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

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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.

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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.

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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 figure remains high: about 64,500 children die annually, largely from preventable deaths. Additionally, widespread variations in the impact of interventions on risk factors and socio-structural inequities across regions indicate the need for additional efforts to address attributable causes of child deaths and improve intervention effectiveness. Siaya County is one of the leading regions in under-five mortality, with 67.4 deaths per 1,000 live births in Kenya. The current study determined the predictors of under-five mortality in Siaya County between 2015 and 2020. Specifically, it estimated the under-five mortality rate, and survival probability and examined the roles of maternal healthcare-seeking behavior and socio-demographic factors on under-five mortality trends in Siaya County. The study analyzed secondary data obtained from the Siaya Health Demographic Surveillance System from 2015 to 2020, a population-based longitudinal survey. The basic information on demography and health was collected semiannually using structured questionnaires from the population of interest. A total of 24452 under-five children were enrolled in the study, with a male-to-female ratio of 1:1. There were 1,540 (6.3%) deaths with a mortality rate of 62.98 deaths per 1,000 live births, of which 41.8% were neonatal deaths. The annualized rate of change of U5MR in the HDSS site was approximately 70^% with a survival probability mean age of 7 months. Cox proportional hazard was used to examine the effects of the predictors on under-five mortality at p-value < 0.05. 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 decreases 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 mortality rate among U5s remains high and is mainly attributable to preventable causes. These observations reinforce the need to strengthen multiple components at the community and institutional levels. Interventions would target increasing uptake of preventive healthcare, risk reduction, and education attainment. The findings from this study are relevant to policymakers as they offer short-term solutions and integrated efforts to address the challenges.

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ACRONYMS

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&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 67.4 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 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 higher under-five mortality of 67.4 deaths per 1000 live births compared to Laikipia County which has the least under-five mortality rate of 27 deaths per 1000 live births. Therefore, the risk of dying is almost three times higher in Siaya County compared to Laikipia County (KNBS, 2022). In Siaya County, there are still variations in under-five mortality across various sub counties. Karemo registered a higher under-five mortality rate of 184 deaths per live birth compared to Uranga which had under-five mortality of 125 deaths per 1000live births in 2010 (Otieno, 2011). Therefore, there is a need to determine the current under-five mortality rate in various sub-counties within the Siaya HDSS area. 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, Bogoni, Babalola, & Louzada, 2022: Oduse, Zewotir, &

North, 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 below 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 Kenya's Western and Nyanza regions 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 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).* Siaya County has a high under-five mortality rate of 67.4 deaths per 1000 live births compared to the national under-five mortality rate of 41.9 deaths per 1000 live births (KNBS, 2022). Since the devolution of health services to the counties, limited resources and organizational challenges have hampered the implementation of primary healthcare services health policies. These challenges have impacted adversely on health services. Understanding annual changes in child mortality rates can provide insight into healthcare performance and provide evidence to inform intervention planning *(Kisiangani et al., 2020).* Since there are cross-country variations in the distribution of risk factors for under-five child mortality in Kenya. There is a need to determine and examine context-specific predictors to enable the tailoring of improvement interventions and service delivery.

1.3 Study justification

The under-five mortality rate is a key indicator of a nation's level of child health and gross development (UNICEF, 2018). It reflects the impact of socioeconomic and environmental circumstances and other causes of death among children below five years old (Moore, McDonald, & McHugh-Dillon, 2015). 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 still has a higher number of under-five mortality from preventable causes.

This study was conducted in Siaya County, which has a high under-five mortality rate of 67.4 deaths per 1000 live births. 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 (NASCOP, 2020; KNBS, 2023). Since the future of growth and development of a country depends on children, preventing child and maternal deaths remains a top priority for the Kenyan government. Therefore, 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 the adoption of cost-effective methods in our resource-limited country.

1.4 Research Objective

Main objective

To determine predictors of under-five mortality in Siaya HDSS, Siaya County between 2015 and 2020.

Specific Objectives

1. To estimate the mortality rate of under-five mortality in Siaya HDSS, Siaya County between 2015 to 2020.
2. To estimate 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 and 2020.

1.5 Research Questions

1. What is the under-five mortality rate in Siaya HDSS, Siaya County?
2. What is the survival probability of under-five children living in Siaya HDSS, Siaya County over time?
3. What are the predictors, which influence under-five mortality in Siaya HDSS, Siaya County

1.6 Significance of the Study

The study results clarified the annualized rate of change of under-five mortality, demographic variations, and key predictors. This knowledge will inform the planning of improvement interventions targeting health promotion and service delivery strengthening in the county. It also provides information to enable advocacy responses among different agencies.

1.7 Scope and Limitations of this study

The study was conducted in the Siaya HDSS region (Asembo, Gem, and Karemo Divisions). The study aimed to determine the under-five mortality rate, and the survival probability of children below five years and examine the predictors of under-five mortality within the HDSS region.

It utilized data from Siaya HDSS collected between 2015 to 2020. Since the data used are secondary, they might not include additional variables that were highlighted in the literature review. The study focused on dead or alive children born within the study period. The sociodemographic and maternal characteristics were collected from parents or household heads of those children. The data was collected semiannually to reduce recall bias, under-reporting and non-coverage errors. The validity of the data was done by the HDSS data specialists to check for data completion and quality before the data was exported to KEMRI servers.

Finally, the data may not represent all-cause mortality among children under the age of five in the Siaya HDSS area, as the information was obtained only from families who agreed to be part of the HDSS and are willing to provide the socio-demographic data.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter focused on the literature associated with under-five mortality among children below 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 least 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). Finally, 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).

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, Madhi, & Breiman, 2019; Kiross, Chojenta, Barker, Tiruye, & Loxton, 2019). Better-educated mothers have better access to healthcare 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 (Grépin & Bharadwaj, 2015). 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, in their study, Monden & Smits (2013) 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, a study by *Kaguthi et al. (2018)* found that maternal education was not associated with under-five mortality, which may be due to an undersized sample size of mothers attending sick visits or hospital stays (Kaguthi, Nduba, Borgdorff, & Verver, 2018). This contrasts with a study by Awiti (2018*)* which showed 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 (Paul Awiti, 2018). 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 sanitary/toilets. Child survival is greatly influenced by household financial position, and a child is far much better at surviving if they are from a household with a high economic level (Lartey, Khanam, & Takahashi, 2016). Stahl & Alexander (2012) found that socioeconomic status emerged as one of the main predictors of survival. They further argued that children in the lower socioeconomic class are 44% more likely not to survive to their fifth birthday than those in the high socioeconomic class. In addition, the likelihood of crucial child survival treatments being covered across the continuum of care reveals that wealthier families are three times more likely than poorer families to receive care (Stahl & Alexander, 2012).

However a study done by Lu, Stewart Williams, & Sommar (2019) found that the likelihood of death in the post-neonatal period in the wealthiest households was 85% lower than in the poorest households. No connection between wealth and newborn death was statistically significant and the final analysis (Lu, Stewart Williams, & Sommar, 2019). 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, no scientifically documented evidence of the relationship between wealth index and under-five mortality within Siaya HDSS or 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). 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, Channon, & Chintsanya, 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. They further argued that offspring born to mothers below 19 years and over 35 years have a greater risk of under-five mortality, due to their 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, no such research has been done in Siaya HDSS which has 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 LFC & Odimegwu COO (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, Bishwajit, Okonofua, & Uthman, 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. He further reported that the sample size was small, necessitating a study in Siaya HDSS 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. In contrast, Apostolic mothers have solid social ties and support in their communities (Ede, Chen, Lin, & Chen, 2017). 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, Rao & Bishai (2022) found that different religions increased child mortality in the district, but there was no association between under-five mortality and household religious affiliation. They argued that the greater risk of death in religious minorities was due to poor health systems and quality

(Richards, Rao, & Bishai, 2022). 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 a study done in Ethiopia (Gebretsadik & Gabreyohannes, 2016: Dendup, Zhao, & Dema, 2018). Furthermore, a study found that children from polygamous families experience higher mortality. They argued that the higher mortality may be because of domestic violence and neglect from the household head from the polygamous family (Titilayo, Anuodo, & Palamuleni, 2017). However, Wambugu (2014) ascertains that children born in bigger families have a higher probability of dying than those with smaller families. He further explained that this may be due to poor health-seeking behavior experienced in large families (Wambugu, 2014). 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

Prenatal care is crucial for the mother's health and the growth of the unborn child *(Larrañaga et al., 2009).* According to 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 receiving 4 – 9 ANC visits and those who received antenatal care visits 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. He 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 (Pervin, Rahman, Rahman, Aktar, & Rahman, 2020). 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.

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, other studies have shown that private hospitals perform better than public hospitals (R. 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, Arbab, Murad, Khan, & Abdullah (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 of membrane before labor are also the major causes of preterm delivery (Wagura, Wasunna, Laving, Wamalwa, & Ng'ang'a, 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 (Kiwan 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). Although 96% of women aged between 15 – 49 received at least one ANC visit from a skilled provider (KNBS, 2016), about 82% in urban areas and 50.2% in rural areas in Kenya delivered in hospitals (UNICEF, 2016). *Mwangi et al., (2018)* in their study observed that mothers who seek the care of skilled health attendants have experienced a low number of maternal and neonatal mortality. However, Badriah1, Abe, &, Baequni1 (2014) found a considerably higher risk of neonatal deaths among mothers delivered by unskilled birth attendants compared with skilled birth attendants. He 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 (Badriah1 et al., 2014). Furthermore, Pal (2015) argued that hospital delivery endures that advanced medicine, timely medical attention, and modern diagnostics benefit both mother and child and help 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. He furthermore argued that culture, economic influences, and the healthcare system are the three most important factors influencing maternal birthplace decisions. In addition, he 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, Kpozehouen, Degbey, Ahanhanzo, & Paraïso, 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 & Cairncross,

2021). Hence, WHO 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 (Bereka & Habtewold, 2017). In addition, a study by *Gaffan et al., (2023)* revealed a relationship between water drinking source and under-five mortality. They further argued that there was a significant association between the source of drinking water 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, Yang, & Xu, 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, Mofoluwake, Adenike, & Oluwatomisin, 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, Muga, Pan, & Kuo, 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, Page, & Agho, 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, Page, & Agho, 2017). Children in the kitchen with their mother at all times during cooking (Chakraborty, Mondal, & Datta, 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. 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)**.

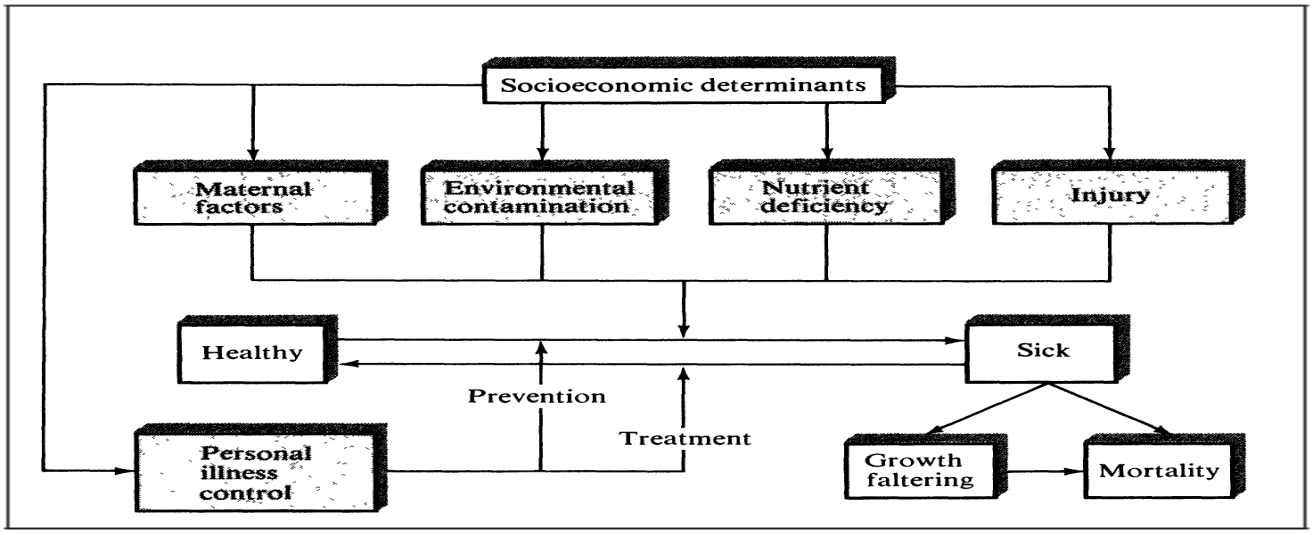
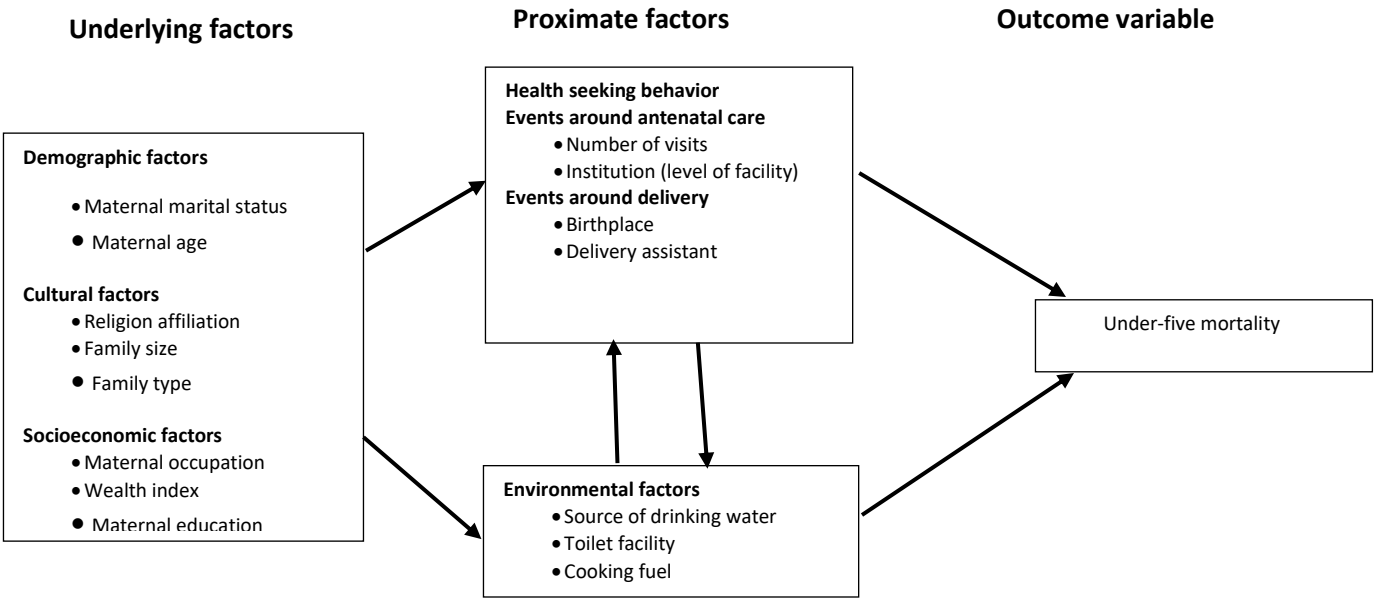


Figure 2.1: Analytical framework for childhood survival in developing countries

2.8.1 Conceptual Framework

The conceptual framework was developed from Mosley and Chen's (1984) theoretical framework. In this study, 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

Operational hypothesis

1. Married women with stable relationships are associated with improved under-five[1] mortality
2. The age of the mother at the time of birth is associated with higher under-five mortality.
3. A safe source of drinking water is associated with reduced under-five mortality.
4. Women with higher education are associated with decreased chances of under-five mortality.
5. Maternal occupation reduces under-five mortality.
6. Appropriate toilet facility is associated with decreased under-five mortality.
7. A safe source of drinking water reduces under-five mortality.
8. Increase the number of ANC attendance improved under-five mortality.
9. Hospital delivery is likely to decrease under-five mortality.

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 0 26 to 0 18 north latitude and 33 58 east and 34 33 west longitudes. It is divided into 6 sub-counties with a total population of 842,304 **(Appendix 1_Study area map)** (KNBS, 2009). The KEMRI/CDC HDSS 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 below five years. 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 67.4 deaths per 1000 live births. The total area is approximately 700km^2 with 393 villages 64317 homes, and 44461 compounds.

3.2 Study Design

The study utilized secondary data from Siaya HDSS, conducted between 2015 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". They also collect verbal autopsies of all deaths that are used to track the definitive cause of death. 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. Our study used a retrospective longitudinal cohort study design.

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, between 0 days old to 5 years of age.

3.6 Exclusion criteria

Data for stillbirths and children aged 5 years and above.

3.7 Research Instrument

The HDSS uses standardized questionnaires. The questionnaires include a household registration form, socioeconomic status (SES) form, and verbal autopsy form. This study used data abstraction tools to abstract HDSS data **(Appendix 3: Data Abstraction Tool)**

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 of 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: 1st quantile to 5: 5th 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.

The institution (level of a 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 Siaya HDSS data downloaded from their server, which is maintained in 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 **will be** stored for up to one month after the results have 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 disk.

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:

$$h(t) = h_0(t)\,\mathbf{exp}\left(b_1X_1 + b_2X_2 + \ldots + b_pX_p\right)$$

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). We used Multivariate Imputation by Chained Equation (MICE) to impute for variables missing values less than 10% (van Buuren & Groothuis-Oudshoorn, 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. The analysis was conducted using R software.

3.10 Ethical Considerations

I obtained approval from Jaramogi Oginga Odinga University of Science and Technology Postgraduate Studies, and Jaramogi Oginga Odinga Teaching and Referral Institutional Scientific and Ethics Review Committee. A confidential agreement form from the Centre Director Kenya Medical Research Institute Centre for Global Health Research permitted me to use HDSS data. 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 an 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

4.1.1 Sociodemographic characteristics of the study participants

From Table 4.1, a total of 24,452 children were enrolled in a study to attempt to examine the under-mortality mortality rate, risk factors associated with child mortality & survival probability of children born in Siaya. At the end of the follow-up, 1540 (6.4%) new deaths were recorded during the six years of 2015 to 2020. 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 2nd quantile status and the 3rd quantile at 21.3% and 21.1%, respectively.

Table 4.1 Sociodemographic characteristics of the study participants in Siaya HDSS using 2015 – 2020 HDSS data.

Characteristic	Overall, N = 24,452[1]	Alive, N = 16,914[1]	Outmigration, N = 5,998[1]	Under-five dead, N = 1,540[1]
Maternal age category				
less than 18 years	1,809 (7.4%)	869 (5.1%)	793 (13.2%)	147 (9.5%)
18 - 34 years	**19,075 (78.0%)**	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%)
Family size category				
1- 3 members	7,365 (34.9%)	4,539 (27.1%)	2,272 (72.9%)	554 (45.5%)
4- 6 members	**11,755 (55.8%)**	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%)
Marital status				
Divorce/separated	690 (3.7%)	406 (3.0%)	244 (6.1%)	40 (3.3%)
Don't Know	37 (0.2%)	25 (0.2%)	8 (0.2%)	4 (0.3%)
Married	7 (0.0%)	7 (0.1%)	0 (0.0%)	0 (0.0%)
Married/Cohabiting	**15,654 (83.2%)**	11,706 (85.8%)	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%)
Wealth Index/Quantile				
1st quantile	3,710 (18.8%)	2,360 (17.5%)	1,092 (21.8%)	258 (21.1%)
2nd quantile	**4,200 (21.3%)**	2,936 (21.8%)	994 (19.8%)	270 (22.1%)

Characteristic	Overall, N = 24,452[1]	Alive, N = 16,914[1]	Outmigration, N = 5,998[1]	Under-five dead, N = 1,540[1]
3rd quantile	4,164 (21.1%)	2,903 (21.5%)	1,016 (20.3%)	245 (20.0%)
4th quantile	3,889 (19.7%)	2,747 (20.4%)	901 (18.0%)	241 (19.7%)
5th quantile	3,753 (19.0%)	2,537 (18.8%)	1,006 (20.1%)	210 (17.2%)
Education level				
None	184 (0.8%)	129 (0.8%)	33 (0.6%)	22 (1.4%)
Primary	**15,168 (62.4%)**	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%)
Religion				
Protestants	4,246 (17.6%)	2,886 (17.3%)	1,122 (18.9%)	238 (15.7%)
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%)
Others	**9,181 (38.0%)**	6,379 (38.3%)	2,210 (37.2%)	592 (39.0%)
Individual occupation				
Fishery	39 (0.4%)	31 (0.4%)	5 (0.3%)	3 (0.4%)
H-Wife/Not working	1,268 (11.7%)	902 (10.7%)	281 (16.8%)	85 (11.7%)
Farming	**6,476 (59.8%)**	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%)

4.1.2 Under-five children, environmental and maternal health care-seeking behavior of the study participant.

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. Finally, Catholics contributed to 23.1% of the religion, 21.2% were Legio maria/roho, 17.6% were protestants, and others constituted 38.0%.

Table 4.2 Under-five children, environmental and maternal health care seeking behavior of the study participant using HDSS data (2015 – 2020)

Characteristic	Overall, N = 24,452[1]	Alive, N = 16,914[1]	Outmigration, N = 5,998[1]	Under-five dead, N = 1,540[1]
Gender				
Male	**12,341 (50.5%)**	8,556 (50.6%)	2,933 (48.9%)	852 (55.3%)
Female	12,111 (49.5%)	8,358 (49.4%)	3,065 (51.1%)	688 (44.7%)
Place of Delivery				
Home/ way to Hospital	2,131 (8.7%)	1,355 (8.0%)	543 (9.1%)	233 (15.2%)
Private hospital	4,087 (16.7%)	3,095 (18.3%)	821 (13.7%)	171 (11.1%)
Government Hospital	**18,189 (74.5%)**	12,438 (73.6%)	4,619 (77.2%)	1,132 (73.7%)
Birth Assistance				
Nurse/Midwife/Doctor/CHW	**22,870 (93.7%)**	15,926 (94.3%)	5,584 (93.3%)	1,360 (88.5%)
Traditional Birth Attendant	1,548 (6.3%)	970 (5.7%)	401 (6.7%)	177 (11.5%)
Place of ANC visit				
Gov. Dispensary	2,813 (12.0%)	2,218 (13.5%)	473 (8.4%)	122 (8.3%)
Gov. Health Center	3,916 (16.6%)	3,042 (18.5%)	718 (12.7%)	156 (10.6%)
Gov. Hospital	**15,539 (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%)
ANC times				
None	108 (0.5%)	63 (0.4%)	34 (0.6%)	11 (0.8%)
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%)
Above 4	**14,731 (64.7%)**	10,468 (65.5%)	3,407 (63.4%)	856 (60.7%)
Water for drinking				
Tap water	4,306 (18.2%)	2,935 (17.9%)	1,122 (19.4%)	249 (16.6%)
Lake/River	6,094 (25.8%)	4,250 (26.0%)	1,396 (24.1%)	448 (29.9%)
Rainfall	3,986 (16.8%)	2,833 (17.3%)	952 (16.4%)	201 (13.4%)
Unprotected spring/borehole/well	**6,117 (25.9%)**	4,209 (25.7%)	1,510 (26.1%)	398 (26.6%)
Protected spring	3,159 (13.4%)	2,142 (13.1%)	815 (14.1%)	202 (13.5%)
Distance to water source				
IN COMPOUND	4,985 (20.6%)	3,514 (21.0%)	1,231 (20.7%)	240 (15.7%)
<500M	**13,976 (57.7%)**	9,721 (58.0%)	3,342 (56.2%)	913 (59.9%)
500M-2KM	4,783 (19.7%)	3,189 (19.0%)	1,251 (21.1%)	343 (22.5%)
2KM-5KM	186 (0.8%)	131 (0.8%)	42 (0.7%)	13 (0.9%)
>5KM	10 (0.0%)	5 (0.0%)	5 (0.1%)	0 (0.0%)
DK	291 (1.2%)	204 (1.2%)	71 (1.2%)	16 (1.0%)
cooking methods				
Charcoal/Firewood	**23,915 (97.8%)**	16,559 (97.9%)	5,837 (97.3%)	1,519 (98.6%)
Gas/Paraffin/Stove	537 (2.2%)	355 (2.1%)	161 (2.7%)	21 (1.4%)
Toilet type				
Neighbor -No	2,375 (9.8%)	1,590 (9.5%)	584 (9.8%)	201 (13.2%)

Characteristic	Overall, N = 24,452[1]	Alive, N = 16,914[1]	Outmigration, N = 5,998[1]	Under-five dead, N = 1,540[1]
facility/Bush/field				
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%)

4.1.3 Estimation of under-five mortality rate in Siaya HDSS using 2015 – 2020 HDSS data

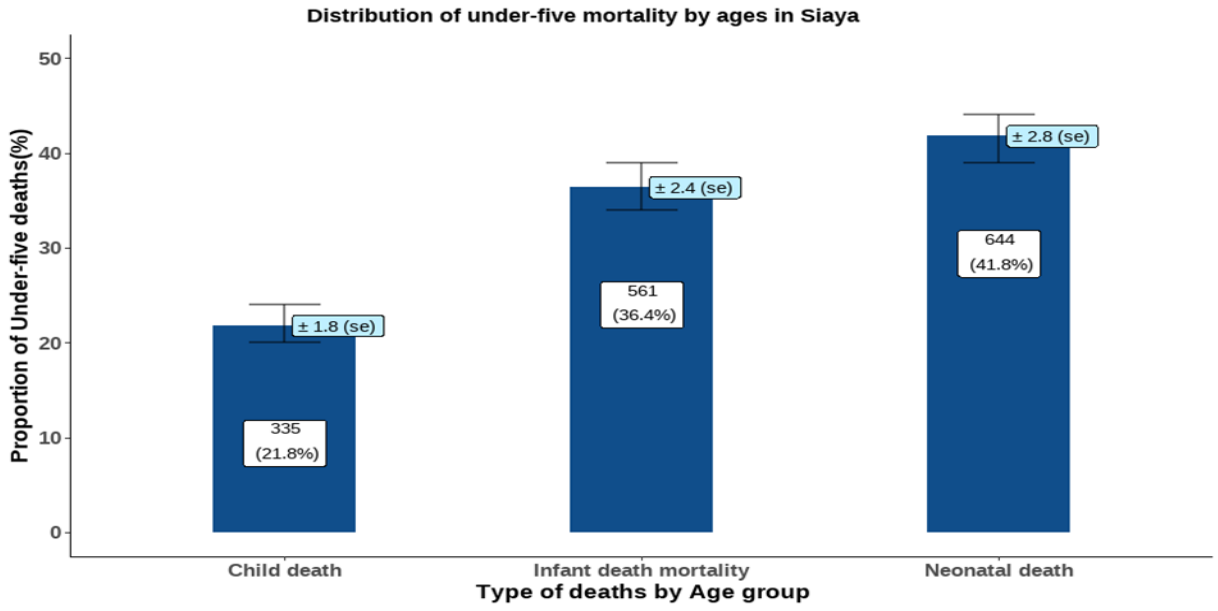
The under-five mortality rate was estimated to be 62.98 deaths per 1000 live births among the children enrolled in the study between 2015 to 2020.

Und**er-five mortality rate** = (1540/24,452) *1000 = 62.98 deaths per 1000 livebirths

4.1.4 Distribution of under-five mortality by age

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). The overall number of recorded under-five deaths within the study period is 1540, with most deaths being neonatal deaths 644 (41.8%) followed by infant deaths 561 (36.4%), and child deaths being the least experienced deaths 335 (21.8%). It was observed that with different age groups the likelihood of death declines.

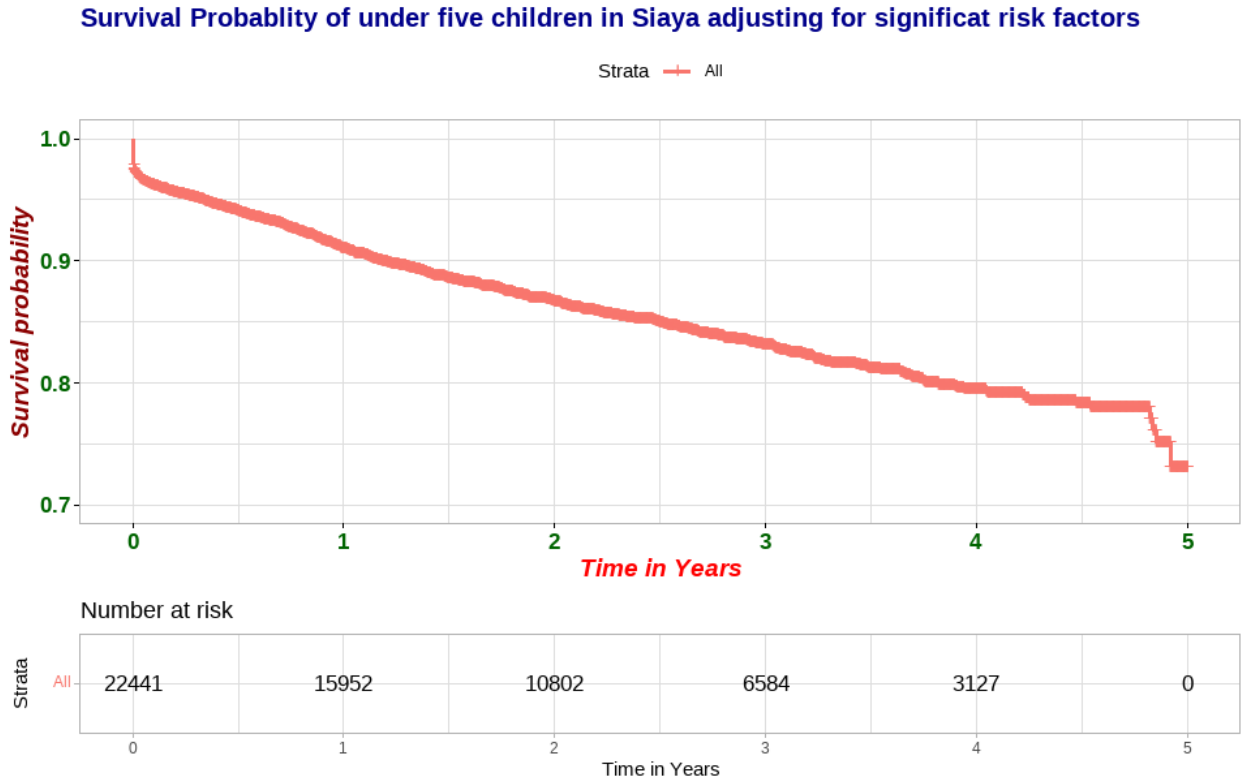
Figure 4.1: Distribution of under-five mortality by age in Siaya HDSS using 2015 – 2020 HDSS data.



4.2 Survival Probability of Children Under Five in Siaya

Figure 4.2 shows the survival probability of children in Siaya after adjusting for other significant risk factors. 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, 4570 (39.1%) participants, and in Year four, 3,348 participants, respectively. The cumulative survival probability was approximately 70% among the children born in the study area after adjusting for given risk factors like maternal age, maternal level of education, Number of ANC visits, Toilet type, place of birth, cooking method, and child gender. On average, per every unit increase in the year, the survival probability increases by approximately 60%.

Figure 4.2: Survival probability of children under five in Siaya HDSS adjusting for significant risk factors using 2015 – 2020 HDSS data.



4.3 Log-rank test for the predictors of under-five mortality

In Table 4.3, there were statistically significant differences in under-five survival probabilities by child gender, maternal level of education, maternal age at delivery of the child,family size, maternal marital status, marriage type, wealth index, place of birth, place of ANC visit, number of ANC visits, religion, source of drinking water, source of income, distance to water source, cooking methods, toilet type, and birth assistance over the study

period (log-rank, $p<0.05$). All these statistically significant variables were considered candidates for inclusion in the final model.

Table 4.3: Log-rank test for the predictors of under-five mortality in Siaya HDSS using Siaya HDSS data.

Characteristic	N	Observed	Expected	(O-E)^2	(O-E)^2/V	p-value[2]
Religion						**<0.03**
Protestants	4,246 (17.6%)	238	267	3.115	3.796	
Catholic	5,584 (23.1%)	328	348	1.193	1.555	
Roho/legion maria	5,120 (21.2%)	359	321	4.381	5.583	
Others	9,181 (38.0%)	592	580	0.235	0.383	
	$X^2 = 9$ df = 3					
Maternal age category						**<0.001**
less than 18 years	1,809 (7.4%)	147	104	17.67	19.06	
18 - 34 years	19,075 (78.0%)	1140	1205	3.47	16.02	
Greater than 34 years	3,568 (14.6%)	253	231	2.05	2.43	
	$X^2 = 23.3$ df = 2					
Family size category						**<0.001**
1- 3 members	7,365 (34.9%)	554	403	56.7	85.2	
4- 6 members	11,755 (55.8%)	584	697	18.3	43.1	
7 + members	1,964 (9.3%)	79	117	12.4	13.8	
	$X^2 = 87.9$ df = 2					
Wealth Index						<0.2
1st quantile	3,710 (18.8%)	258	230	3.44083	4.2528	
2nd quantile	4,200 (21.3%)	370	265	0.09667	0.1239	
3rd quantile	4,164 (21.1%)	245	261	1.03461	1.3206	
4th quantile	3,889 (19.7%)	241	240	0.00608	0.0076	
5th quantile	3,753 (19.0%)	210	228	1.41291	1.7431	
	$X^2 = 6$ df = 4					
Education level						**<0.001**
None	184	22	11.4	9.8	9.91	
Primary	15,168 (62.4%)	1085	976.5	12.0	33.46	
Secondary/High	7,629 (31.4%)	374	461.5	16.6	23.87	
Post-Secondary	1,334 (5.5%)	50	81.6	12.2	12.96	
	$X^2 = 50.9$ df = 3					
Source of Income						**<0.001**
Fishery	39 (0.4%)	3	3	0.0137	0.0138	
H-Wife/Not working	1,268 (11.7%)	85	85	0.1411	0.1596	
Farming	6,476 (59.8%)	488	436	6.0445	15.2558	
Skilled labor/worker	1,017 (9.4%)	42	68.53	10.2695	11.3818	
Business Owner	1,898 (17.5%)	98	226.10	6.2602	7.605	
Other	135 (1.2%)	9	9.34	0.0122	0.0124	
	$X^2 = 22.8$ df = 5					
Marital status						0.07
Divorce/Separated	690	40	42.203	0.1150	0.120	
Don't know	37	4	2.511	0.8829	0.888	

Maried/Cohabiting	15661	991	995.105	0.0169	0.101	
Single	2027	121	130.257	0.6579	0.741	
Widowed	398	41	26.416	8.0515	0.264	
	X^2 = 10.3 df = 0.07					
Marital type						0.3
Don't know	8	0	0.604	0.602	0.605	
Monogamous	13746	874	885.163	0.141	1.634	
Polygamous	1282	95	83.234	1.663	1.827	
	X^2 = 2.4 df = 0.3					
Gender						**<0.001**
Male	12,341 (50.5%)	852	776	7.37	14.9	
Female	12,111 (49.5%)	688	764	7.49	14.9	
	X^2 = 14.9 df = 1					
Place of Birth						**<0.001**
Home/ way to Hospital	2,131 (8.7%)	233	144	55.3086	61.35944	
Private hospital	4,087 (16.7%)	171	259	29.8990	36.14375	
Government Hospital	18,189 (74.5%)	1132	1133	0.00124	0.00477	
	X^2 = 85.4 df = 2					
Birth Assistance						**<0.001**
Nurse/Midwife/Doctor/CHW	22,870 (93.7%)	1360	1433	3.74	55.7	
Traditional Birth Attendant	1,548 (6.3%)	177	104	51.67	55.7	
	X^2 = 55.7 df = 1					
ANC times						**<0.001**
None	108 (0.5%)	11	5.35	5.98	6.8	
One	689 (3.0%)	56	45.02	2.68	2.78	
Two	1,893 (8.3%)	164	122.80	13.82	15.20	
Three	5,351 (23.5%)	323	341.38	0.99	1.3	
Above 4	14,731 (64.7%)	856	895.44	1.74	4.79	
	X^2 = 25.3 df = 4					
Distance to water source						**<0.001**
IN COMPOUND	4,985 (20.6%)	240	314.216	17.5295	22.1686	
<500M	13,976 (57.7%)	913	879.284	1.2928	3.0658	
500M-2KM	4,783 (19.7%)	343	299.830	6.2158	7.7687	
2KM-5KM	186 (0.8%)	13	12.399	0.0291	0.0295	
>5KM	10 (0.0%)	0	0.6	0 6085	0.6114	
DK	291 (1.2%)	16	18	0.3799	0.3862	
	X^2 = 26.2 df = 5					
Cooking methods						**0.05**
Charcoal/Firewood	23,915 (97.8%)	1519	1508	0.0796	3.85	
Gas/Paraffin/Stove	537 (2.2%)	21	32	3.7548	3.85	
	X^2 = 3.9 df = 1					
Toilet type						**<0.001**
Neighbor -No facility/Bush/field	2,375 (9.8%)	201	152	15.774	17.593	
Modern latrine	1,936 (8.0%)	86	122	10.385	11.330	
Traditional pit	19,921 (82.2%)	1238	1238	0.144	0.809	

$X^2 = 26.4$ df = 2

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. The Kaplan-Meier curves show that the survival probabilities among the females were higher than that of the males (Fig. 4.3a). Mothers with post-secondary education had their children have the lowest hazard risk of approximately 4% compared to mothers with secondary, primary, and no education (Fig. 4.3b). However, children born to mothers aged 18 – 34 years have a higher survival probability than those of less than 18 years and above 34 years (Fig 4.3c). However, the probability of death among children delivered at home was higher as compared to those delivered in the hospital (Fig. 4.3d). The family size, on the other hand, showed that children below the age of five from families with >7 members had higher probabilities of survival compared to those with fewer members (Fig. 4.3e).

Figure 4.3a Kaplan Meier estimates in Gender

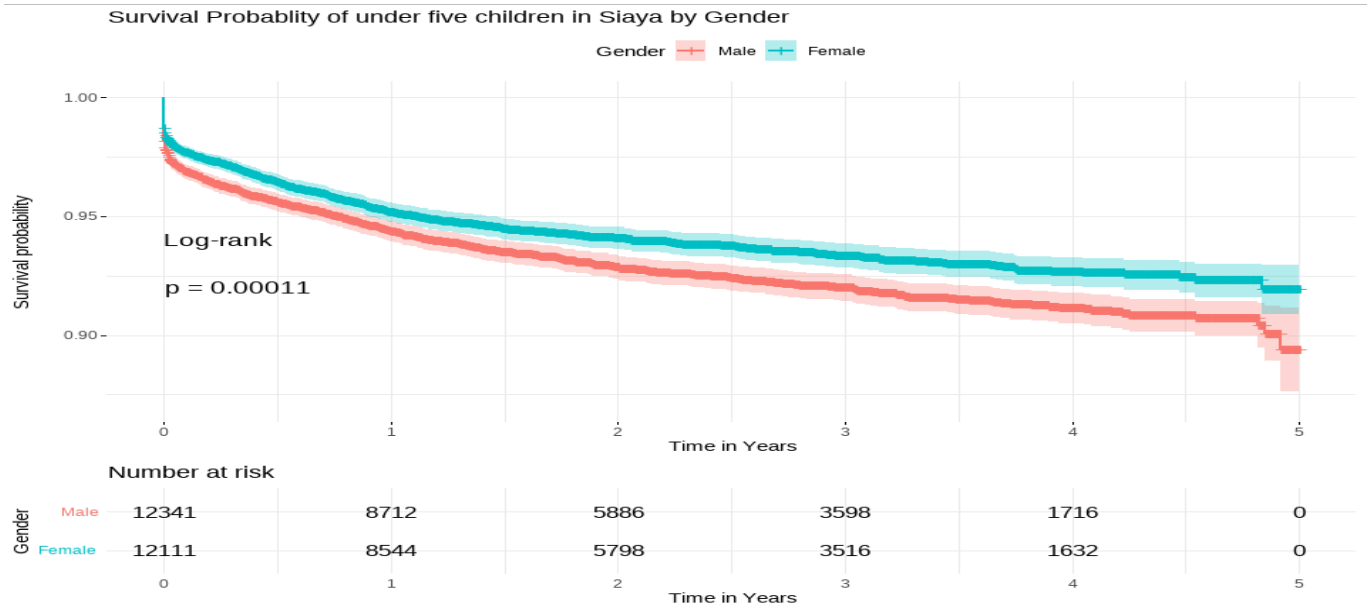


Figure 4.3b Kaplan Meier estimates in the level of education

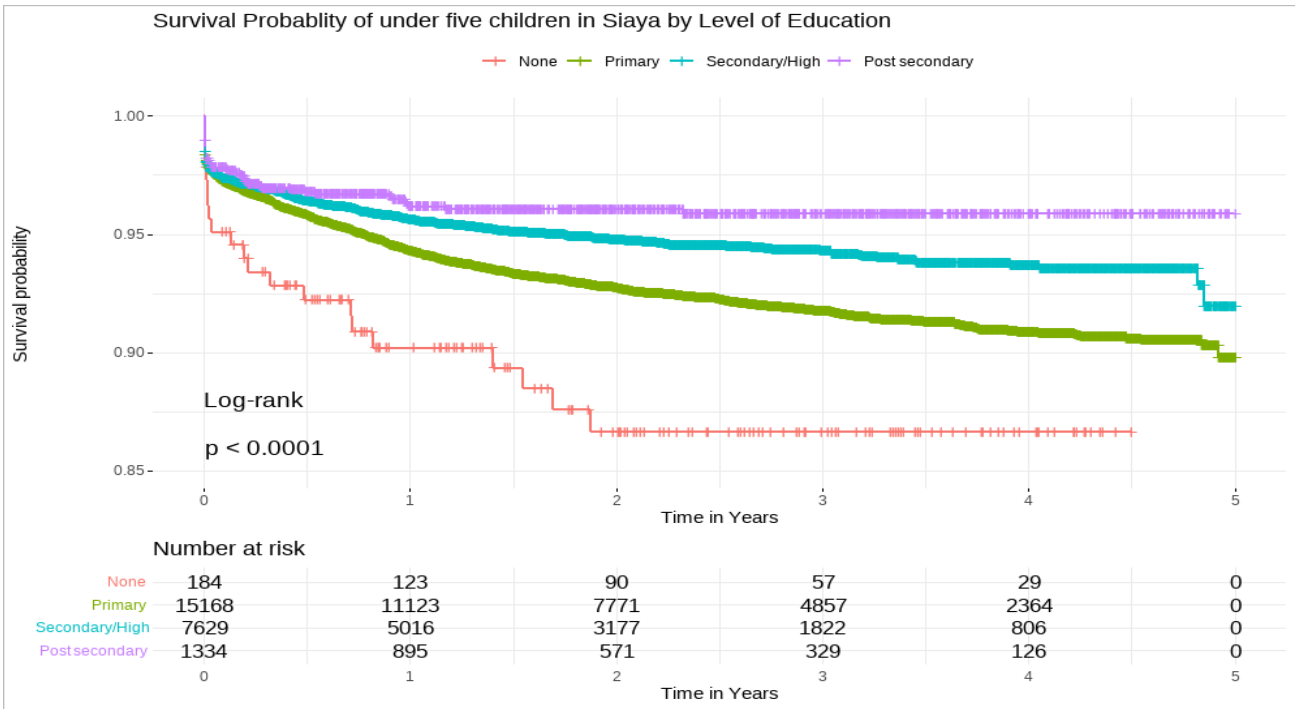


Fig 4.3c Kaplan Meier estimates in Maternal age

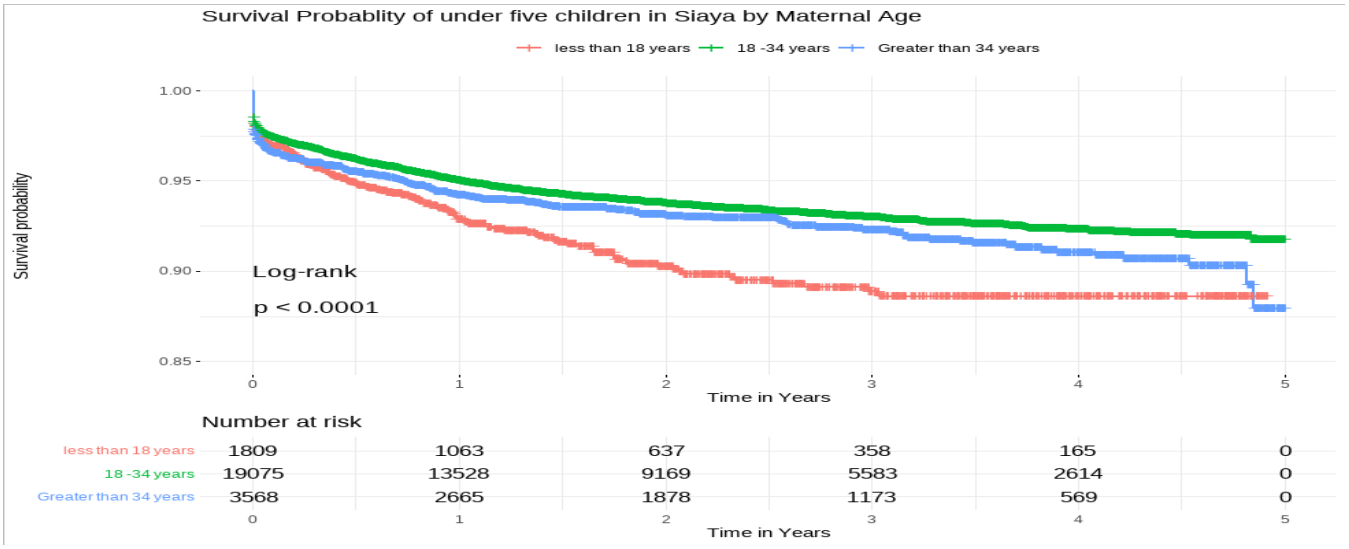


Fig 4.3d Kaplan Meier estimates by place of delivery

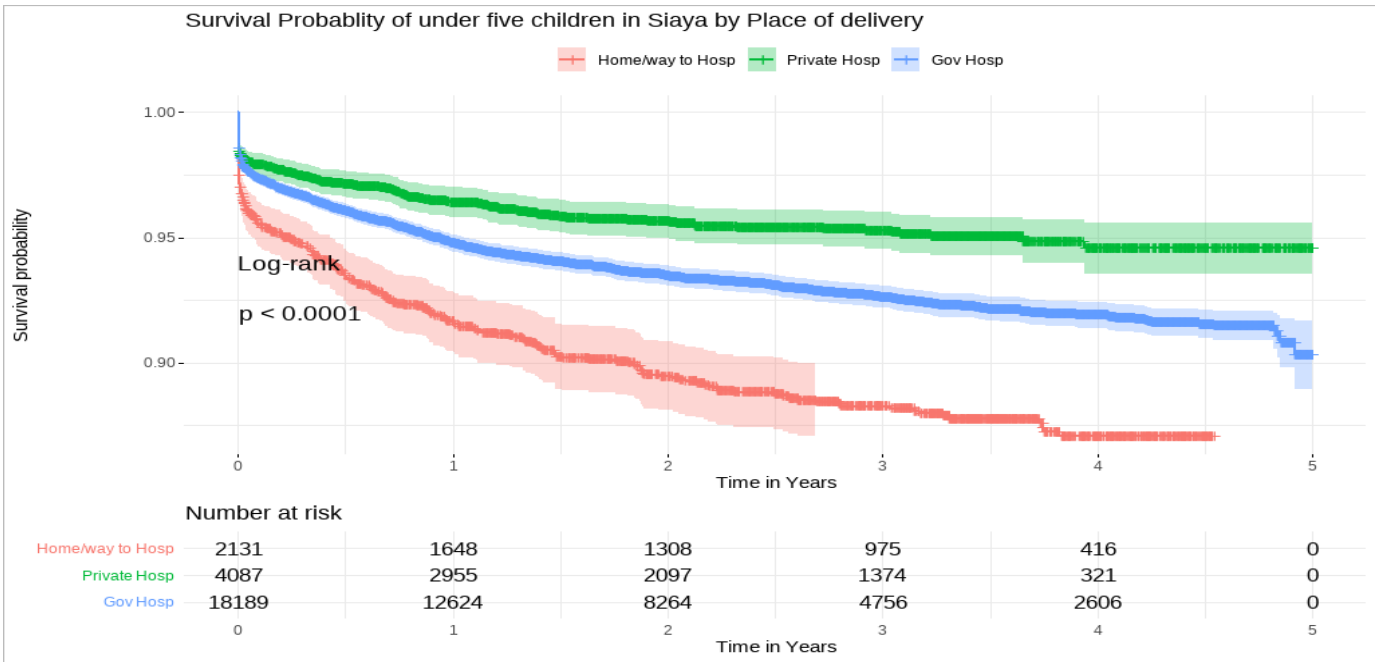
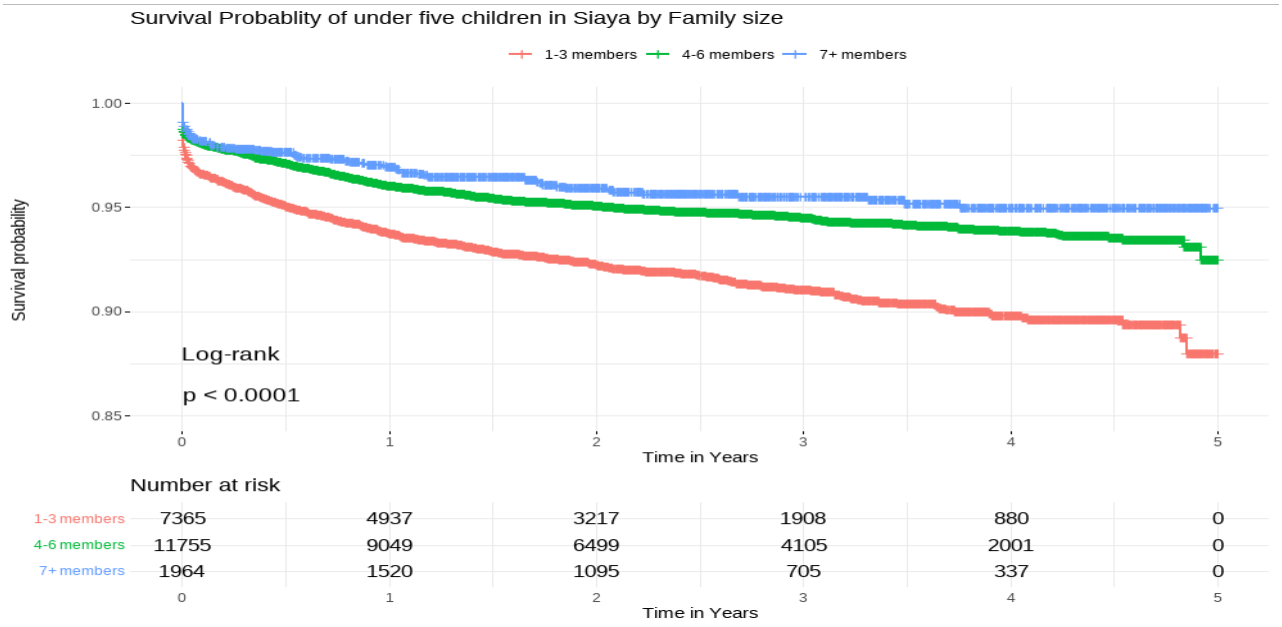


Fig 4.3e Kaplan Meier estimates in family size



4.5 Results of the multivariate analysis

The Cox proportional hazards regression model was used to examine the effects of multiple risk factors 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 0.5 and data missing values of less than 10% 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, and results are shown in 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 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. While those born in government hospitals had a 34% reduced risk of mortality: HR = 0.66, 95% CI 0.57-078.

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 three ANC visits or more than 4 ANC visits had a 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. However, the effect of one or two ANC visits was not statistically significant in the bivariate and multivariate predictive analysis, implying no risk difference between one or two ANC visits and those with just no ANC visit attempt.

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, P-value = 0.4

Table 4.4 The final fitting Cox proportional hazard model in Siaya HDSS using 2015 – 2020 HDSS data

	Crude Hazard Ratio			**Adjusted Hazard Ratio**		
Risk factors	HR[1]	95% CI[1]	p-value	HR[1]	95% CI[1]	p-value
Maternal Level of Education						
None	1.00	—		1.00	—	
Primary	0.58	0.38, 0.88	0.010	0.67	0.42, 1.07	0.10
Secondary/High	0.42	0.27, 0.65	<0.001	0.52	0.32, 0.84	0.007
Post-Secondary	0.32	0.19, 0.52	<0.001	0.40	0.23, 0.70	0.001
Maternal Age						
less than 18 years	1.00	—		1.00	—	
18 - 34 years	0.67	0.56, 0.79	<0.001	0.74	0.62, 0.90	0.002
Greater than 34 years	0.77	0.63, 0.95	0.014	0.77	0.62, 0.97	0.025
Number of ANC visit						
None	1.00	—		1.00	—	
One	0.60	0.31, 1.15	0.13	0.53	0.27, 1.03	0.063
Two	0.65	0.35, 1.20	0.2	0.60	0.32, 1.12	0.11
Three	0.46	0.25, 0.84	0.012	0.45	0.24, 0.84	0.011
Above 4	0.46	0.25, 0.84	0.012	0.48	0.26, 0.88	0.018
Place of birth						
Home/ way to Hospital	1.00	—		1.00	—	
Private hospital	0.41	0.33, 0.50	<0.001	0.47	0.38, 0.58	<0.001
Government Hospital	0.62	0.53, 0.71	<0.001	0.66	0.57, 0.78	<0.001
Method of cooking						
Charcoal/Firewood	1.00	—		1.00	—	

Gas/Paraffin/Stove	0.65	0.42, 1.01	0.053	0.82	0.50, 1.32	0.4
Toilet type						
Neighbor -No facility/Bush/field	1.00	—		1.00	—	
Modern latrine	0.53	0.42, 0.69	<0.001	0.69	0.53, 0.90	0.006
Traditional pit	0.75	0.64, 0.87	<0.001	0.82	0.70, 0.96	0.014
Child Gender						
Male	1.00	—		1.00	—	
Female	0.82	0.74, 0.91	<0.001	0.82	0.74, 0.91	<0.001

[1]HR = Hazard Ratio, CI = Confidence Interval

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.

The study revealed a high under-five mortality rate of 62.98 deaths per 1000 live births, with variation across ages. This suggests that the SDG goal to reduce under-five mortality to 25 deaths per 1000 live births by the year 2030 may not be met despite the steady decline from 99 deaths per 1000 live births in 2014 to 67.4 deaths in 2023 (WHO, 2016). The findings are slightly lower than the findings from the Kenya health demographic and economic survey, with an under-five mortality rate of 67.4 deaths per 100 live births in Siaya (KNBS, 2022). These differences in the under-five mortality rate may be due to the sample size and study setting difference used in the Kenya Demographic Survey Indicator. However, the findings were higher than the national under-five mortality rate of 41.9 deaths per 1000 live births (UN - IGME, 2022). These variations might be related to inequalities in socioeconomic status across the regions, with poverty higher in some counties than others (KIPPRA, 2020). Besides, Siaya County is a malaria endemic zone with the highest malaria prevalence of 19%; malaria is among the top five causes of under-five mortality globally, hence high mortality among children below five years of age (DNMP, 2021). In addition, differences in the community on the utilization of health services during pregnancy, delivery, and post-delivery may have contributed to high mortality. Furthermore, the overall steady decline in the under-five mortality rate in Siaya can also be explained by the reduced poverty index seen in the county for the past 5years (KIPPRA, 2020) and the increase in uptake of ANC services, hospital delivery, immunization services, and utilization of insecticides treated nets (Ikamari, 2020).

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. 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, Dangisso, & Hibstu, 2020). In addition, most facilities in Siaya HDSS are level 2 and 3, hence cannot manage conditions associated with birth complications such as birth asphyxia. Therefore, the study suggests that programs to reduce mortality should prioritize neonates, as this could reduce mortality under the age of five. Furthermore, a high proportion of deliveries at home or on the way to the hospital without being attended to by skilled birth attendants, and poor access to quality maternal and childcare services during ANC, deliveries, and postneonatal period have a tremendous impact on under-five mortality during this period *(Tesfa et al., 2021).* Hence, mobilization and sensitization should be tailored toward improving hospital delivery and delivery units.

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*(Costa et al., 2017; Fagbamigbe et al., 2022).* 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, Diarra, Mabeu, & Pongou, 2018). 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).

The observed lower reduction in under-five mortality among children of mothers with high levels of education attainment indicates that improving maternal education could increase child survival outcomes, consistent with other previous studies (Bado & Sathiya Susuman, 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, Leon, & Baker, 2012).

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, Singh, Rai, & Singh, 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, Woldu, & Gizaw, 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, Fagbamigbe, & Adebowale, 2018). The results conform with the results from other studies *(Adebowale et al., 2017; Motsima et al., 2020)* . Of interest was the unobserved cooking method association with under-five mortality. There is no doubt that the health of children is largely dependent on modern cooking methods (Latona, Yusuf, & Adebowale, 2017). Our study showed no significant association with 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 under-five mortality rate of 62.692 deaths per 1000 births in Siaya was about twice as high as the national average, mainly in the neonatal and immediate postnatal periods, mostly attributable to preventable causes. This indicates the importance of understanding local variations in trends and the main drivers of under-five mortality and their predictors.
2. The survival probability of children in Siaya was reduced by approximately 30% when adjusted for maternal socio-demographic factors, uptake of health interventions, and infant-related risk factors.
3. Maternal age at delivery, level of education, number of ANC visits, place of delivery, and type of delivery were the main predictors of under-five mortality.

6.2 Recommendation

6.2.1 recommendations for programs

1. The government or policymakers should intensify maternal health care services in the early stages of child life by promoting health education and community awareness on early 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. Women's empowerment should be promoted by encouraging them to join community-based programs that generate income such as catering services and poultry farming. This will boost the financial status of the mothers. In addition, promoting compulsory secondary education to delay early marriages, and helping mothers make health decisions will improve the survival probability of children under five years.

3. 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. Finally, policymakers should educate the community about the importance of toilet use through programs such as WASH programs and ODF-free campaigns.

6.2.1 recommendations for further research

1. There is a need to establish a more robust health demographic surveillance system nationwide to help track real-time data on under-five mortality to reduce recall bias experienced during cross-sectional surveys. In addition, it will also help understand the differences in maternal sociodemographics, socioeconomic factors, and maternal health behaviors in different communities that might influence infant mortality.

2. 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.

3. 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.

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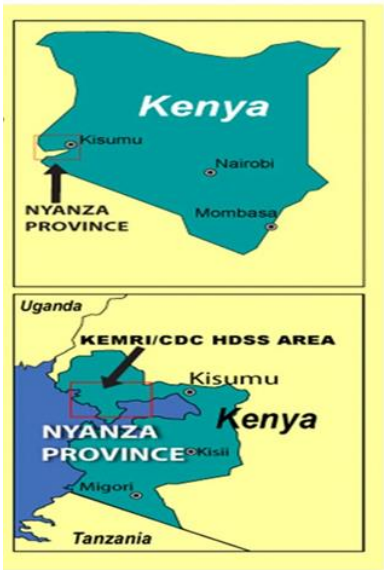
Appendix 1: MAP OF STUDY AREA

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: _____

C o m m e n t s :

_____

_____

QA Review: _____Initials: _____ Date: _____

Appendix 3: DATA ABSTRACTION RETREVAL 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

P.O. BOX 210 - 40601
BONDO

Our Ref: H153/4269/2018

Date: 9th 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.

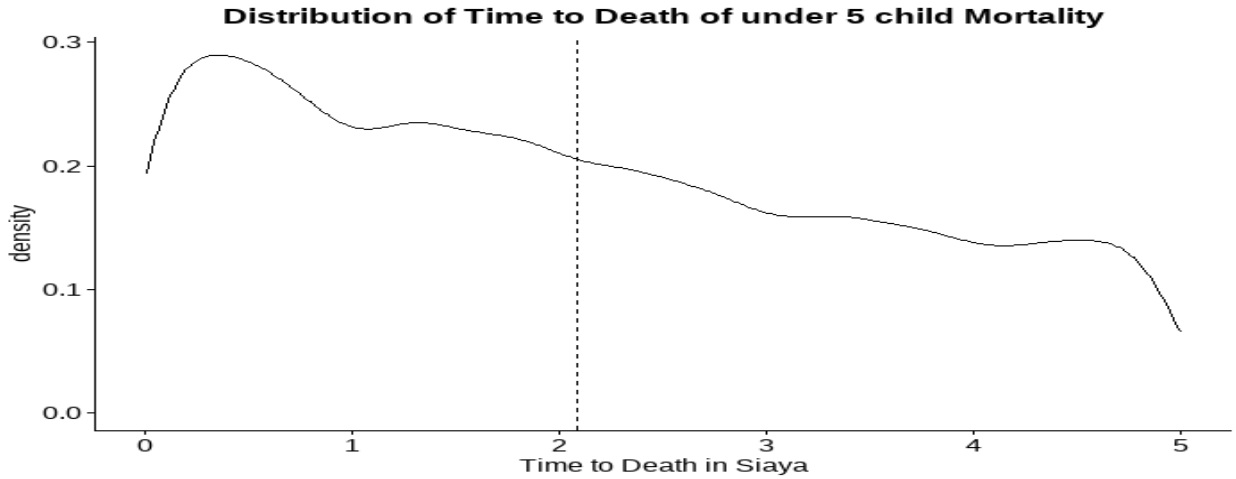
Thank you.

JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE & TECHNOLOGY BOARD OF POST GRADUATE STUDIES JAN 2023 P.O. Box 210 - 40601, BONDO

Prof. Dennis Ochuodho
DIRECTOR, BOARD OF POSTGRADUATE STUDIES

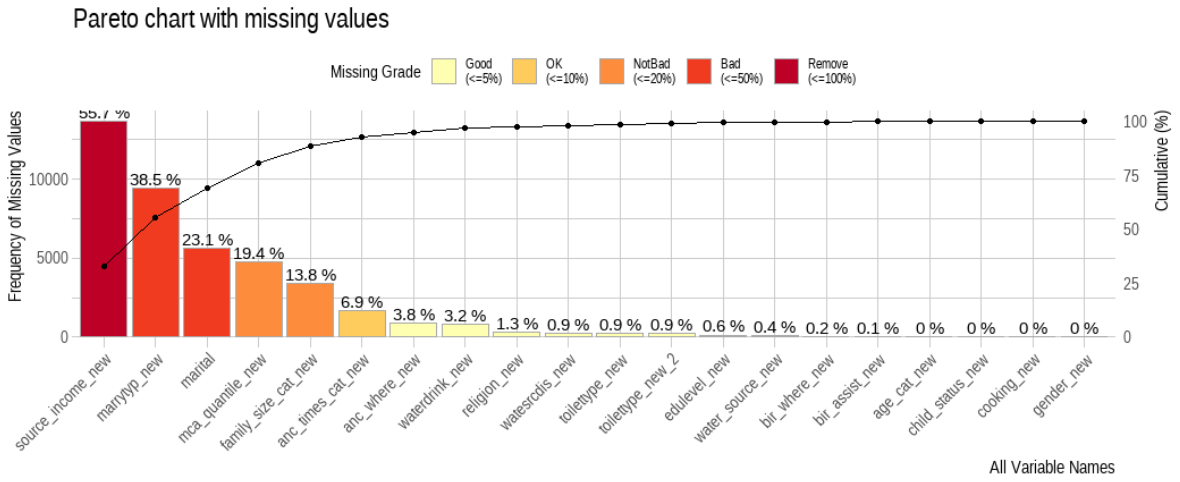
Appendix 5: Additional graphs and tables for data analysis

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



The density plot checks for 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

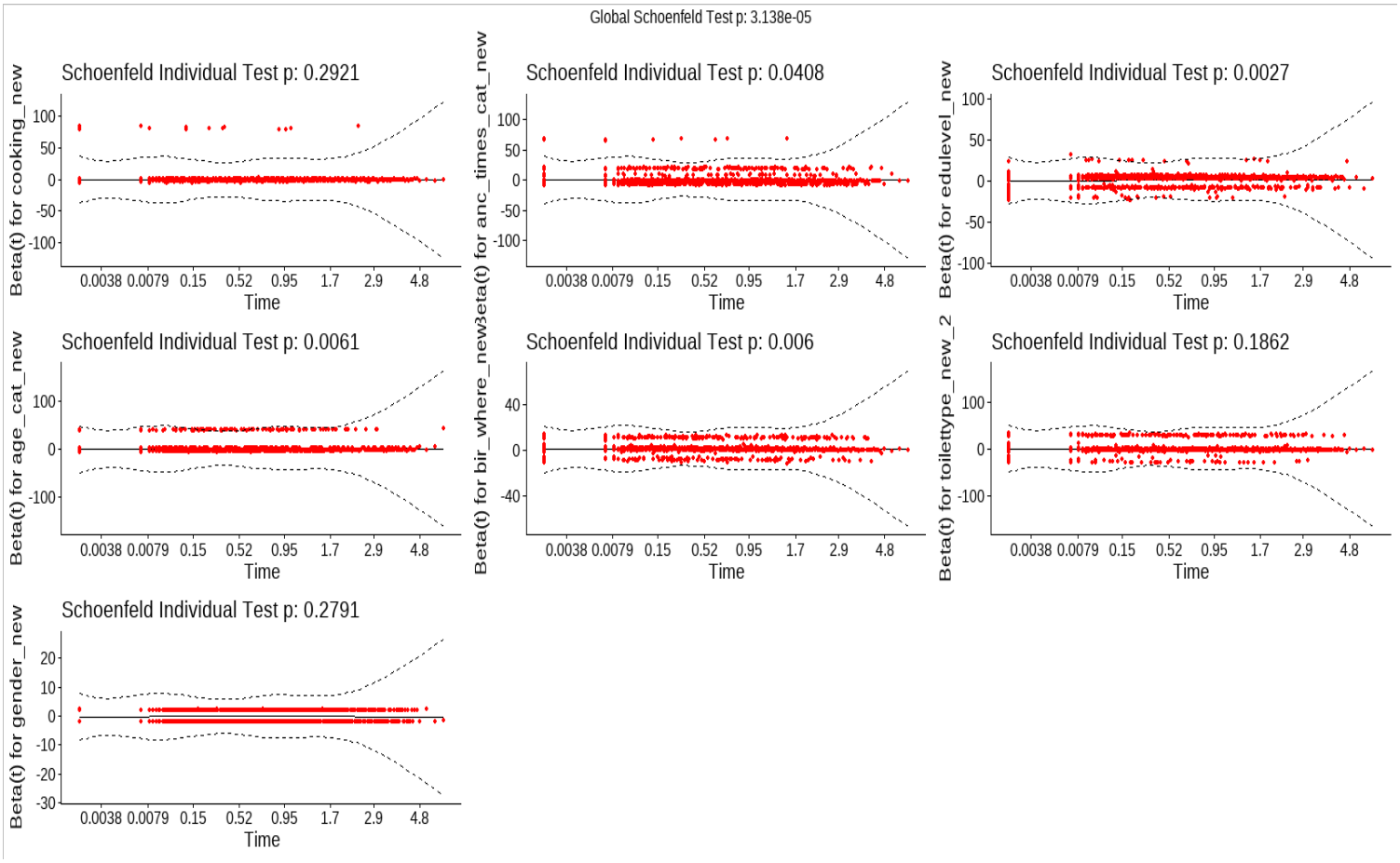


Table 6.1: The final model with coefficient of under-five mortality in Siaya HDSS using Siaya HDSS data.

```
Call:
coxph(formula = Surv(Time_event, event = censored) ~ edulevel_new +
    year_of_death + age_cat_new + anc_times_cat_new + bir_where_new +
    cooking_new + toilettype_new_2 + gender_new, data = Surv_data,
    robust = T)

                                    coef exp(coef) se(coef) robust se       z        p
edulevel_newPrimary              -0.09323   0.91098  0.23824   0.24092  -0.387 0.698765
edulevel_newSecondary/High       -0.33491   0.71540  0.24285   0.24587  -1.362 0.173144
edulevel_newPost Secondary       -0.62435   0.53561  0.28734   0.28969  -2.155 0.031144
year_of_death                    -0.93546   0.39241  0.01698   0.01668 -56.078  < 2e-16
age_cat_new18 - 34 years          0.20918   1.23266  0.09665   0.09868   2.120 0.034022
age_cat_newGreater than 34 years  0.80922   2.24615  0.11566   0.11899   6.801 1.04e-11
anc_times_cat_newOne             -0.83872   0.43226  0.33108   0.36253  -2.314 0.020693
anc_times_cat_newTwo             -0.85163   0.42672  0.31262   0.34682  -2.456 0.014066
anc_times_cat_newThree           -1.12637   0.32421  0.30783   0.34351  -3.279 0.001042
anc_times_cat_newAbove 4         -1.01390   0.36280  0.30475   0.34137  -2.970 0.002977
bir_where_newPrivate hospital    -0.15973   0.85238  0.10838   0.10937  -1.460 0.144183
bir_where_newGovernment Hospita  -0.27888   0.75663  0.07837   0.07728  -3.609 0.000308
cooking_newGas/Parrafine/Stove   -0.23756   0.78855  0.25090   0.25233  -0.941 0.346469
toilettype_new_2Modern latrin    -0.28618   0.75113  0.13789   0.13627  -2.100 0.035728
toilettype_new_2Traditional pit  -0.10721   0.89834  0.08109   0.08041  -1.333 0.182420
gender_newFemale                 -0.22785   0.79625  0.05401   0.05376  -4.238 2.25e-05

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

```
Concordance= 0.864  (se = 0.005 )
Likelihood ratio test= 3028  on 16 df,   p=<2e-16
Wald test            = 3428  on 16 df,   p=<2e-16
Score (logrank) test = 5715  on 16 df,   p=<2e-16,   Robust = 944.9  p=<2e-16
```

Model fit is 86.4% from concordance.