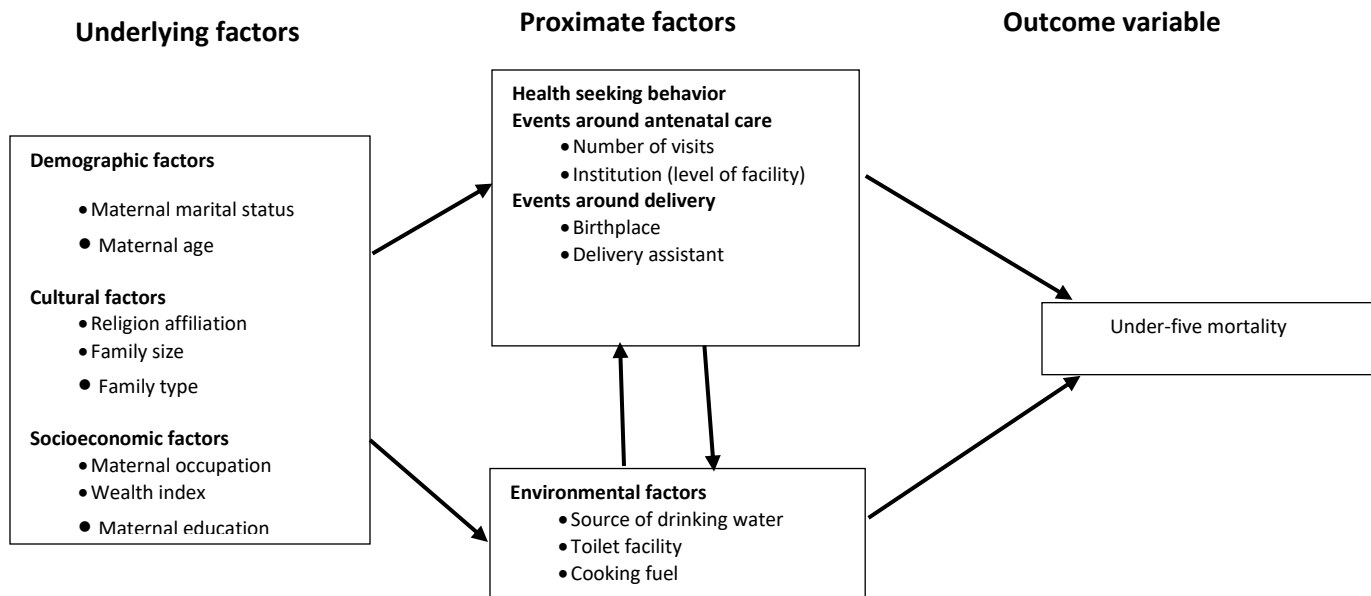


Figure 2.1: Analytical framework for childhood survival in developing countries.

### 2.8.1 Conceptual Framework

The conceptual framework was developed from Mosley and Chen's (1984) theoretical framework. In this study, we chose this model because it's widely used and well-known in child survival research. Regarded as essential and all-encompassing within systematic analytical frameworks, it is highly valued for its biosocial perspective on child survival in developing nations. Plus, it can be changed to work for different situations. The framework was modified such that the socioeconomic determinants are the underlying factors. They include maternal education, wealth index, occupation, marital status, region affiliation, marital status, family size, and maternal age at birth. They will operate through maternal and environmental factors, which include maternal health-seeking behavior that is events around antenatal care and delivery, and environmental factors such as type of toilet, cooking fuel, and source of drinking water to determine under-five mortality

Figure 2.2: Conceptual framework modeled from Mosley and Chan



Source: Adopted from Mosley and Chen (1984) conceptual framework

## **CHAPTER THREE**

### **RESEARCH METHODOLOGY**

#### **3.1 Study Area:**

The study was carried out in Siaya County, Western Kenya. The county is bordered by Busia County to the north, Kakamega and Vihiga County to the northeast, and Kisumu County to the southeast. The total area is approximately 2,496.1 km and the county lies between latitude 0° 26' to 0° 18' north and longitude 33° 58' east and 34° 33' west. It is divided into 6 sub-counties with a total population of 842,304 (**Appendix 1\_Study area map**) (KNBS, 2009). Over 95% of the population is from the Luo ethnic community and lives primarily in rural areas with local trade and subsistence farming as their main sources of income. In addition, the county is a malaria endemic zone with a high HIV prevalence of 21% and an under-five mortality rate of 63 deaths per 1000 live births. Finally, the KEMRI/CDC HDSS where data was retrieved is conducted in three sub-counties: Rarieda, Siaya, and Gem. It follows a population of approximately 256 000 individuals with 42% of the population being children under five years. The total area is approximately 700km<sup>2</sup> with 393 villages, 64317 homes, and 44461 compounds.

#### **3.2 Study Design**

The study used a retrospective longitudinal cohort study design. The study retrieved secondary data from Siaya HDSS data set, conducted between 2015 and 2020. Siaya HDSS is a system of continuous longitudinal monitoring of demographic events in a geographically defined population, with timely production of data on all births, deaths, and migrations. Information on births, deaths, pregnancies, migrations, morbidity, parent survival status, immunization, educational status, religion, marital status, and ethnicity are collected during the HDSS data collecting "rounds". Data on verbal autopsies of all deaths that are used to track the definitive cause of death are collected. The data collected was used to regularly track and measure demographic and health dynamics, including birth rates, mortality rates, causes of death, sickness, migration, and socioeconomic indicators. Besides, it serves as a platform to monitor infectious and non-infectious disease indicators and compute disease rates by providing accurate denominators.

#### **3.3 Study population and duration**

The study population for the analysis included any child born within the study period. The child may be alive or dead at the time of the interview. This study was conducted between 2015 to 2020.

### **3.4 Sampling and Sample Size Determination**

The Siaya Health Demographic Survey (HDSS) is a longitudinal study and uses a consecutive sampling method to identify and collect data from the general population that meets their eligibility criteria. The data is collected through face-to-face interviews with women aged 15 to 49 years. Since children are the basic unit of analysis, data was transformed such that each child constitutes a unit of observation. The study used the data for the entire HDSS population.

### **3.5 Inclusion criteria**

In this study, the criteria for inclusion in the analysis was data for children born alive (24452), between 0 days old to less than 5 years of age.

### **3.6 Exclusion criteria**

In complete data at the time of abstraction.

### **3.7 Research Instrument**

A data abstraction tool was developed to abstract data from the HDSS database according to specific objectives (**Appendix 3: Data Abstraction Tool**). The tool was developed based on the selected variable of interest that will help answer our objectives. The data abstraction tool helps streamline the research process, improve data quality, and facilitate analysis by providing researchers with access to structured and organized data. It also helps ensure consistency and standardization in data extraction, which is crucial for accurate interpretation and comparison across studies.

We assessed the reliability of the tool by conducting a test-retest analysis where a subset of data is abstracted by the tool, and then the same data is re-abstracted at a later time to check for consistency. To ensure the validity of the tool, we sort for data manager review to ensure that all the relevant variables are accurately captured by the tool. In addition, the tool's outputs were compared with theoretical expectations of under-five mortality rates and associated predictors.

Finally, the HDSS uses standardized questionnaires to collect longitudinal data on vital events such as births, deaths, migrations, and other demographic characteristics within Siaya County. The questionnaires include a household registration form, socioeconomic status (SES) form, and verbal autopsy form.

### 3.8 Description of variables

#### 3.8.1 Dependent variable

**Under-five mortality:** Number of children between 0 – 59 months who died within the 6 years of the study period. The variable will be derived from information on the survival duration since birth in months. It is measured as 1: dead or 0: censored (still alive, migrated).

#### 3.8.2 Independent variables

These are factors that influence under-five mortality. They include the following:

##### Underlying determinants

###### a) Demographic factors

**Maternal age at birth** – The actual age of a woman at the time of delivery of the index child. The age was classified as 1: under 18, 2: 18 – 34, and 3: above 34 years. The breakpoints were chosen due to the need to cover different reproduction trajectories (Mustafa, 2008). Ages below 18 and above 34 years were considered extreme ages hence we expect higher mortality.

**Maternal marital status** – it is the marital position of the mother. Whether one is single, married, separated, divorced, or widowed. It was categorized as 0; divorce/separation, 1. Don't know, 2. Married, 3. Single, 4. Widowed

###### b) Socioeconomic factors

**Individual occupation** – A person's usual work or business, i.e. the type of job an individual is doing. It was categorized as 1: Fishery/Fishing, 2: Housewife/Not working 3: Farming 4: Skilled labor/Salaried worker (eg. teacher, nurse, office) 5: Business owner 6: others

**The wealth index** – refers to measures of a household's cumulative standards where the woman resides. It was categorized as 1: 1<sup>st</sup> quantile to 5: 5<sup>th</sup> quantile.

**Maternal education** – The highest level of education attained by the mother was categorized as 1: None, Primary Education, Secondary Education, post-secondary.

###### c) Cultural factors

**Religion affiliation** - Association of a person with religion (the church an individual attends). They were categorized into 1: Protestants, 2: Catholic, 3: Roho/Legio Maria, 4: Others.

**Family size** – The number of individuals living within a given household. It was classified into 1: 1 – 3 members, 2: 4 – 6 members, and 3: 7+ members.

### **Immediate or proximate determinants**

#### **a) Maternal Health seeking behavior**

##### **Events around delivery**

**Delivery assistant** – It refers to an individual who assists the entire process of delivery. It was categorized into 1: Health care worker, 2: Traditional Birth Attendant.

**Place of delivery** refers to the institution where the child was born. It was categorized into 1: Home, 2: Government facility, 3: Private facility.

##### **Events around antenatal care**

**The number of ANC Visits** – The number of visits while seeking ANC care. It was categorized into 1: None, 2: 1 time, 3: 2 times, 4: 3 times, 5: 4 times.

**Hospital levels (level of facility) of ANC visits** – Referred to as the level of institution the mother attended during ANC services. It was categorized into 1: Government dispensary, 2: Government health center, 3: Government Hospital, 4: Home, 5: Private facility, and 6: Others.

#### **b) Environmental factors**

**Water for drinking** – Refer to the water used in the household for drinking. It was categorized into 1: Tap water, 2: Lake/River, 3: Rainfall, 4: Unprotected spring/borehole/well, 5: Protected spring.

**Distance to water source:** Refers to the distance between sources of water for household consumption. It was categorized as 1: In compound, 2: <500M, 3: 500M-2KM, 4: 2KM-5KM, 5: >5KM, and 6: DK.

**Toilet facility** – The place where the family dispose of the excreta. The type of toilet facility was recorded as a toilet and was categorized into 1: Those without toilets facility, 2: Modern latrines, and 3: Pit latrines.

**Cooking fuel** – What household use for cooking. It was categorized into 1: Charcoal/Firewood, 2: Gas cooker/Paraffin/Stove.

### **3.90 Data Management and Statistical Analysis**

#### **3.9.1 Data Source**

The study utilized secondary data from the HDSS dataset downloaded from the KEMRI server, which is maintained in the Microsoft SQL database at the KEMRI Center for Global Health Research in Kisumu.

#### **3.9.2 Data collection**

Data with variables of interest were downloaded from the KEMRI server into the abstraction tool. The abstract was then compared with the data in the server for uniformity, consistency, and accuracy.

#### **3.9.3 Data storage**

The data obtained from HDSS was password-protected and stored in Microsoft SQL. The encrypted hard disk was used as a backup. The data was stored for up to one month after the results had been disseminated. The analyzed data was shared again with the HDSS data manager and then they were destroyed by deleting from the Microsoft SQL and encrypted hard di as per the agreement with KEMRI.

#### **3.9.4 Data security and confidentiality**

The data obtained did not include the identities of the respondents who participated in the HDSS study or those of the data collectors. In addition, the data was kept in password-protected Microsoft SQL, computers and encrypted hard disks. In case an interested person wishes to access data, they sign the attached data confidentiality form (**Appendix 2: Data Confidentiality Tool**).

#### **3.9.5 Statistical analysis**

The covariates analyzed in this study were based on the associated literature review and the high degree of missing data in the dataset, which influenced the selection of covariates. Data cleaned and exported to R software. Exploratory data analysis was carried out to check missing values, possible outliers, and multicollinearity levels. Since not all children survived to their fifth birthday or out-migrated during the study period, I used Cox proportional hazard regression to account for censoring in the estimation over time. The outcome variable in this study was treated as the time between birth and death before the fifth birthday or until they were censored. The method took into consideration the children's survival status as well as the month of their death. Cox regression was important, as it allowed for investigating the effects of different socio-economic, demographic, cultural, maternal, and environmental factors on under-five mortality over time. It did not assume any survival model, but it was not truly nonparametric because it assumed that the effects of the predictor variables upon survival were constant over time and

were additive in one scale. The hazard ratio associated with the predictor variable was given by the exponent of its coefficient. The model was presented as follows:

$$h(t) = h_0(t) \exp(b_1X_1 + b_2X_2 + \dots + b_pX_p)$$

Where:

$h(t)$  – Hazard of under-five mortality

$h_0(t)$  – Base hazard rate at start

$B_1$  – Parameter estimate

$X_i$  – Predictor variable

How to fit the model

A Cox proportional hazard bivariate model was fitted for the outcome against the predictors independently to identify the confounding and adjusted variables for the final model. A p-value of 0.05 was used to identify the covariates to adjust for in the full model (Guffey, 2012). An adjusted Cox proportional hazard model was then fitted for the assumptions checked in trying to explore the risk factors for under-5 mortality. To assess whether a fitted Cox regression model adequately described the data, Schoenfeld residual was used to check proportional hazard assumptions. The covariates that violated the Proportional hazard assumptions were excluded in the final Cox proportional hazard analysis except for those supported by literature and biologically plausible. In addition, the Pareto chart was used to check the proportion of ‘missingness’ and variables with more than 10% missing values excluded from the final model (Dong & Peng, 2013). Multivariate Imputation by Chained Equation (MICE) was used to impute variables missing values less than 10% (Buuren & Groothuis, 2011). Stepwise Cox proportion hazard regression (backward and forward) was used for the final model and Hazard ratio (HR) was reported at p-value <0.05. Chi-square model fit was used to check the final model fit. The analysis was conducted using R software.

### **3.10 Ethical Considerations**

Approval was obtained from Jaramogi Oginga Odinga University of Science and Technology Postgraduate Studies, and Jaramogi Oginga Odinga Teaching and Referral Institutional Scientific and Ethics Review Committee. Permission to use HDSS data was obtained Centre Director Kenya Medical Research Institute Centre for Global Health Research. A formal request was then made to the HDSS

data manager to request the variable of interest needed in the analysis. The Results were made available to the public through the JOOUST and KEMRI websites and the publication of the work in a reputable journal. In addition, the findings were disseminated through data to action plan that included community engagements, sub-county and county monthly meetings, and CME at KEMRI headquarters.

## CHAPTER FOUR

### RESULTS

This chapter presents the study findings and interpretations of the findings. The descriptive analysis was used to describe and summarize the data in terms of tables, frequencies, and percentages. Inferential statistics was used to help conclude. Kaplan-Meier curve and log-rank test were performed to assess the children's survival experience across the variable categories. Cox regression proportional hazard was used in multivariate analysis. R version 4.2.2 was used to analyze the data.

#### 4.1 Descriptive statistic of the study population

A total of 24,452 children were observed in a study during the study period to attempt to examine the predictors (sociodemographic, sociocultural, socioeconomic, maternal health care seeking behaviors, and environmental factors) of child mortality & survival probability of children born in Siaya. Neonates were 1095, infants were 6243, and children were 17114 hours. At the end of the follow-up, 1540 (6.4%) new deaths were recorded during the six years of 2015 to 2020. Figure 4.1 shows the proportions distribution of under-five child mortality by different age clusters; classified as neonatal deaths (deaths of less than 28 days after birth), infant deaths (deaths between 28 days to 1 year), and child deaths (deaths between 1 year to 5 years of age).

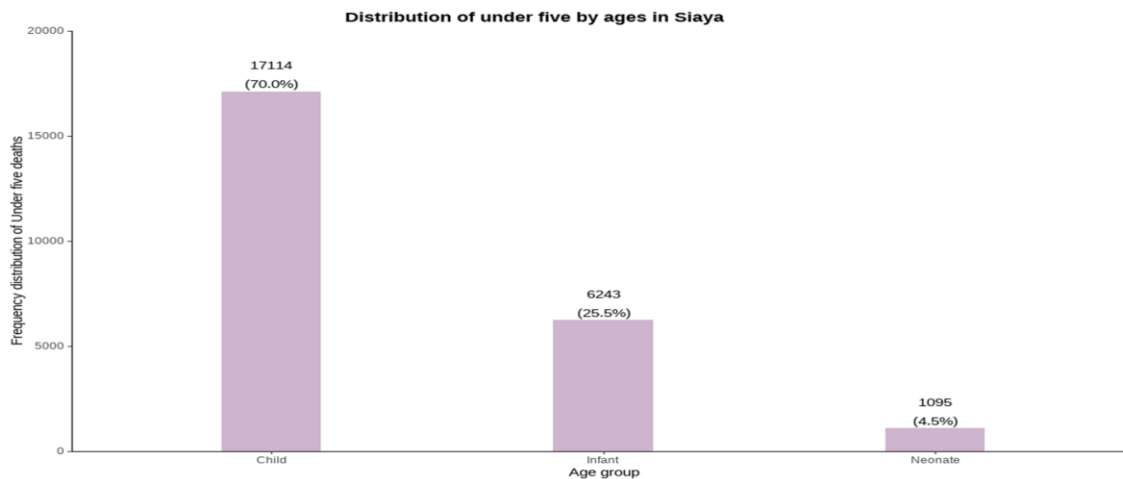


Figure 4.1a: Distribution of under-five children by age in Siaya County

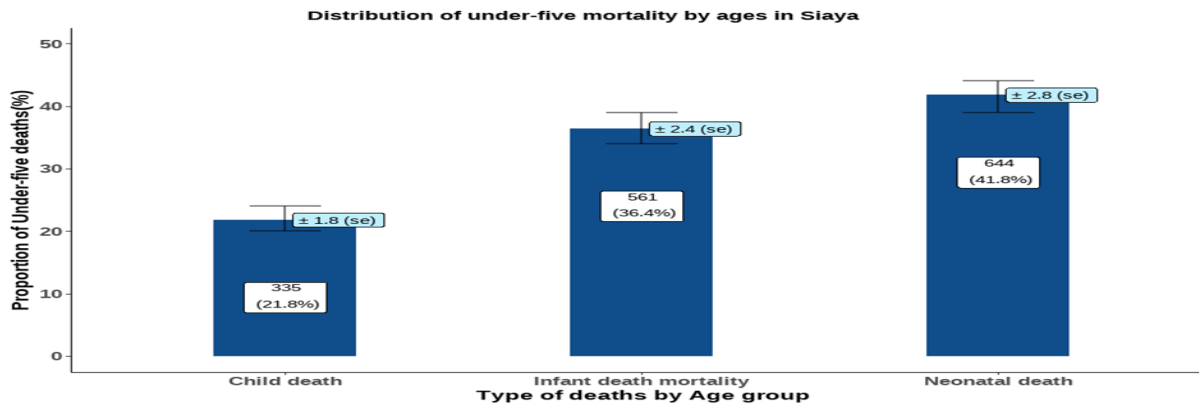


Figure 4.1b: Distribution of under-five mortality by age in Siaya County using 2015 – 2020 HDSS data.

#### 4.1.1 Socioeconomic, sociocultural, and sociodemographic characteristics of the study population

The greater percentage of children were from a family of 4 – 6 members at 55.8%, while 78.0% of mothers were 18 -34 years old, with 7.4% of mothers having teenage pregnancies. 83.2% of mothers were married. Most mothers attained primary education at 62.4%, while 59.8% of the family heads were farmers. However, most of the families come from the 2<sup>nd</sup> quantile status and the 3<sup>rd</sup> quantile at 21.3% and 21.1%, respectively.

**Table 4.1 Selected socioeconomic, sociodemographic, and sociocultural characteristics of the study population in Siaya County using 2015 – 2020 HDSS data.**

Characteristic	Overall, N = 24,452 <sup>1</sup>	Alive, N = 16,914 <sup>1</sup>	Outmigration, N = 5,998 <sup>1</sup>	Under-five dead, N = 1,540 <sup>1</sup>	P value
<b>Sociocultural and demographic factors</b>					
<b>Maternal age category</b>					
less than 18 years	1,809 (7.4%)	869 (5.1%)	793 (13.2%)	147 (9.5%)	<0.001
18 - 34 years	<b>19,075 (78.0%)</b>	12,984 (76.8%)	4,951 (82.5%)	1,140 (74.0%)	
Greater than 34 years	3,568 (14.6%)	3,061 (18.1%)	254 (4.2%)	253 (16.4%)	
<b>Family size category</b>					
1- 3 members	7,365 (34.9%)	4,539 (27.1%)	2,272 (72.9%)	554 (45.5%)	<0.001
4- 6 members	<b>11,755 (55.8%)</b>	10,421 (62.2%)	750 (24.1%)	584 (48.0%)	
7 + members	1,964 (9.3%)	1,792 (10.7%)	93 (3.0%)	79 (6.5%)	
<b>Religion</b>					
Protestants	4,246 (17.6%)	2,886 (17.3%)	1,122 (18.9%)	238 (15.7%)	<0.03
Catholic	5,584 (23.1%)	3,815 (22.9%)	1,441 (24.2%)	328 (21.6%)	
Roho/legion maria	5,120 (21.2%)	3,587 (21.5%)	1,174 (19.7%)	359 (23.7%)	

Characteristic	Overall, N = 24,452 <sup>1</sup>	Alive, N = 16,914 <sup>1</sup>	Outmigration, N = 5,998 <sup>1</sup>	Under-five dead, N = 1,540 <sup>1</sup>	P value
Others	<b>9,181 (38.0%)</b>	6,379 (38.3%)	2,210 (37.2%)	592 (39.0%)	
<b>Marital status</b>					
Divorce/separated	690 (3.7%)	406 (3.0%)	244 (6.1%)	40 (3.3%)	<0.07
Don't Know	37 (0.2%)	25 (0.2%)	8 (0.2%)	4 (0.3%)	
Married/Cohabiting	<b>15,663 (83.2%)</b>	11,713 (85.9%)	2,957 (74.5%)	991 (82.8%)	
Single	2,027 (10.8%)	1,206 (8.8%)	700 (17.6%)	121 (10.1%)	
Widowed	398 (2.1%)	296 (2.2%)	61 (1.5%)	41 (3.4%)	
<b>Socioeconomic factors</b>					
<b>Wealth Index/Quintile</b>					
1st quintile	3,710 (18.8%)	2,360 (17.5%)	1,092 (21.8%)	258 (21.1%)	<0.2
2nd quintile	<b>4,200 (21.3%)</b>	2,936 (21.8%)	994 (19.8%)	270 (22.1%)	
3rd quintile	4,164 (21.1%)	2,903 (21.5%)	1,016 (20.3%)	245 (20.0%)	
4th quintile	3,889 (19.7%)	2,747 (20.4%)	901 (18.0%)	241 (19.7%)	
5th quintile	3,753 (19.0%)	2,537 (18.8%)	1,006 (20.1%)	210 (17.2%)	
<b>Education level</b>					
None	184 (0.8%)	129 (0.8%)	33 (0.6%)	22 (1.4%)	<0.001
Primary	<b>15,168 (62.4%)</b>	10,690 (63.6%)	3,393 (56.8%)	1,085 (70.9%)	
Secondary/High	7,629 (31.4%)	5,077 (30.2%)	2,178 (36.5%)	374 (24.4%)	
Post-Secondary	1,334 (5.5%)	918 (5.5%)	366 (6.1%)	50 (3.3%)	
<b>Individual occupation</b>					
Fishery	39 (0.4%)	31 (0.4%)	5 (0.3%)	3 (0.4%)	<0.001
H-Wife/Not working	1,268 (11.7%)	902 (10.7%)	281 (16.8%)	85 (11.7%)	
Farming	<b>6,476 (59.8%)</b>	5,123 (60.7%)	865 (51.7%)	488 (67.3%)	
Skilled labor/worker	1,017 (9.4%)	770 (9.1%)	205 (12.3%)	42 (5.8%)	
Business Owner (Duka Kiosk Jua-kali)	1,898 (17.5%)	1,518 (18.0%)	282 (16.9%)	98 (13.5%)	
Other	135 (1.2%)	92 (1.1%)	34 (2.0%)	9 (1.2%)	

<sup>1</sup>n (%)

<sup>2</sup>Long rank test

#### 4.1.2 Environmental, Child, and maternal health care-seeking behavior characteristics of the study population.

The results in Table 4.2 showed that 50.5% of the children were males and 49.5% were females. Most mothers (74.5%) delivered in government hospitals while 8.7% delivered on the way to the hospital, or at home. However, qualified birth attendants assisted 93.7% during delivery. In addition, during antenatal care visits, 64.7% of the mothers attended ANC more than 4 times, and 66% preferred seeking

ANC services at government hospitals. The results showed that most families were consuming drinking water from the lakes/ rivers and unprotected springs, boreholes/ wells at 25.8% and 25.9%, respectively. Notably, 82.2% of the families were using traditional pit latrines, while 97.8% were cooking using charcoal or firewood.

**Table 4.2 Environmental Child and maternal healthcare seeking characteristics of the study population using HDSS data (2015 – 2020)**

Characteristic	Overall, N = 24,452 <sup>1</sup>	Alive, N = 16,914 <sup>1</sup>	Outmigration, N = 5,998 <sup>1</sup>	Under-five dead, N = 1,540 <sup>1</sup>	P value
<b>Child and Maternal health-seeking behaviors factors</b>					
<b>Gender</b>					
Male	<b>12,341</b> (50.5%)	8,556 (50.6%)	2,933 (48.9%)	852 (55.3%)	<0.001
Female	12,111 (49.5%)	8,358 (49.4%)	3,065 (51.1%)	688 (44.7%)	
<b>Place of Delivery</b>					
Home/ way to Hospital	2,131 (8.7%)	1,355 (8.0%)	543 (9.1%)	233 (15.2%)	<0.001
Private hospital	4,087 (16.7%)	3,095 (18.3%)	821 (13.7%)	171 (11.1%)	
Government Hospital	<b>18,189</b> (74.5%)	12,438 (73.6%)	4,619 (77.2%)	1,132 (73.7%)	
<b>Birth Assistance</b>					
Nurse/Midwife/Doct or/CHW	<b>22,870</b> (93.7%)	15,926 (94.3%)	5,584 (93.3%)	1,360 (88.5%)	<0.001
Traditional Birth Attendant	1,548 (6.3%)	970 (5.7%)	401 (6.7%)	177 (11.5%)	
<b>Place of ANC visit</b>					
Gov. Dispensary	2,813 (12.0%)	2,218 (13.5%)	473 (8.4%)	122 (8.3%)	<0.001
Gov. Health Center	3,916 (16.6%)	3,042 (18.5%)	718 (12.7%)	156 (10.6%)	
Gov. Hospital	<b>15,539</b> (66.0%)	10,171 (61.9%)	4,229 (75.0%)	1,139 (77.7%)	
Home	13 (0.1%)	9 (0.1%)	2 (0.0%)	2 (0.1%)	
Private/mission	1,239 (5.3%)	978 (6.0%)	215 (3.8%)	46 (3.1%)	
Others	8 (0.0%)	7 (0.0%)	1 (0.0%)	0 (0.0%)	
<b>ANC times</b>					
None	108 (0.5%)	63 (0.4%)	34 (0.6%)	11 (0.8%)	<0.001
One	689 (3.0%)	450 (2.8%)	183 (3.4%)	56 (4.0%)	
Two	1,893 (8.3%)	1,263 (7.9%)	466 (8.7%)	164 (11.6%)	
Three	5,351 (23.5%)	3,740 (23.4%)	1,288 (23.9%)	323 (22.9%)	

Characteristic	Overall, N = 24,452 <sup>1</sup>	Alive, N = 16,914 <sup>1</sup>	Outmigration n, N = 5,998 <sup>1</sup>	Under-five dead, N = 1,540 <sup>1</sup>	P value
Above 4	14,731 (64.7%)	10,468 (65.5%)	3,407 (63.4%)	856 (60.7%)	
<b>Environmental factors</b>					
<b>Cooking methods</b>					
Charcoal/Firewood	23,915 (97.8%)	16,559 (97.9%)	5,837 (97.3%)	1,519 (98.6%)	0.05
Gas/Paraffin/Stove	537 (2.2%)	355 (2.1%)	161 (2.7%)	21 (1.4%)	
<b>Toilet type</b>					
Neighbor -No facility/Bush/field	2,375 (9.8%)	1,590 (9.5%)	584 (9.8%)	201 (13.2%)	<0.001
Modern latrine	1,936 (8.0%)	1,302 (7.8%)	548 (9.2%)	86 (5.6%)	
Traditional pit	19,921 (82.2%)	13,873 (82.7%)	4,810 (80.9%)	1,238 (81.2%)	

<sup>1</sup>n (%)

<sup>2</sup>Long rank test

#### 4.2 Survival Probability of children under five years in Siaya County

Figure 4.2 shows the survival probability of children in Siaya County. A total of 24,452 children were at risk of under-five mortality at the beginning of the study. The at-risk group was observed and followed up for a five-year study period to examine the event or outcome of interest. At the end of year one, 7,196 (29.4%) participants had either developed the outcome or were exited in Year 2, 5,572 (32.3%) participants; in the third year, 4,570 (39.1%) participants, and in Year four, 3,348 participants, respectively. The cumulative survival probability within the first five years was approximately 90% among the children born in the study area.

#### 4.4 Kaplan Meier curve estimate

The survival probability of children below the age of five years was estimated using the Kaplan-Meier curve estimate. Analysis of the Kaplan-Meier curves revealed that the survival probability is low among neonates and starts stabilizing when the child reaches the first year (Figure 4.2a). The probability of death was lower among female children than that of the male children (Fig. 4.2b). Furthermore, children born to mothers with post-secondary education had the lowest hazard of death compared to mothers with secondary, primary, and no education (Fig. 4.2c). Additionally, children born to mothers aged 18 – 34 years showed a higher survival probability than those of less than 18 years and above 34 years (Fig

4.2d). Notably, the probability of death was high among children delivered at home compared to those delivered in the hospital (Fig. 4.2e). Regarding the family size, children below the age of five from families with >7 members had higher probabilities of survival compared to those with fewer members (Fig. 4.3f).

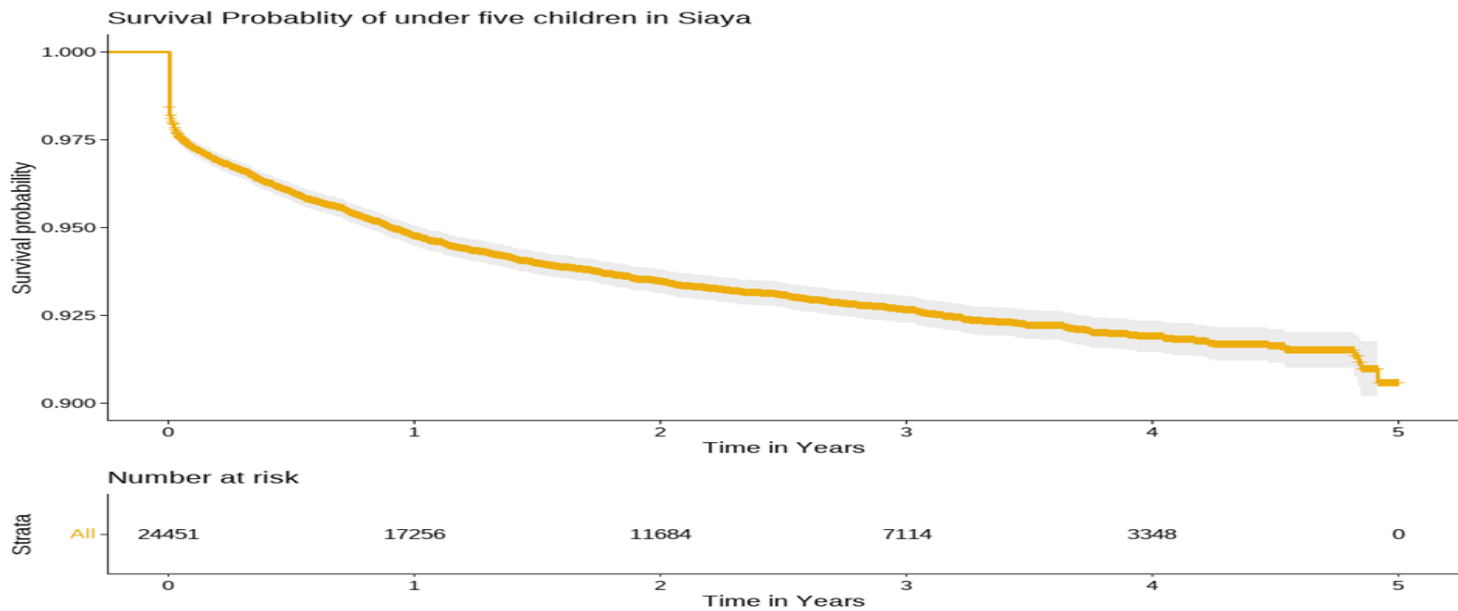
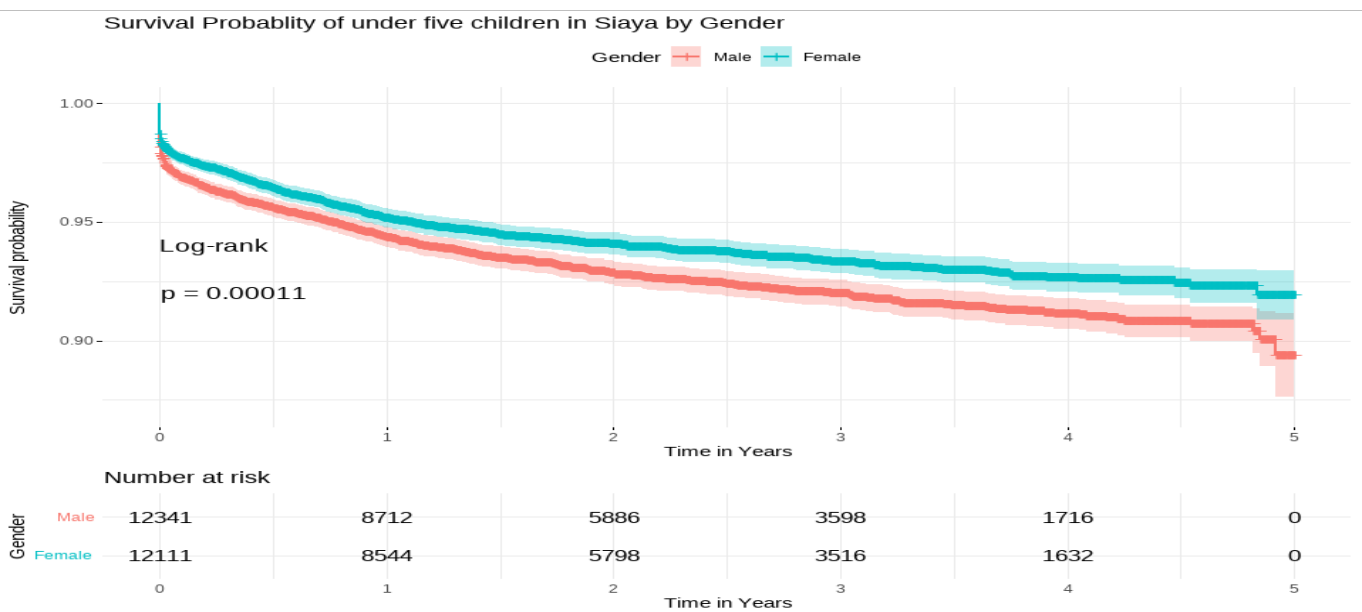
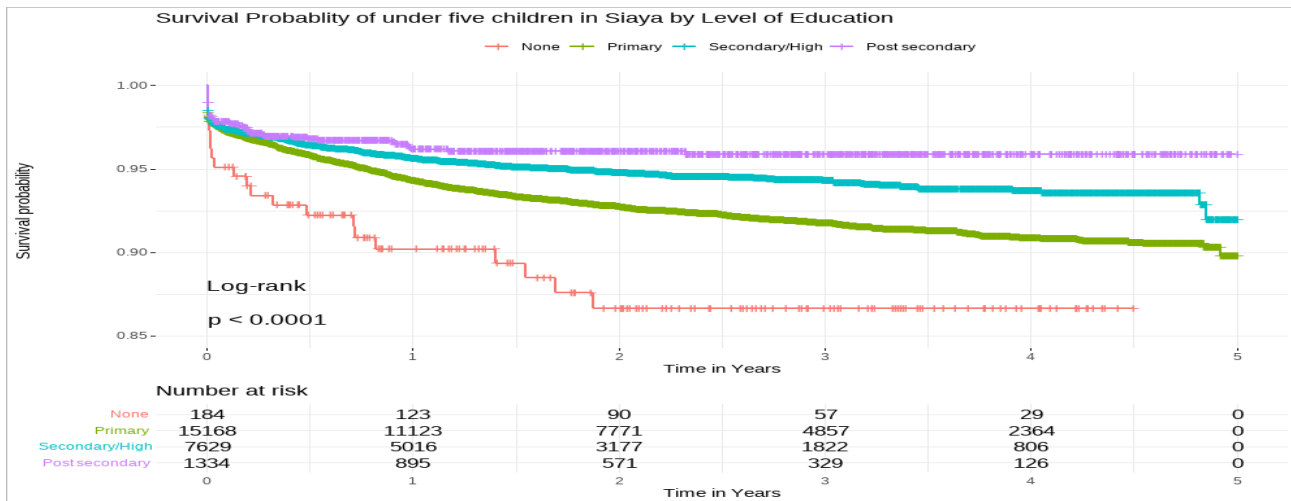


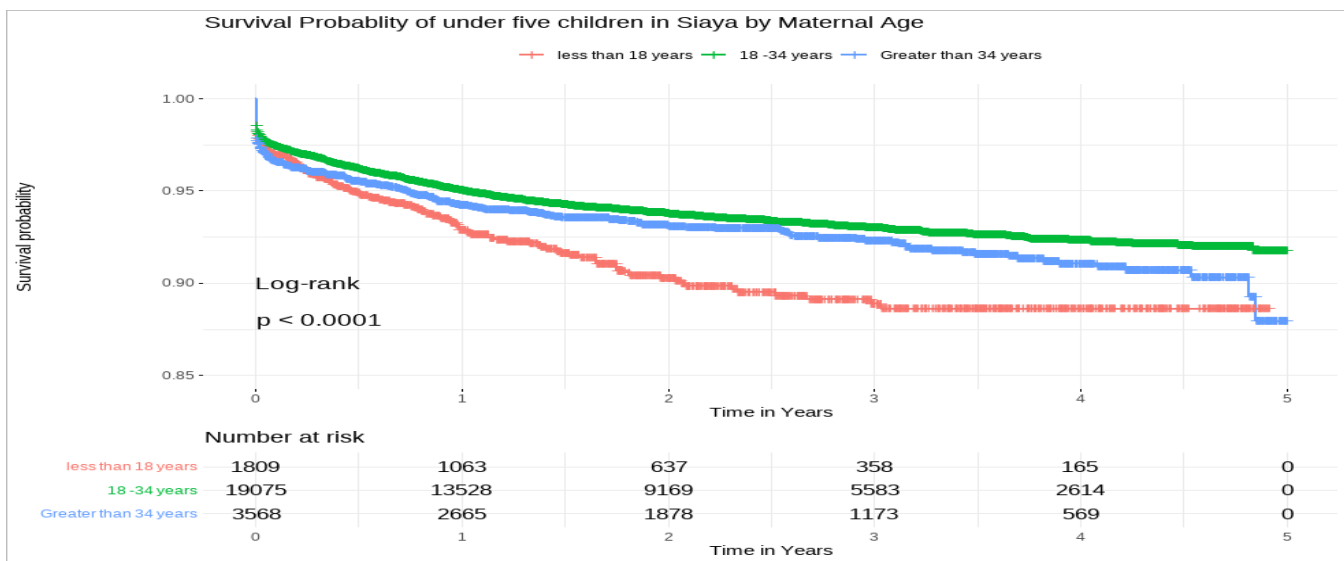
Figure 4.2a: Survival probability of children under five in Siaya County using 2015 – 2020 HDSS data.



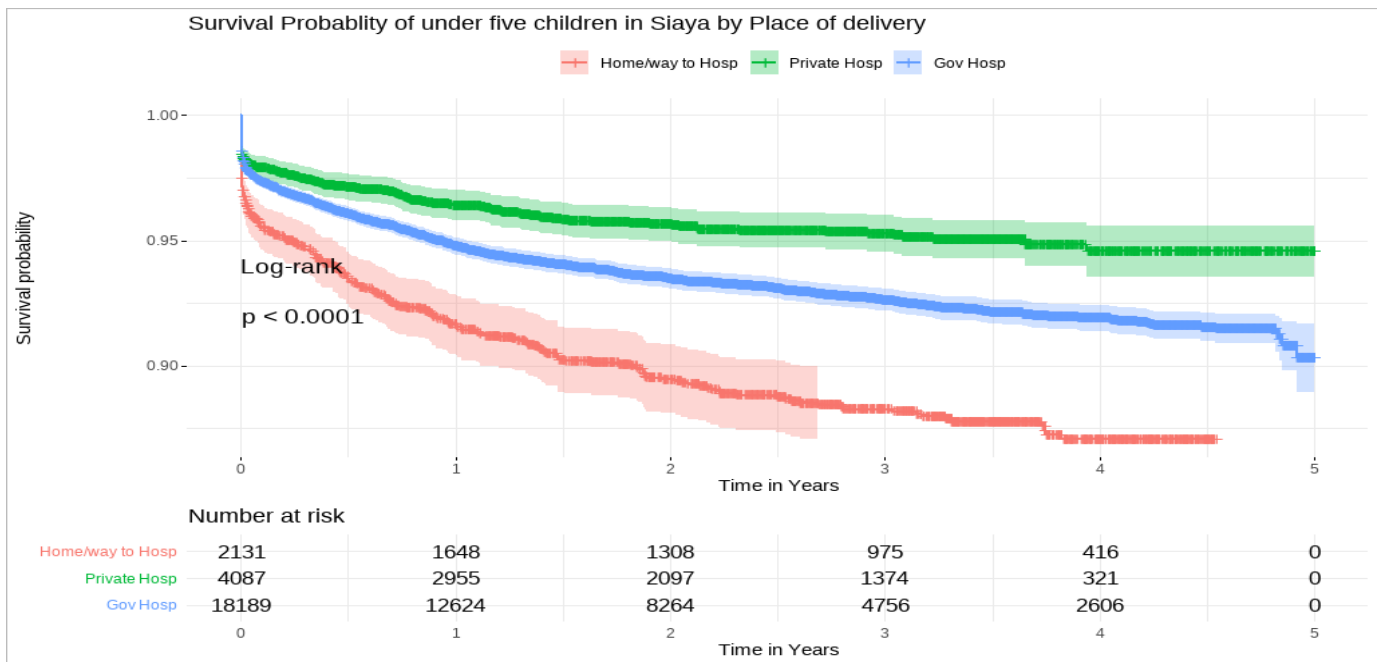
**Figure 4.2b** Kaplan Meier estimates in Gender



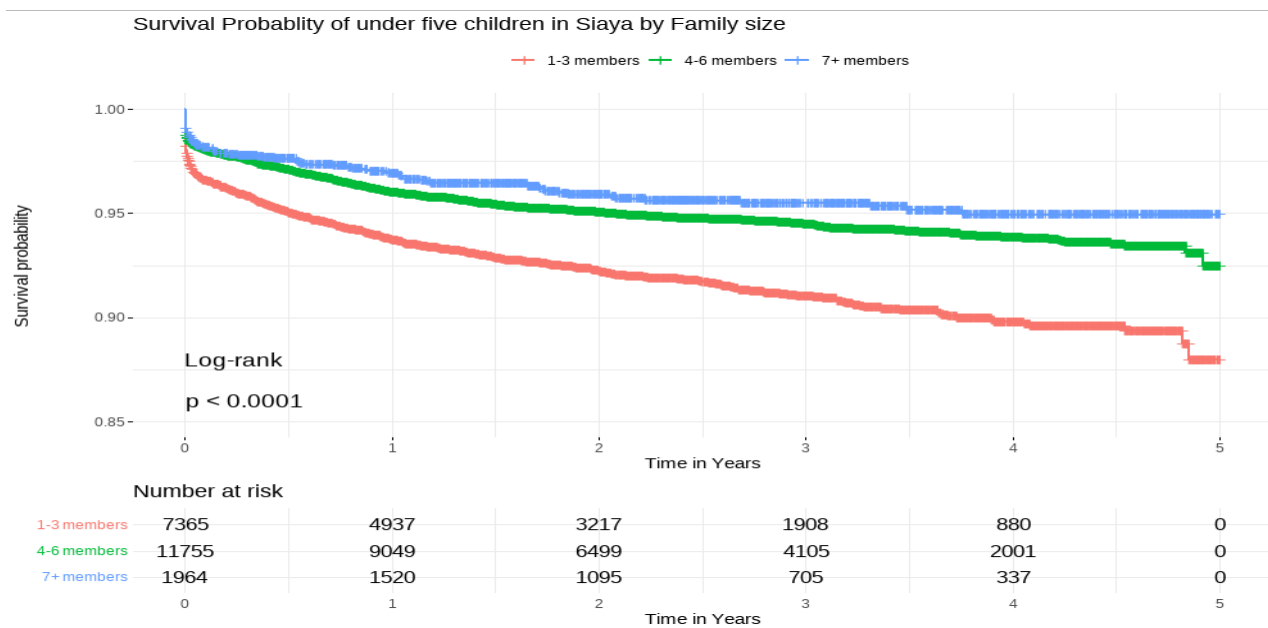
**Figure 4.2c** Kaplan Meier estimates in the level of education



**Fig 4.2d** Kaplan Meier estimates in Maternal age



**Fig 4.2e** Kaplan Meier estimates by place of delivery



**Fig 4.2f** Kaplan Meier estimates in family size

#### 4.5 Results of the multivariate analysis

The Cox proportional hazards regression model was used to determine the net effect of some selected socio-economic, socio-cultural environmental, and child and maternal variables and survival time in children under the age of five. To avoid too many variables and unstable estimates in the final model, only variables with p-values less than 0.05 and data missingness (absent values in a dataset where values were expected to be present) less than 10%, biologically plausible or supported literature were retained for subsequent analysis in multivariate analysis. The model adjusted for maternal level of education, maternal age, number of ANC visits made by the mother, location of delivery, gender of the newborn, method of cooking, and type of toilet used which were significant in bivariate analysis (Table 4.4). The study findings revealed that most of the covariates assessed significantly affected the mortality of children under the age of five. Adjusting for other predictors, the effect of child gender is significantly associated with under-five child mortality in Siaya County over the years from 2015 to 2020. The sex of the child being female reduces the risk of mortality by 18% as compared to their male counterparts HR = 0.82, 95% CI 0.74-0.82.

Children born to mothers with secondary or post-secondary education had a lower mortality risk than those born to mothers with no education: HR=0.52, 95% CI 0.32-0.84, and HR=0.40, 95% CI 0.23-0.70, respectively. Those born to mothers with a primary level of education had a 33% lower risk of death when compared to those with no level of education, though this was not statistically significant (p-value > 0.05).

The effect of maternal age on child mortality was significant. Children born to mothers between the ages of 18 and 34 had a 26% lower risk of mortality compared to those born to mothers under 18 when all other factors were held constant: HR=0.74, 95% CI 0.62-0.90. While children born to mothers over the age of 34 also had a lower risk of mortality, HR = 0.77, 95% CI 0.62-0.97.

Children born in a hospital (public/private), had a reduced risk of mortality compared to children born outside a hospital set-up while adjusting for other predictors. For instance, the risk of mortality among children born in private hospitals was reduced by 53% compared to those born outside a hospital setup; HR = 0.47, 95% CI 0.38-0.58.

The effect of the number of ANC visits was significantly associated with under-five mortality in Siaya over the years from 2015 to 2020. Attending ANC at least once improved child survival, However, having three ANC visits or more than 4 ANC visits had a higher (55% and 52%) lower risk of under-

five mortality as compared to those with no ANC visits adjusting for all other factors: HR = 0.45, 95% CI 0.24, 0.84, HR = 0.48, 95% CI [0.26, 0.8], respectively.

Children born in homesteads with modern latrines had a 31% decreased risk of mortality than those born in homesteads that relied on neighbors or bushes: HR =0.69, 95% CI 0.53-0.90. Homesteads utilizing traditional pit latrines also experienced a reduced risk of mortality, HR = 0.82, 95% CI 0.70-0.96.

Homesteads using gas, paraffin, or stove as a method of cooking, experienced an 18% decreased risk of mortality when compared to homesteads using charcoal or firewood: HR = 0.82, 95% CI 0.50-1.32. This difference was not significant in the final model, P-value = 0.65.

**Table 4.3 The final fitting Cox proportional hazard model in Siaya County using 2015 – 2020 HDSS data**

<b>Risk factors</b>	<b>Overall, N=24452<sup>1</sup></b>	<b>Alive, N=16,914<sup>1</sup></b>	<b>Outmigration N=5,998<sup>1</sup></b>	<b>U5 Death N=1540<sup>1</sup></b>	<b>CHR(95% CI)</b>	<b>AHR(95% CI)</b>
<b>Maternal education</b>						
None	184 (0.8%)	129 (0.8%)	33 (0.6%)	22 (1.4%)	ref	ref
Primary	<b>15,168 (62.4%)</b>	10,690 (63.6%)	3,393 (56.8%)	1,085 (70.9%)	0.58(0.38, 0.88)	0.67(0.42, 1.07)
Secondary/High	7,629 (31.4%)	5,077 (30.2%)	2,178 (36.5%)	374 (24.4%)	0.42(0.27, 0.65)*	0.52(0.32, 0.84)*
Post-Secondary	1,334 (5.5%)	918 (5.5%)	366 (6.1%)	50 (3.3%)	0.32(0.19, 0.52)*	0.40(0.23, 0.70)*
<b>Maternal Age</b>						
<18 years	1,809 (7.4%)	869 (5.1%)	793 (13.2%)	147 (9.5%)	ref	ref
18 - 34 years	<b>19,075 (78.0%)</b>	12,984 (76.8%)	4,951 (82.5%)	1,140 (74.0%)	0.67(0.56, 0.79)*	0.74(0.62, 0.90)*
>34 years	3,568 (14.6%)	3,061 (18.1%)	254 (4.2%)	253 (16.4%)	0.77(0.63, 0.95)*	0.77(0.62, 0.97)*
<b>No. of ANC visit</b>						
None	108 (0.5%)	63 (0.4%)	34 (0.6%)	11 (0.8%)	ref	ref
One	689 (3.0%)	450 (2.8%)	183 (3.4%)	56 (4.0%)	0.60(0.31, 1.15)	0.53(0.27, 1.03)
Two	1,893 (8.3%)	1,263 (7.9%)	466 (8.7%)	164 (11.6%)	0.65(0.35, 1.20)	0.60(0.32, 1.12)
Three	5,351 (23.5%)	3,740 (23.4%)	1,288 (23.9%)	323 (22.9%)	0.46(0.25, 0.84)*	0.45(0.24, 0.84)*
Above 4	<b>14,731 (64.7%)</b>	10,468 (65.5%)	3,407 (63.4%)	856 (60.7%)	0.46(0.25, 0.84)*	0.48(0.26, 0.88)*
<b>Place of birth</b>						
Home	2,131 (8.7%)	1,355 (8.0%)	543 (9.1%)	233 (15.2%)	ref	ref

Private hospital	4,087 (16.7%)	3,095 (18.3%)	821 (13.7%)	171 (11.1%)	0.41(0.33, 0.50)*	0.47(0.38, 0.58)*
Gov. Hospital	<b>18,189 (74.5%)</b>	12,438 (73.6%)	4,619 (77.2%)	1,132 (73.7%)	0.62(0.53, 0.71)*	0.66(0.57, 0.78)*
<b>Method of cooking</b>						
Charcoal/Firewood	<b>23,915 (97.8%)</b>	16,559 (97.9%)	5,837 (97.3%)	1,519 (98.6%)	ref	ref
Gas/Paraffin/Stove	537 (2.2%)	355 (2.1%)	161 (2.7%)	21 (1.4%)	0.65(0.42, 1.01)	0.82(0.50, 1.32)
<b>Toilet type</b>						
Neighbor/No facility/Bush/field	2,375 (9.8%)	1,590 (9.5%)	584 (9.8%)	201 (13.2%)	ref	ref
Modern latrine	1,936 (8.0%)	1,302 (7.8%)	548 (9.2%)	86 (5.6%)	0.53(0.42, 0.69)*	0.69(0.53, 0.90)*
Traditional pit	<b>19,921 (82.2%)</b>	13,873 (82.7%)	4,810 (80.9%)	1,238 (81.2%)	0.75(0.64, 0.87)*	0.82(0.70, 0.96)*
<b>Child Gender</b>						
Male	<b>12,341 (50.5%)</b>	8,556 (50.6%)	2,933 (48.9%)	852 (55.3%)	ref	ref
Female	12,111 (49.5%)	8,358 (49.4%)	3,065 (51.1%)	688 (44.7%)	0.82(0.74, 0.91)*	0.82(0.74, 0.91)*

<sup>1</sup>HR = Hazard Ratio, CI = Confidence Interval, \* = p value <0.005, <sup>1</sup>n (%)

Likelihood ratio test =3028 on 16df, p=<2.2e – 16, n=22441, number of events = 1390

Concordance=0.864 (se=0.005)

Log rank test = 5715 on 16 df, p=<2e – 16, robust = 944.9 p =<2e – 16

Model fit is 86.4%

## CHAPTER FIVE

### DISCUSSION

The main objective of the study was to estimate the under-five mortality rate and determine its predictors. The study used data from the Siaya Health Demographic Surveillance System (HDSS) to achieve its goal. The dataset was suitable for the study because it contained a large sample size and detailed information on socioeconomic and demographic, sociocultural, maternal behavior in seeking health care, and environmental factors suitable for understanding under-five mortality.

Our study also demonstrated that maternal age, maternal level of education, number of ANC visits, toilet type, place of birth, and gender significantly influenced the survival probability of children under the age of five years. The overall under-five survival rate was approximately 70%, with the survival probability of children under the age of five decreasing enormously within the first month of life. This means that neonates have the greatest hazard of death and risk decreases as the child age increases. The findings are consistent with the results of a study in Ethiopia and Nigeria (Ayele *et al.*, 2017; Egbon *et al.*, 2022). This may be explained by the easy susceptibility of neonates to preventable child deaths such as neonatal sepsis and hypothermia since they are new to the environment and have low immunity (Lawn *et al.*, 2014). Newborns' exposure to adverse maternal outcomes such as birth asphyxia, prematurity, and low birth weight also play a critical role in the child's survival status at this stage (Limaso *et al.*, 2020). In addition, most facilities in Siaya County are dispensaries and health centers, hence cannot manage conditions associated with birth complications such as birth asphyxia, hence delay in seeking care as children await to be referred. Therefore, the study suggests that intervention programs aimed at reducing mortality rates should prioritize children within the first two months of life, as this approach has the potential to significantly decrease the overall under-five mortality rate in Siaya County.

The study observed a lower reduction in under-five mortality among children of mothers with high levels of education attainment indicating that improving maternal education could increase child survival outcomes, consistent with other previous studies (Bado *et al.*, 2016, Wu, 2022).. Previous evidence (UNICEF, 2016: Andriano & Monden, 2019) shows that better-educated mothers are likely more knowledgeable about their illness and can access health services early once they identify symptoms, routine checkups, and skilled birth attendants during delivery. Moreover, they would know more about various modern contraceptives, timely vaccination, proper hygiene, and proper nutrition for

their child, thereby increasing the survival rate (Patel & Olickal, 2021). In addition, most educated mothers work, which increases their financial flexibility, allowing them to afford better health care and seek treatment from well-equipped health facilities or specialized doctors (Greenaway *et al.*, 2012). Furthermore, the significant association of reduced child survival among children born to mothers with an age below 18 years can be attributed to the younger maternal body, which has more frequent birth complications and advanced maternal outcomes such as preeclampsia and preterm birth during pregnancy and childbirth (Cavazos-reh'g *et al.*, 2016). In addition, mothers of younger age are more likely to be stigmatized and face barriers in accessing maternal and healthcare services that predispose their children to mortality (Chirwa *et al.*, 2019). They have low wealth status and educational attainment which might impact their health-seeking behavior (Chirwa *et al.*, 2019). The finding conforms to the results of the previous study (Ahinkorah, 2021).

Globally, when boys and girls are valued equally and have equal access to health care, boys are more likely to die than girls. In this study, we observed that male infants have a high risk of dying before the age of 5 years, consistent with findings from other studies (Fagbamigbe *et al.*, 2022; Costa *et al.*, 2017). This may be explained by the biological and genetical differences that make them susceptible to many diseases that cause death. Besides, male children are less resistant to disease and prone to risks of prematurity hence high hazard risk of death (Yaya *et al.*, 2018). Delivery in facilities, with the help of trained healthcare workers, protects against child mortality. In our study, the low mortality rate among children delivered in hospitals can be explained by comprehensive healthcare services to women and their children during labor and the postpartum period (Greenaway *et al.*, 2012) and higher utilization of maternity services (Kumar *et al.*, 2013). The findings are similar to other studies and reports (Machio, 2018; WHO, 2018). In addition, WHO recommends at least four visits during pregnancy, with the first visit in the first trimester. In this study, ANC visits were significantly associated with child mortality, consistent with results from a study in Ethiopia (Oduse *et al.*, 2021). This positive impact may be due to the provision of ANC services by skilled healthcare workers who continuously educate mothers about dangerous signs of pregnancy during their routine checkups, and the administration of the tetanus toxoid vaccine that is of great value in preventing neonatal tetanus infection, which is usually transmitted vertically during pregnancy period (Doku & Neupane, 2017).

Access to modern toilets was significantly associated with an increase in child survival. Health effects can explain this decrease in child mortality since exposure to human excreta is harmful and responsible

for disease spread and child mortality (Bitew *et al.*, 2017). Furthermore, people sharing toilets is one of the ways children can contract the disease. If a healthy mother shares a toilet with an infected person, there may be a high chance of contracting the disease and transmitting it to the child (Gbadebo *et al.*, 2018). The results conform with the results from other studies (Adebowale *et al.*, 2017; Motsima *et al.*, 2020). There is no doubt that the health of children is largely dependent on modern cooking methods (Latona *et al.*, 2017). However, the findings from the study showed no relationship or association between the cooking method and under-five mortality. The findings differ from most previous findings (Owili *et al.*, 2017; Naz *et al.*, 2016). The difference in the outcome may be due to the study setting, sample size, and geographical factors.

## CHAPTER 6

### CONCLUSIONS AND RECOMMENDATIONS

#### 6.1 Conclusion

After performing Cox regression to identify covariates that significantly influence under-five mortality and the extent of their influence, the following conclusions were made:

1. The hazard of death among under-five children was higher at an early age and then decreased as age advanced which means that the survival probability was very low among newborns.
2. Maternal education and maternal age were identified as the socioeconomic and demographic predictors of under-five mortality. Lack of post-primary education and giving birth before the age of 18 were associated with a higher hazard of death.
3. Child gender, number of ANC visits, and place of birth were the child and maternal predictors for under-five mortality. Attending ANC more than 3 times, delivering in health facilities, and being female were associated with a lower risk of death among children under the age of five in Siaya County.
4. Environmental factor; toilet use was found to be a significant predictor of under-five mortality with families with latrines having a lower hazard of death compared to families without latrines.

#### 6.2 Recommendation

##### 6.2.1 recommendations for programs

1. The policymakers in Siaya County could intensify maternal health care services in the early stages of child life by promoting health education and community awareness on early and regular attendance of ANC, hospital delivery, and early detection of danger signs during pregnancy and to neonates. This will reduce pregnancy and birth complications and improve prompt referral for mothers and their children. Hence, reducing under-five mortality and this critical age.
2. Promoting compulsory secondary education to delay early marriages, and helping mothers make health decisions will improve the child's survival. In addition, health policy should focus on raising awareness of giving birth over the age of 18 years and using family planning to prevent early pregnancy. This program will help reduce teenage pregnancies, lengthen birth spacing, and reduce school dropout chances.

3. It's crucial to incentivize community health workers to engage with pregnant mothers, providing guidance and support throughout pregnancy and delivery to ensure they choose healthcare facilities for delivery.
4. The government and other stakeholders need to boost parental education on the importance of a healthy living environment and the use of safe drinking water. This would control cases of water-borne diseases and related mortality.

### **6.2.1 recommendations for further research**

1. There is a need to conduct a study of sociocultural factors that determine health in a multicultural country to understand belief and denominational affiliations across different religions and how they impact the survival probabilities of under-five mortality.
2. It is necessary to reassess the data related to wealth index, occupation of the head of household, and family size that were significant in the bivariate analysis but were omitted in the final analysis due to a high level of missing data.

## REFERENCES

- Adebowale, S. A., Morakinyo, O. M., & Ana, G. R. (2017). Housing materials as predictors of under-five mortality in Nigeria: Evidence from 2013 demographic and health survey. *BMC Pediatrics*, 17(1), 1–13. <https://doi.org/10.1186/s12887-016-0742-3>
- Ahinkorah, B. O. (2021a). Maternal age at first childbirth and under-five morbidity in sub-Saharan Africa: analysis of cross-sectional data of 32 countries. *Archives of Public Health*, 79(1), 1–10. <https://doi.org/10.1186/s13690-021-00674-5>
- Ahinkorah, B. O. (2021b). Under-5 mortality in sub-Saharan Africa: Is maternal age at first childbirth below 20 years a risk factor? *BMJ Open*, 11(9). <https://doi.org/10.1136/bmjopen-2021-049337>
- Alam, M. B., Acharjee, S., Mahmud, S. M. A., Tania, J. A., Ali Khan, M. M., Islam, M. S., & Khan, M. N. (2022). Household air pollution from cooking fuels and its association with under-five mortality in Bangladesh. *Clinical Epidemiology and Global Health*, 17(July), 101134. <https://doi.org/10.1016/j.cegh.2022.101134>
- Andriano, L., & Monden, C. W. S. (2019). Andriano-Monden2019\_Article\_The Causal Effect Of Maternal Educa.pdf. *Demography*, 56(5), 1765–1790. Retrieved from <internal-pdf://199.140.25.74/Andriano-2019-The-causal-effect-of-maternal-ed.pdf>
- Andriano, L., & S Monden, C. W. (2017). Maternal education and child mortality: Evidence from a quasi-experiment in Malawi and Uganda. (Ipc), 1–7.
- Appiah, P. K., Bukari, M., Yiri-Erong, S. N., Owusu, K., Atanga, G. B., Nimirkpen, S., ... Adjuik, M. (2020). Antenatal Care Attendance and Factors Influenced Birth Weight of Babies Born between June 2017 and May 2018 in the Wa East District, Ghana. *International Journal of Reproductive Medicine*, 2020, 1–10. <https://doi.org/10.1155/2020/1653076>
- Ayele, D. G., Zewotir, T. T., & Mwambi, H. (2017). Survival analysis of under-five mortality using Cox and frailty models in Ethiopia. *Journal of Health, Population, and Nutrition*, 36(1), 25. <https://doi.org/10.1186/s41043-017-0103-3>
- Bado, A. R., & Susuman, A. S. (2016). Women's education and health inequalities in under-five mortality in selected sub-Saharan African countries, 1990-2015. *PLoS ONE*, 11(7), 1–18. <https://doi.org/10.1371/journal.pone.0159186>
- Badriah1\*, F., Abe2, T., & , Baequni1, 3 and Akihito Hagihara3. (2014). Skilled Versus Unskilled Assistance in Home Delivery: Maternal Complications, Stillbirth and Neonatal Death in Indonesia. *Journal of Nursing & Care*, 03(05). <https://doi.org/10.4172/2167-1168.1000198>
- Bereka, S. G., & Habtewold, F. G. (2017). Under-five Mortality of Children and its Determinants in Ethiopian Somali Regional State, Eastern Ethiopia. *Health Science Journal*, 11(3), 1–8. <https://doi.org/10.21767/1791-809X.1000507>
- Bhusal, M. K., & Khanal, S. P. (2022). A Systematic Review of Factors Associated with Under-Five Child Mortality. *BioMed Research International*, 2022. <https://doi.org/10.1155/2022/1181409>
- Bitew, B. D., Woldu, W., & Gizaw, Z. (2017). Childhood diarrheal morbidity and sanitation predictors in a nomadic community. *Italian Journal of Pediatrics*, 43(1). <https://doi.org/10.1186/s13052-017-0412-6>

- Cavazos-rehg, P. A., Krauss, M. J., Spitznagel, E. L., Bommarito, K., Madden, T., Olsen, M. A., ... Bierut, L. J. (2016). Maternal age and risk of labor and delivery complications *Patricia*. 19(6), 1202–1211. <https://doi.org/10.1007/s10995-014-1624-7>. Maternal
- Chakraborty, D., Mondal, N. K., & Datta, J. K. (2014). Indoor pollution from solid biomass fuel and rural health damage: A micro-environmental study in a rural area of Burdwan, West Bengal. *International Journal of Sustainable Built Environment*, 3(2), 262–271. <https://doi.org/10.1016/j.ijsbe.2014.11.002>
- Chirwa, G. C., Mazalale, J., Likupe, G., Nkhoma, D., Chiwaula, L., & Chintsanya, J. (2019). An evolution of socioeconomic related inequality in teenage pregnancy and childbearing in Malawi. *PLoS ONE*, 14(11), 1–16. <https://doi.org/10.1371/journal.pone.0225374>
- Costa, J. C., Da Silva, I. C. M., & Victora, C. G. (2017). Gender bias in under-five mortality in low/middle-income countries. *BMJ Global Health*, 2(2). <https://doi.org/10.1136/bmjgh-2017-000350>
- Dendup, T., Zhao, Y., & Dema, D. (2018). Factors associated with under-five mortality in Bhutan: An analysis of the Bhutan National Health Survey 2012. *BMC Public Health*, 18(1), 1–15. <https://doi.org/10.1186>
- DNMP. (2021). Kenya Malaria Indicator Survey 2020. Ministry of Health, (September), 39.
- Doku, D. T., & Neupane, S. (2017). Survival analysis of the association between antenatal care attendance and neonatal mortality in 57 low- And middle-income countries. *International Journal of Epidemiology*, 46(5), 1668–1677. <https://doi.org/10.1093/ije/dyx125>
- Dong, Y., & Peng, C. Y. J. (2013). Principled missing data methods for researchers. *SpringerPlus*, 2(1), 1–17. <https://doi.org/10.1186/2193-1801-2-222>
- Ede, C., Chen, X., Lin, M., & Chen, Y. Y. (2017). religious affiliation and under-five mortality in Mozambique. 5(5), 395–404. <https://doi.org/10.1021/acssynbio.5b00266>. Quantitative
- Egbon, O. A., Bogoni, M. A., Babalola, B. T., & Louzada, F. (2022). Under age five children survival times in Nigeria: a Bayesian spatial modeling approach. *BMC Public Health*, 22(1), 1–17. <https://doi.org/10.1186>
- Ely, D. M., & Driscoll, A. K. (2020). Infant mortality in the United States, 2018: Data from the period linked birth/infant death file. *National Vital Statistics Reports*, 69(7), 1–17.
- Ettarh, R. R., & Kimani, J. (2012). Determinants of under-five mortality in rural and urban Kenya. *Rural and Remote Health*, 12(1). <https://doi.org/10.22605/rrh1812>
- Fagbamigbe, A. F., Morakinyo, O. M., & Balogun, F. M. (2022). Sex inequality in under-five deaths and associated factors in low and middle-income countries: a Fairlie decomposition analysis. *BMC Public Health*, 22(1), 1–16. <https://doi.org/10.1186/s12889-022-12679-y>
- Foster, M. (2014). DFID's Contribution to the Reduction of Child Mortality in Kenya. (March). Retrieved from <http://icai.independent.gov.uk/wp-content/uploads/2014/03/ICAI-Child-Mortality-FINAL-120714.pdf>
- Francisco, A. R. L. (2013). The impact of mother's marital status on child mortality in sub-Saharan

Africa: an analysis of birth and marital histories. *Journal of Chemical Information and Modeling*, 53(9), 1689–1699. <https://doi.org/10.1017/CBO9781107415324.004>

- Gaffan, N., Kpozehouen, A., Degbey, C., Ahanhanzo, Y. G., & Paraïso, M. N. (2023). Effects of household access to water, sanitation, and hygiene services on under-five mortality in Sub-Saharan Africa. *Frontiers in Public Health*, 11(April), 1–13. <https://doi.org/10.3389/fpubh.2023.1136299>
- Gbadebo, B. M., Fagbamigbe, A. F., & Adebowale, S. A. (2018). Environmental Factors as Predictors of Childhood Mortality Experience in Nigeria. *Afr J of Env Health Sc.*, 5(11), 23–34.
- Gebretsadik, S., & Gabreyohannes, E. (2016). Determinants of Under-Five Mortality in High Mortality Regions of Ethiopia: An Analysis of the 2011 Ethiopia Demographic and Health Survey Data. *International Journal of Population Research*, 2016, 1–7. <https://doi.org/10.1155/2016/1602761>
- Greenaway, E. S., Leon, J., & Baker, D. P. (2012). Understanding the association between maternal education and use of health services in Ghana: Exploring the role of health knowledge. *Journal of Biosocial Science*, 44(6), 733–747. <https://doi.org/10.1017/S0021932012000041>
- Grépin, K. A., & Bharadwaj, P. (2015). Maternal education and child mortality in Zimbabwe. *Journal of Health Economics*, 44(August), 97–117. <https://doi.org/10.1016/j.jhealeco.2015.08.003>
- Guffey, D. (2012). Hosmer-Lemeshow goodness-of-fit test: Translations to the Cox Proportional Hazards Model. Retrieved from <https://digital.lib.washington.edu/443/researchworks/handle/1773/22648>
- Gupta, R., & Talukdar, B. (2017). Frequency and Timing of Antenatal Care Visits and Its Impact on Neonatal Mortality in EAG States of India. *Journal of Neonatal Biology*, 06(03). <https://doi.org/10.4172/2167-0897.1000263>
- Hallfors, D. D., Iritani, B. J., Zhang, L., Hartman, S., Luseno, W. K., Mpofu, E., & Rusakaniko, S. (2016). I thought if I marry the prophet I would not die: The significance of religious affiliation on marriage, HIV testing, and reproductive health practices among young married women in Zimbabwe. 13(1), 178–187.
- Ikamari, L. (2020). Uptake of maternal services and associated factors in the western region of Kenya. *Pan African Medical Journal*, 37(192), 1–15. <https://doi.org/10.11604/pamj.2020.37.192.22406>
- Kagabo, D. M., Kirk, C. M., Bakundukize, B., Hedt-Gauthier, B. L., Gupta, N., Hirschhorn, L. R., ... Amoroso, C. L. (2018). Care-seeking patterns among families that experienced under-five child mortality in rural Rwanda. *PLoS ONE*, 13(1), 1–18. <https://doi.org/10.1371/journal.pone.0190739>
- Kaguthi, G., Nduba, V., Borgdorff, M. W., & Verver, S. (2018). Predictors of postneonatal mortality in Western Kenya: A cohort study. *Pan African Medical Journal*, 31, 1–11. <https://doi.org/10.11604/pamj.2018.31.114.16725>
- Keats, E. C., Macharia, W., Singh, N. S., Akseer, N., Ravishankar, N., Ngugi, A. K., ... Bhutta, Z. A. (2018). Accelerating Kenya's progress to 2030: understanding the determinants of under-five mortality from 1990 to 2015. 1–15. <https://doi.org/10.1136/bmjgh-2017-000655>
- Kebede, W., Tolcha, A., Soboksa, N. E., Negassa, B., Kanno, G. G., & Aregu, M. B. (2023). Utilization of Insecticide-Treated Nets in Households for Under-5 Children and Associated Factors in East Mesekan District, Gurage Zone, Southern Ethiopia. *Environmental Health Insights*, 17.

<https://doi.org/10.1177/11786302231164287>

- KIPPRA. (2020). KENYA ECONOMIC REPORT 2020: Creating an Enabling Environment for Inclusive Growth in Kenya. 1–230.
- Kiross, G. T., Chojenta, C., Barker, D., Tiruye, T. Y., & Loxton, D. (2019). The effect of maternal education on infant mortality in Ethiopia: A systematic review and meta-analysis. *PLoS ONE*, 14(7), 1–12. <https://doi.org/10.1371/journal.pone.0220076>
- Kisiangani, I., Elmi, M., Bakibinga, P., Mohamed, S. F., Kisia, L., Kibe, P. M., ... Ziraba, A. K. (2020). Persistent barriers to the use of maternal, newborn and child health services in Garissa sub-county, Kenya: A qualitative study. *BMC Pregnancy and Childbirth*, 20(1), 1–12. <https://doi.org/10.1186/s12884-020-02955-3>
- Kiwan R, A. Q. N. (2018). Outcome of vaginal birth after cesarean section: A retrospective comparative analysis of spontaneous versus induced labor in women with one previous cesarean section. (pp. 145–150). pp. 145–150.
- KNBS. (2016). 2014 Kenya Demographic and Health Survey (KDHS). Kenya National Bureau of Statistics, 01, 1–11.
- KNBS. (2022). Economic survey 2022.
- KNBS. (2023). Demographic and Health Survey 2022. Demographic and Health Survey 2022, 1–23.
- Kumar, C., Singh, P. K., Rai, R. K., & Singh, L. (2013). Early neonatal mortality in India, 1990-2006. *Journal of Community Health*, 38(1), 120–130. <https://doi.org/10.1007/s10900-012-9590-8>
- Larrañaga, I., Martín, U., Bacigalupe, A., María Begiristain, J., José Valderrama, M., & Arregi, B. (2009). Puntualizaciones sobre las desigualdades de género en salud y calidad de vida en el cuidado informal. *Gaceta Sanitaria*, 23(6), 566–567. <https://doi.org/10.1016/j.gaceta.2009.05.001>
- Lartey, S. T., Khanam, R., & Takahashi, S. (2016). The impact of household wealth on child survival in Ghana. *Journal of Health, Population, and Nutrition*, 35(1), 38. <https://doi.org/10.1186/s41043-016-0074-9>
- Latona, O. O., Yusuf, O. B., & Adebawale, S. A. (2017). Patterns and predictors of mortality among children under five years in Nigeria. *African Journal of Biomedical Research*, 20(1), 37–43.
- Lawn JE, Blencowe H, Oza S, You D, Lee AC, Waiswa P, Lalli M, Bhutta Z, Barros AJ, Christian P, Mathers C, Cousens SN; Lancet Every Newborn Study Group. Every Newborn: progress, priorities, and potential beyond survival. *Lancet*. 2014 Jul 12;384(9938):189-205. doi: 10.1016/S0140-6736(14)60496-7. Epub 2014 May 19. Erratum in: *Lancet*. 2014 Jul 12;384(9938):132. PMID: 24853593.
- Limaso, A. A., Dangisso, M. H., & Hibstu, D. T. (2020). Neonatal survival and determinants of mortality in Aroresa district, Southern Ethiopia: A prospective cohort study. *BMC Pediatrics*, 20(1), 1–8. <https://doi.org/10.1186/s12887-019-1907-7>
- Lin, L., Yang, H., & Xu, X. (2022). Effects of Water Pollution on Human Health and Disease Heterogeneity: A Review. *Frontiers in Environmental Science*, 10(June). <https://doi.org/10.3389/fenvs.2022.880246>

- Lindström, M., & Rosvall, M. (2019). Marital status and 5-year mortality: A population-based prospective cohort study. *Public Health*, 170, 45–48. <https://doi.org/10.1016/j.puhe.2019.02.015>
- Lu, S. S. M., Stewart Williams, J., & Sommar, J. N. (2019). Inequalities in early childhood mortality in Myanmar - Association between parents' socioeconomic status and early childhood mortality. *Global Health Action*, 12(1). <https://doi.org/10.1080/16549716.2019.1603516>
- Macharia, M. R. (2008). FACTORS AFFECTING UNDER FIVE MORTALITY IN COAST AND CENTRAL KENYA Rachel Mukuhi Macharia.
- Macharia, P. M., Giorgi, E., Thurania, P. N., Joseph, N. K., Sartorius, B., Snow, R. W., & Okiro, E. A. (2019). Sub-national variation and inequalities in under-five mortality in Kenya since 1965. *BMC Public Health*, 19(1), 1–12. <https://doi.org/10.1186/s12889-019-6474-1>
- Machio, P. M. (2018). Determinants of Neonatal and Under-five Mortality in Kenya: Do Antenatal and Skilled Delivery Care Services Matter? *Journal of African Development*, 20(1), 59–67.
- MOH. (2018). Kenya AIDS Progress Report 2018. 81. Retrieved from [https://www.lvcthealth.org/wp-content/uploads/2018/11/KARPR-Report\\_2018.pdf](https://www.lvcthealth.org/wp-content/uploads/2018/11/KARPR-Report_2018.pdf)
- MOH Kenya. (2020). Kenya Community Health Strategy 2020 - 2025. 1–44. Retrieved from [https://www.health.go.ke/wp-content/uploads/2021/01/Kenya-Community-Health-Strategy-Final-Signed-off\\_2020-25.pdf](https://www.health.go.ke/wp-content/uploads/2021/01/Kenya-Community-Health-Strategy-Final-Signed-off_2020-25.pdf)
- Monden, C. W. S., & Smits, J. (2013). Maternal education is associated with reduced female disadvantages in under-five mortality in sub-Saharan Africa and southern Asia. *International Journal of Epidemiology*, 42(1), 211–218. <https://doi.org/10.1093/ije/dys201>
- Moore, T., McDonald, M., & McHugh-Dillon, H. (2015). Evidence review: Early childhood development and the social determinants of health inequities. Murdoch Childrens Research Institute, (9).
- Mosley W, H., & Chen L C. (2003). Extracted from : Population and Development Review 1984 ; 10 Suppl : 25 – 45. *Bull World Health Organ*, 81(2), 140–145.
- Motsima, T., Zuma, K., & Rapoo, E. (2022). Levels and Trends of Under-Five Mortality in South Africa from 1998 to 2012. (February).
- Mustafa, H. E. (2008). Socioeconomic determinants of infant mortality in Kenya. *Humanities and Social Sciences*, 2(2), 1–16. Retrieved from <http://hdl.handle.net/10539/5805%5Cnhttp://wiredspace.wits.ac.za>
- Musuva, R. M., Odiero, M. R., Mwinzi, P. N. M., Omondi, I. O., Rawago, F. O., Matendechero, S. H., ... Colley, D. G. (2021). Unprotected water sources and low latrine coverage are contributing factors to persistent hotspots for schistosomiasis in western Kenya. *PLoS ONE*, 16(9 September), 1–20. <https://doi.org/10.1371/journal.pone.0253115>
- Mwangi, W., Gachuno, O., Desai, M., Obor, D., Were, V., Odhiambo, F., ... Laserson, K. F. (2018). Uptake of skilled attendance along the continuum of care in rural Western Kenya: Selected analysis from Global Health initiative survey-2012. *BMC Pregnancy and Childbirth*, 18(1), 1–13. <https://doi.org/10.1186/s12884-018-1803-4>

- NASCOP. (2020). Kenya Population-Based HIV Impact Assessment. Ministry of Health, 151(2), 10–17.
- Naz, S., Page, A., & Agho, K. E. (2016). Household air pollution and under-five mortality in India (1992-2006). *Environmental Health: A Global Access Science Source*, 15(1). <https://doi.org/10.1186/s12940-016-0138-8>
- Naz, S., Page, A., & Agho, K. E. (2017). Household air pollution from use of cooking fuel and under-five mortality: The role of breastfeeding status and kitchen location in Pakistan. *PLoS ONE*, 12(3), 1–14. <https://doi.org/10.1371/journal.pone.0173256>
- Neal, S., Channon, A. A., & Chintsanya, J. (2018). The impact of young maternal age at birth on neonatal mortality: Evidence from 45 low and middle-income countries. *PLoS ONE*, 13(5), 1–16. <https://doi.org/10.1371/journal.pone.0195731>
- Ochieng, C. A., & Odhiambo, A. S. (2019). Barriers to formal health care seeking during pregnancy, childbirth and postnatal period: A qualitative study in Siaya County in rural Kenya. *BMC Pregnancy and Childbirth*, 19(1), 1–14. <https://doi.org/10.1186/s12884-019-2485-2>
- Odhiambo, F. O., Laserson, K. F., Sewe, M., Hamel, M. J., Feikin, D. R., Adazu, K., ... Vulule, J. M. (2012). Profile: The KEMRI/CDC health and demographic surveillance system in Western Kenya. *International Journal of Epidemiology*, 41(4), 977–987. <https://doi.org/10.1093/ije/dys108>
- Oduse, S., Zewotir, T., & North, D. (2021). The impact of antenatal care on under-five mortality in Ethiopia: a difference-in-differences analysis. *BMC Pregnancy and Childbirth*, 21(1), 1–9. <https://doi.org/10.1186/s12884-020-03531-5>
- Ogbo, F. A., Agho, K., Ogeleka, P., Woolfenden, S., Page, A., Eastwood, J., ... Gunasekera, H. (2017). Infant feeding practices and diarrhea in sub-Saharan African countries with high diarrhea mortality. In *PLoS ONE* (Vol. 12). <https://doi.org/10.1371/journal.pone.0171792>
- OHCHR. (2020). Status of teenage pregnancies per county 2016-2020 Number of adolescents presenting with pregnancy at first antenatal clinic. 10562.
- Owili, P. O., Muga, M. A., Pan, W. C., & Kuo, H. W. (2017). Cooking fuel and risk of under-five mortality in 23 Sub-Saharan African countries: a population-based study. *International Journal of Environmental Health Research*, 27(3), 191–204. <https://doi.org/10.1080/09603123.2017.1332347>
- Pal, S. (2015). Impact of hospital delivery on child mortality: An analysis of adolescent mothers in Bangladesh. *Social Science and Medicine*, 143(8970), 194–203. <https://doi.org/10.1016/j.socscimed.2015.08.003>,
- Patel, N., & Olickal, J. J. (2021). Maternal and child factors of under-five mortality in India. Findings from NFHS-4. *Clinical Epidemiology and Global Health*, 12(July), <https://doi.org/10.1016/j.cegh.2021.100866>
- Paul Awiti. (2018). Assessment of maternal factors influencing mortality of children under five years of age in Karemo Sub-county in Siaya County, Kenya by a thesis submitted in partial fulfillment for the requirements for the degree of master of public health.
- Pervin, J., Rahman, S. M., Rahman, M., Aktar, S., & Rahman, A. (2020). Association between antenatal care visit and preterm birth: a cohort study in rural Bangladesh. *BMJ Open*, 10(7), e036699. <https://doi.org/10.1136/bmjopen-2019-036699>

- Raghunathan, P. L., Madhi, S. A., & Breiman, R. F. (2019). Illuminating Child Mortality: Discovering Why Children Die. *Clinical Infectious Diseases*, 69, S257–S259. <https://doi.org/10.1093/cid/ciz562>
- Raghupathi, V., & Raghupathi, W. (2020). The influence of education on health: An empirical assessment of OECD countries for the period 1995-2015. *Archives of Public Health*, 78(1), 1–18. <https://doi.org/10.1186/s13690-020-00402-5>
- Richards, B., Rao, K., & Bishai, D. (2022). District-level religious composition and child health in India. *Journal of Health, Population, and Nutrition*, 41(1), 1–16. <https://doi.org/10.1186/s41043-022-00298-7>
- Rutstein, S. O. and K. J. (2004). DHS Wealth index. 77, 4. Retrieved from [http://www.ghbook.ir/index.php?n=book&task=read&book\\_id=13650&page=73&chkhask=ED9C9491B4&Itemid=218&lang](http://www.ghbook.ir/index.php?n=book&task=read&book_id=13650&page=73&chkhask=ED9C9491B4&Itemid=218&lang)
- Samuel, O., Mofoluwake, A., Adenike, I., & Oluwatomisin, O. (2016). iMedPub Journals Levels and Trends in Household Source of Cooking Fuel in Nigeria : Implications on Under-Five Mortality. 1–5.
- Sharma Waddington, H., & Cairncross, S. (2021). PROTOCOL: Water, sanitation, and hygiene for reducing childhood mortality in low- and middle-income countries. *Campbell Systematic Reviews*, 17(1). <https://doi.org/10.1002/cl2.1135>
- Shifa, G. T., Ahmed, A. A., & Yalew, A. W. (2018). Maternal and child characteristics and health practices affecting under-five mortality: A matched case-control study in Gamo Gofa Zone, Southern Ethiopia. *PLoS ONE*, 13(8), 1–11. <https://doi.org/10.1371/journal.pone.0202124>
- Singh, R. M., & Gupta, A. (2017). Water Pollution-Sources, Effects and Control Water Pollution-Sources, Effects and Control. *Research Gate*, 5(3), 1–17.
- Singh, R., & Tripathi, V. (2013). Maternal factors contributing to under-five mortality at birth order 1 to 5 in India: A comprehensive multivariate study. *SpringerPlus*, 2(1), 1–12. <https://doi.org/10.1186/2193-1801-2-284>
- Smith-Greenaway, E., & Clark, S. (2017). Variation in the link between parental divorce and children's health disadvantage in low and high divorce settings. *SSM - Population Health*, 3(January), 473–486. <https://doi.org/10.1016/j.ssmph.2017.04.004>
- Stahl, M., & Alexander, G. R. (2012). Maternal and Child Health (MCH). *Encyclopedia of Health Care Management*, 1–4. <https://doi.org/10.4135/9781412950602.n491>
- Takele, K., Zewotir, T., & Ndanguza, D. (2019). Risk factors of morbidity among children under age five in Ethiopia. 1–9.
- Tesfa, D., Tiruneh, S. A., Azanaw, M. M., Gebremariam, A. D., Engdaw, M. T., Kefale, B., ... Dessalegn, T. (2021). Time to death and its determinants among under-five children in Sub-Saharan Africa using the recent (2010–2018) demographic and health survey data: country-based shared frailty analyses. *BMC Pediatrics*, 21(1), 1–11. <https://doi.org/10.1186/s12887-021-02950-3>
- Thanh, B. Y. L., Lumbiganon, P., Pattanittum, P., Laopaiboon, M., Vogel, J. P., Oladapo, O. T., ... Souza, J. (2019). Mode of delivery and pregnancy outcomes in preterm birth: a secondary analysis of the WHO Global and Multi-country Surveys. *Scientific Reports*, 9(1), 1–8.

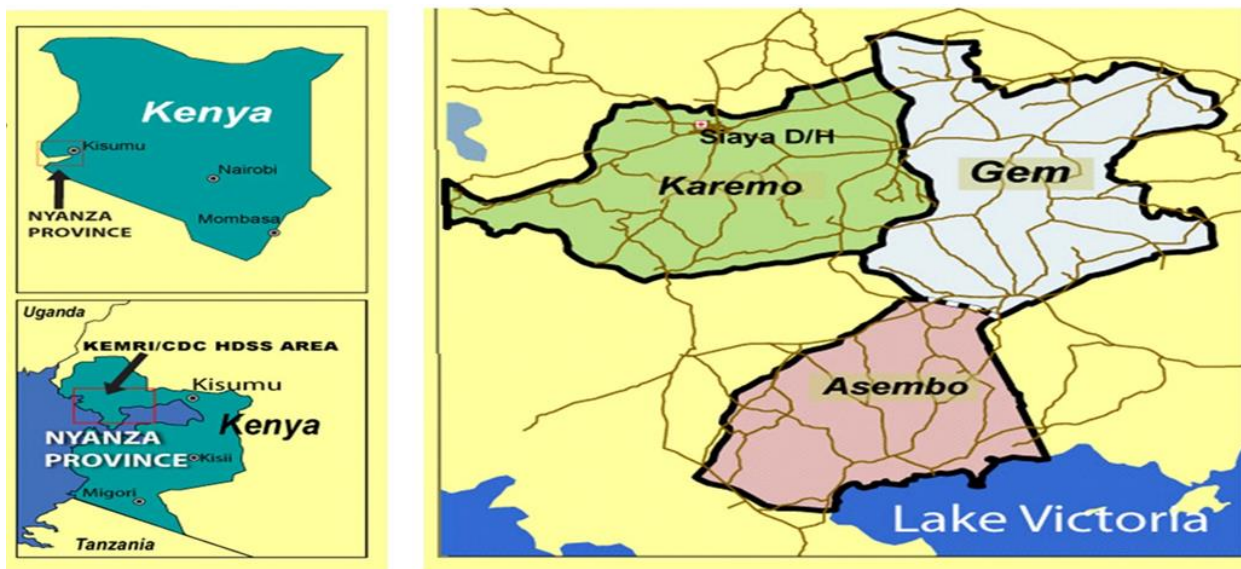
<https://doi.org/10.1038/s41598-019-52015-w>

- Titilayo, A., Anuodo, O. O., & Palamuleni, M. E. (2017). Family type, domestic violence and under-five mortality in Nigeria. *African Health Sciences*, 17(2), 538–548. <https://doi.org/10.4314/ahs.v17i2.30>
- Umutesi, G., McEvoy, M. D., Bonnet, K., Druffner, S., Schlundt, D. G., Atieli, H. E., ... Newton, M. W. (2021). Factors influencing mothers' decisions regarding obstetrical care in Western Kenya: a mixed-methods study. *BMC Women's Health*, 21(1), 1–9. <https://doi.org/10.1186/s12905-021-01355-9>
- UN. (2018). SDG 6 Synthesis Report 2018 on Water and Sanitation. In SDG 6 Synthesis Report 2018 on Water and Sanitation. <https://doi.org/10.18356/e8fc060b-en>
- UN - IGME. (2018). Level & Trends in Child Mortality. Retrieved from <https://data.unicef.org/wp-content/uploads/2018/09/UN-IGME-Child-Mortality-Report-2018.pdf>
- UN - IGME. (2022). Levels and Trends in Child Mortality Report 2022.
- UNFPA. (2020). End term evaluation of the UN H6 joint programme on reproductive, maternal, newborn, child and adolescent health (RMNCAH) 2015-2020. 2015–2020.
- UNICEF. (2016). Maternal and Newborn Health Disparities. Unicef, Maternal and Newborn Health Disparities, 8. [https://doi.org/10.1016/S1386-9477\(02\)00298-9](https://doi.org/10.1016/S1386-9477(02)00298-9)
- UNICEF. (2018). The report begins by examining the state of child survival and primary health care for children, with a strong emphasis on trends in child. Retrieved from [https://www.unicef.org/sowc08/docs/sowc08\\_panels.pdf](https://www.unicef.org/sowc08/docs/sowc08_panels.pdf)
- UNICEF. (2019). Progress on household drinking water , sanitation and hygiene I 2000-2017 Progress on household drinking water , sanitation and hygiene I 2 000-2017.
- United Nations Inter-agency Group for Child Mortality Estimation (UN, & IGME). (2021). Levels & Trends in. Retrieved from <file:///C:/Users/User/Downloads/UNICEF-IGME-2021-Child-Mortality-Report.pdf>
- van Buuren, S., & Groothuis-Oudshoorn, K. (2011). mice: Multivariate imputation by chained equations in R. *Journal of Statistical Software*, 45(3), 1–67. <https://doi.org/10.18637/jss.v045.i03>
- Vogel, J., Vogel, J. P., & Chawanpaiboon, S. (2018). The global epidemiology of preterm birth Best Practice & Research Clinical Obstetrics and Gynaecology The global epidemiology of preterm birth. *Best Practice & Research Clinical Obstetrics & Gynaecology*, (November). <https://doi.org/10.1016/j.bpobgyn.2018.04.003>
- Wagura, P., Wasunna, A., Laving, A., Wamalwa, D., & Ng'ang'a, P. (2018). Prevalence and factors associated with preterm birth at kenyatta national hospital. *BMC Pregnancy and Childbirth*, 18(1), 2–9. <https://doi.org/10.1186/s12884-018-1740-2>
- Wambugu, M. R. (2014). Determinants of Under-5 Mortality in Kenya During Upsurge and Declining Trends Period By a Research Project Submitted in Partial Fulfilment of the Requirement for the Award of Master of Science Degree in Population Studies , University of Nairobi.
- WHO. (2016). WORLD HEALTH STATISTICS SDG s. *World Health Statistics 2016*, 130. <https://doi.org/10.1071/AN12067>

- WHO. (2018a). Definition of skilled health personnel providing. 1–4. Retrieved from [www.unfpa.org/sowmy](http://www.unfpa.org/sowmy)
- WHO. (2018b). WHO Recommendations on Antenatal Care for a Positive Pregnancy Experience : Summary Highlights and Key Messages from the World Health Organization ' s 2016 Global Recommendations for Routine Antenatal Care. 10(January), 1–10. <https://doi.org/10.1186/1742-4755-10-19.5>
- WHO. (2018c). World Health Organisation Water, Sanitation and Hygiene: Strategy 2018-2025. Geneva: World Health Organisation; 2018(WHO/CED/PHE/WSH/18.03) Licence: CC BY-NC-SA 3.0 IGO. 50. Retrieved from <https://apps.who.int/iris/rest/bitstreams/1149463/retrieve>
- World Health Organization. (2018). Kenya: WHO Statistical Profile. 1–3. Retrieved from <http://www.who.int/gho/countries/ken.pdf?ua=1>
- Wroblewska, L., Kitada, T., Endo, K., Siciliano, V., Stillo, B., Saito, H., & Weiss, R. (2016). Religious Belonging, Religious Agency, and Women's Autonomy in Mozambique Victor. 33(8), 839–841. <https://doi.org/10.1038/nbt.3301.Mammalian>
- Wu, H. (2022). The Effect of Maternal Education on Child Mortality in Bangladesh. *Population and Development Review*, 48(2), 475–503. <https://doi.org/10.1111/padr.12467>
- Yaya, S., Bishwajit, G., Okonofua, F., & Uthman, O. A. (2018). Under five mortality patterns and associated maternal risk factors in sub-Saharan Africa: A multi-country analysis. *PLoS ONE*, 13(10), 1–14. <https://doi.org/10.1371/journal.pone.0205977>
- Yaya, S., Diarra, S., Mabeu, M. C., & Pongou, R. (2018). The sex gap in neonatal mortality and the AIDS epidemic in sub-Saharan Africa. *BMJ Global Health*, 3(5), 1–5.

## Appendix 1: MAP OF STUDY AREA

Figure 6.1 shows the map of Siaya county health demographic surveillance system.



**Appendix 2: DATA CONFIDENTIALITY FORM**

**PREDICTORS OF UNDER-FIVE MORTALITY IN SIAYA HEALTH DEMOGRAPHIC SURVEILLANCE SYSTEM (HDSS), SIAYA COUNTY WESTERN KENYA BETWEEN 2015 AND 2020**

**Confidentiality Agreement Form**

I \_\_\_\_\_

**(Full Names)**

Hereby understand that it is my ethical responsibility to protect the confidentiality of patient health information and further identity. I will abide by quality and security standards of the study patient level data.

I hereby declare that I fully understand the patients or participant’s rights to confidentiality with regards to identity and health information and will adhere to this principle as an

**Supervisor**  / **Data analyst**  the project at all times. **(Tick as appropriate)**

I shall not disclose patient information to anyone outside the PI either during or after my period of engagement with the study.

If I am in breach of this agreement, I fully understand that the ethics committee has the right to take action against me.

**Signature:** \_\_\_\_\_ **Date:** \_\_\_\_\_

DD/MM/YYYY

**Witness:** \_\_\_\_\_

**Comments:**

\_\_\_\_\_  
\_\_\_\_\_

**QA Review:** \_\_\_\_\_ **Initials:** \_\_\_\_\_ **Date:** \_\_\_\_\_

## **Appendix 3: DATA ABSTRACTION RETRIEVAL FORM**

### **PREDICTORS OF UNDER-FIVE MORTALITY IN SIAYA HEALTH DEMOGRAPHIC SURVEILLANCE SYSTEM (HDSS), SIAYA COUNTY WESTERN KENYA BETWEEN 2015 AND 2020**

Globally, it is estimated that 1 in 26 children worldwide dying before the age of five, with more than 50% of these deaths occurring in sub-Saharan Africa. In Kenya, the under-five mortality rate in 2020 is estimated at 43.7 deaths per 1000 live births, with widespread regional and income variation. Siaya county is leading in under-five mortality with 99 deaths per 1000 live births, despite several government interventions in collaboration with various NGOs. This is more than double the national U5MR; Therefore, understanding the predictors is required to quickly track progress toward achieving Sustainable Development Goal 3 (SDG) by 2030. Hence the study aims to estimate the under-five mortality rate and determine its predictors.

A retrospective cohort study will be conducted using socio-demographic and health survey data collected between 2015 and 2020 in a rural and semi-urban area of Siaya County (Siaya Health Demographic Surveillance System)

The study is set to:

1. To estimate the mortality rate of under-five mortality in Siaya HDSS, Siaya County between 2015 to 2020.
2. To describe the survival probability over time among under five living in Siaya HDSS, Siaya County between 2015 – 2020
3. To determine predictors of under-five mortality in Siaya HDSS, Siaya County between 2015-2020.

#### **List of key variables collected between 2015 - 2020**

- Maternal age at birth
- Gender
- Maternal age category
- Family size category
- Marital status
- Marital type
- Wealth index
- Place of Birth
- Place of ANC visit
- ANC times
- Education level
- Religion
- Water sources
- Source of income
- Distance to water source
- Cooking methods
- Toilet type
- Birth Assistance

## DATA RETRIEVAL FORM

### A. Underlying determinants

Unique ID	SEX	Family size	Marital status	Wealth index	occupation	Religion	Marriage type	Education level	Maternal DOB	Child DOB

### B. Immediate determinants

Unique ID	Place of birth	Place of ANC visit	ANC times	Water sources	Distance to water source	Cooking methods	Toilet type	Birth assistance

**Appendix 4: Approval letter from JOOUST Board of Postgraduate Studies**



**JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE & TECHNOLOGY**

BOARD OF POSTGRADUATE STUDIES  
Office of the Director

Tel. 057-2501804  
Email: [bps@jooust.ac.ke](mailto:bps@jooust.ac.ke)

P.O. BOX 210 - 40601  
**BONDO**

**Our Ref:** H153/4269/2018

**Date:** 9<sup>th</sup> January 2023

**TO WHOM IT MAY CONCERN**

**RE: HARUN ODHIAMBO OWUOR - H153/4269/2018**

The above-mentioned person is a bonafide postgraduate student of Jaramogi Oginga Odinga University of Science and Technology in the School of Health Sciences, pursuing Master of Science in Epidemiology and Biostatistics. He has been authorized by the University to undertake research on the topic: *“Predictors of Under-Five Mortality in Siaya Health Demographic Surveillance (HDSS), Western Kenya between 2015 and 2020”*.

Any assistance accorded him shall be appreciated.

Thank you.

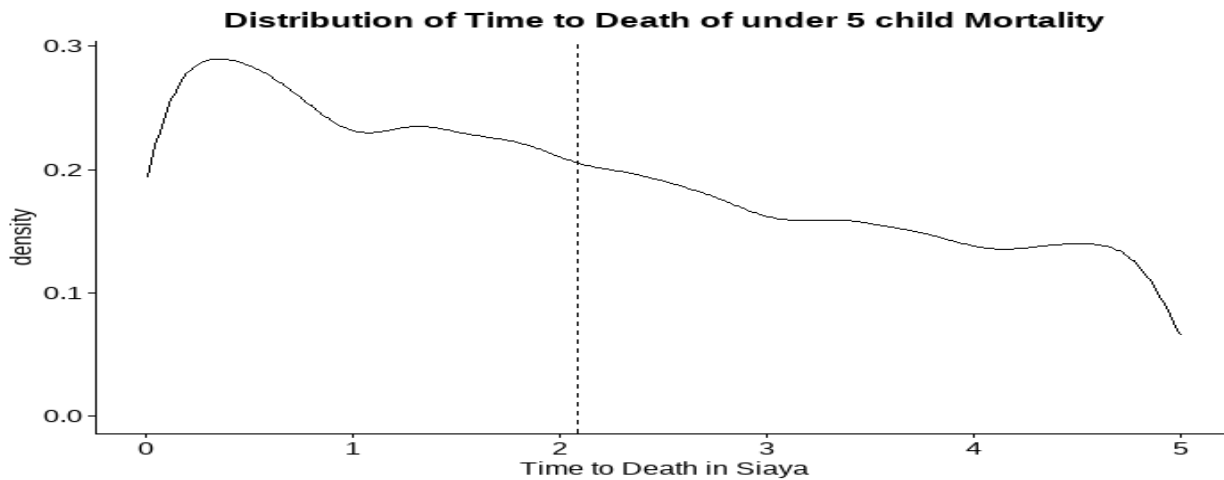
Prof. Dennis Ochuodho

**DIRECTOR, BOARD OF POSTGRADUATE STUDIES**



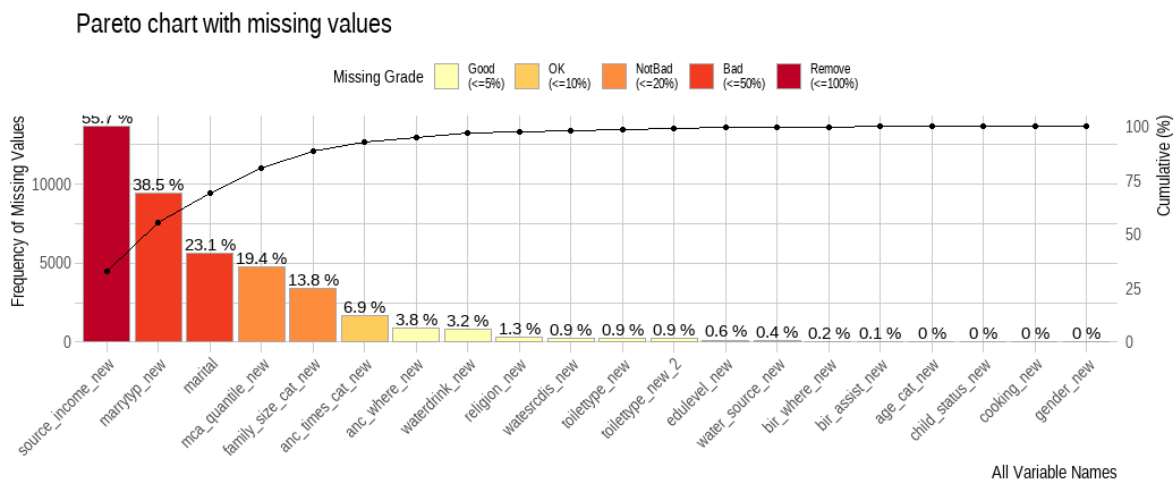
## Appendix 5: Additional graphs and tables for data analysis

**Figure 6.1 Distribution of time to events of under-five mortality in Siaya HDSS using Siaya HDSS data.**



The density plot checks for the distribution of time to child death for the normality assumption. From the density plot the mean time to event is 2.1 years after birth; and the distribution of the data is not even close to normal distribution; hence does not allow for parametric survival model analysis i.e. Weibull and exponential etc.

**Figure 6.2 Plot of variable completeness**



The distribution of key variable completeness. For multivariable analysis variable with more than 10% missing were excluded from the analysis and model prediction building.

### PROPORTION HAZARD ASSUMPTION CHECK

