

Importance of Investing in the First 1,000 Days of Life: Evidence and Policy Options

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HCD-ICCS-004

AFRICAN ECONOMIC RESEARCH CONSORTIUM
CONSORTIUM POUR LA RECHERCHE ÉCONOMIQUE EN AFRIQUE

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August 2024

THIS RESEARCH STUDY was supported by a grant from the African Economic Research Consortium. The findings, opinions and recommendations are those of the author, however, and do not necessarily reflect the views of the Consortium, its individual members or the AERC Secretariat.

Published by: The African Economic Research Consortium
P.O. Box 62882 - City Square
Nairobi 00200, Kenya

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Abstract

Investment in the first 1,000 days of life is important for human capital development. The basic needs and services in these days of life are maternal healthcare; child healthcare; mobilization of mothers to seek early antenatal care; increasing hospital deliveries; enhancing exclusive breastfeeding for the first 6 months of life; increasing knowledge on the proper weaning diet; immunization; and early diagnosis and treatment of common childhood illnesses. However, there is a dearth evidence on the importance of investing in the early years of life. The purpose of this study was to explore the role of investing in the first 1,000 days of life for improved human capital accumulation. The study utilized the Kenya Demographic and Health Survey (KDHS) 2022 data. Using the Cox regression hazard model, the study found out that twins have a higher risk of mortality than single births and firstborns were less likely to die before their fifth birthday than the children born after them. The findings also indicate that an increase in the household size by 1 individual reduces the likelihood of death for children aged less than 1 year and for children aged between 13 and 60 months. Children from female-headed households reported a lower likelihood of mortality. Perhaps this is because of assurance of breastfeeding for the first 6 months of life when the child is living with the mother, increasing the probability of knowledge on the proper weaning diet and improved uptake of immunization by the mother. The likelihood of mortality for children whose mothers reported health comorbidities was higher than for those who reported good health. Children younger than 1 year of mothers who were assisted during delivery were less likely to die than those whose parents were assisted during delivery. In relation to the place of delivery, children who were delivered at a government health facility were less likely to die than those who were born at home. Based on these findings, the study recommends provision of civic education to pregnant and new mothers on the risks facing their new-borns and the importance of following the laid out public health protocols of the first 1,000 days of life to ensure the children's survival..

Key Words: Investing First 1000 Days Kenya, cox hazard regression

1. Background

1.1 Introduction

The first 1,000 days of life refers to the period from conception to the second birthday in a child's life, that is, pregnancy, infancy and toddlerhood. This is an important period since the body is undergoing significant brain, physical and immunity development, and neurodevelopment (Sanefuji et al., 2021). The period is therefore important for public health interventions that will support child development during this critical period, preventing deficiencies such as malnutrition and infections that become counterproductive to the child's health and result in negative economic impacts. This is also a powerful window of opportunity during which investment in the child's health nutrition will have long-term implications for the future health and development of a child and productivity later in life (Martorell, 2018).

A study published by the International Institute for Applied Systems Analysis (IIASA) in 2008 compared demographic and human capital trends in Eastern Europe and in sub-Saharan Africa. The world was forecasted to have two major demographic occurrences in two decades: rapid population growth and rapid population ageing (Lutz *et al*, 2008). From the study, sub-Saharan Africa was predicted to experience a population explosion which would boost the workforce while Eastern Europe would experience a population shrink. It, however, brought up an inverse correlation between population growth and education attainment, predicting a higher per capita productivity in Eastern Europe owing to increased education attainment among the adult working population as compared to sub-Saharan Africa.

With this in mind, human capital comprises knowledge, skills and health accumulated and invested through a person's life to enable them to realize their full potential as productive members of the society (World Bank, 2018). The Human Capital Index (HCI) comprises six inputs in health and education. The health inputs are the probability of a child surviving to age 5 years, adult survival rate and the proportion of children without stunted growth. The education inputs are expected years of schooling, harmonized test scores and learning adjusted years of school. The HCI for Kenya in 2018 was 52% relative to a global average of 56% (Table 1). This implies that a child born in Kenya today will have a productivity of 52% relative to what it could be if the child enjoyed full health and completed education. Seychelles and Mauritius are the best performing among the sub-Saharan Africa countries with a HCI of 68%

and 63% respectively. The main factors explaining the level of HCI include health outcomes since the productivity of individuals is highly dependent on the quality of health and early investment in the education they receive.

Table 1: Human Capital Index and components by country, 2018

	Probability of survival to age 5	Expected years of school	Harmonized test scores	Learning-adjusted years of school	Under 5 not stunted	Adult survival rate	Human Capital Index
Rwanda	0.96	6.6	358	3.8	0.63	0.81	0.37
Kenya	0.95	10.7	455	7.8	0.74	0.79	0.52
Uganda	0.95	7	397	4.4	0.71	0.7	0.38
South Africa	0.96	9.3	343	5.1	0.73	0.63	0.41
Tanzania	0.95	7.8	388	4.8	0.66	0.79	0.40
Mauritius	0.99	12.5	473	9.5		0.86	0.63
Seychelles	0.99	13.7	463	10.1	0.92	0.84	0.68
Namibia	0.96	8.9	407	5.8	0.77	0.71	0.43

Source: World Bank (2018)

Human capital also constitutes the impact of health and education to productivity in the workplace. With a primary focus on human capital formation, it is important to recognize that human capital begins from the time of conception, through pregnancy to delivery of a child and development to adulthood. However, sub-Saharan Africa has a low HCI of 0.57 in 2020 as it has higher mortality rates from childhood to adulthood and the lower education levels amongst the population and high rates of poverty than do developed nations (Shobowale, 2024)..

Maternal healthcare has remained a major public health concern across the globe and more so in low and middle income countries. Specifically, in Kenya in 2022, the maternal mortality ratio (MMR) was 362 maternal deaths per 100,000 live births (translating to about 6,000 maternal deaths per year) and the still birth rate was 23 deaths per 1,000 live births (translating to 35,000 stillbirths per year), far below the target of 147 maternal mortalities per 100,000 live births and 12 stillbirths per 1,000 live births by 2030 (KNBS and ICF, 2023)).

The current levels of child undernutrition illustrate the continuing challenges for reduction of child hunger. Statistics show that stunting affects 2 in every 10 children under 5 years (KNBS and ICF, 2023). This is way below the Sustainable Development Goal (SDG) target of reducing the percentage of stunted children to 14 .7% by 2030 and has long-term effects on human capital development in the country.

Inequities in immunization coverage between populations in Kenya have persisted even with devolution of primary health care in the country. In 2014, there was a 17.7 percentage point difference in DPT3 immunization coverage between the highest coverage in Central Province and the lowest in North Eastern Province (WHO, 2018). With almost 1.5 million children born each year in Kenya, relatively small proportional differences in immunization coverage between subgroups translates into large absolute numbers of under-immunized and zero-dose children (UNICEF, 2019). In 2022,

the vaccination rate was 76% for children aged 12–23 months and 61% for children aged 24–35 months (KNBS and ICF, 2023)..

In addition, despite government efforts to improve the lives of pregnant mothers and unborn children through introduction of various health programmes (such as maternity free services in 2013 introduced in all public health institutions across the country), the number of mothers utilizing the services is still below the targets. Moreover, only about 61.8% of deliveries are attended by skilled providers (Ministry of Health, 2018). Low utilisation of free maternity services was linked to patient's satisfaction in previous deliveries which was influenced by the health care worker's activities and actions towards women in labour. Other factors include, the mother's level of education which played a role in demystifying poor delivery outcomes related beliefs and increased parity (Ngesa et al 2021)

If these issues are left unresolved, related illnesses would reduce productivity and increase health expenditure, burdening Kenya's economy, while addressing the issues would lower under-five morbidity and mortality. Therefore, it is important to address the issues that affect children in their early stages in life for improved health outcomes in future and productivity later in life, especially in the labour market. This study therefore assessed the link between investing in the first 1,000 years of life and health outcomes in Kenya using KDHS 2022 data(KNBS and ICF, 2023)

This study focused on the effects of investing in the first 1,000 days of life, consequently giving each child an opportunity to survive and realize and maximize their potential to adulthood, which is important for human capital development. The basic needs and services at first 1,000 days of life are: maternal healthcare; child healthcare; mobilization of mothers to seek early antenatal care; increasing hospital deliveries; enhancing exclusive breastfeeding for the first 6 months of life; increasing knowledge on the proper weaning diet; immunization; and early diagnosis and treatment of common childhood illnesses.

A comparative study (Timaeus and Lush, 1995) of urban areas of Ghana, Egypt, Brazil and Thailand with an objective of assessing the intra-urban differentials in child health for health transition clearly indicated that children's health is affected by environmental conditions and economic status of the household. Children from better-off households had lower diarrhoea morbidity and mortality in Egypt, Thailand and Brazil. The differentials in diarrhoeal diseases by household economic status were due to differences in childcare practices, such as preparation of weaning foods and personal hygiene (Timaeus and Lush, 1995). Jacoby and Wang (2003) examined the linkages between child mortality and morbidity, and the quality of the household and community environment in rural and urban China using a competing risks approach. The study established that access to immunization reduces diarrhoea incidence in rural areas, and access to modern sanitation facilities like the flush toilets reduces diarrhoea prevalence in urban areas. However, available studies were limited in scope, with none focussed on children aged 2 years and below. Therefore, our study will focus on the role of investing in the first 1,000 days of life on the health outcomes of children under the age of 5 years and, by extension, on human capital development.

Objectives of the Study

The purpose of the study was to explore the role of investing in the first 1000 days on health outcomes among children under the age of 5 years in Kenya. The study specifically aimed to:

- i. Establish the status of the main needs of children and household with children under the age of 2 years (first 1,000 days) in Kenya.
- ii. Estimate the effect of access to critical services on child health mortality outcomes in Kenya.
- iii. Draw implications for policy on how to improve investment in the first 1,000 days for reduced child mortality and improve child health outcomes.

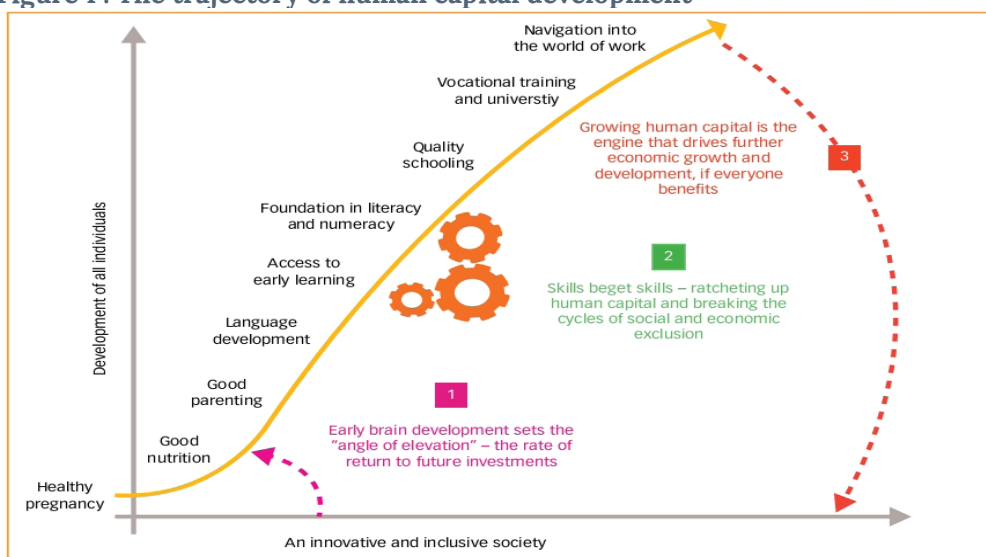
2. Literature review

2.1 Why invest in human capital?

2.1.1 Evolution of human capital

Human capital starts from the point of conception through pregnancy and delivery to development through early childhood and adulthood. The South African Child gauge (Jamieson, 2017) illustrates this trajectory of human capital development. Figure 1 illustrates the urgent need to focus on the formative stages of life and development as a foundation for human capital development.

Figure 1 : The trajectory of human capital development



Source: DG Murray Trust (2017) *Imagine a South Africa where Every Person has the Opportunity to Fulfill their Potential*. Cape Town: DGMT.

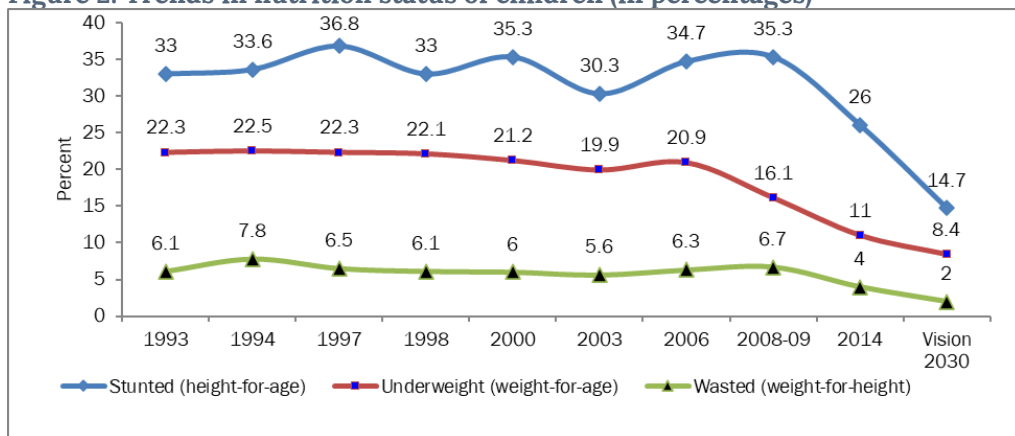
Kenya is ranked 39th with one of the highest levels of child mortality globally. The child mortality rate in children under 5 years in Kenya was 43.2 deaths per 1,000 live births in 2021, having improved from 52 per 1,000 live births (KDHS, 2015). The rates have been improving over the years but the country has not reached the set target. SDG target 3.2 aims to reduce under-5 mortality rate to less than 25 deaths per 1,000 live births and neonatal mortality rate to less than 12 deaths per 1,000 live births. The country can only reach this target once there is adequate treatment and prevention of the common causes of child mortality, which are pneumonia, diarrhoea, malaria and malnutrition. The morbidities accounts for a third of the causes of child morbidities.

Low investment in a child's early days of life has been associated with stunting, underweight and wasting which have long-term implications on human capital accumulation. According to the KDHS (2015), the prevalence of stunting was estimated

at 26%, wasting at 4% and underweight (11%) in 2014. The levels improved in 2022 to child stunting at 18%, wasting at 5% and underweight at 10% (KDHS and ICF, 2023). Stunting refers to low height for age and is a marker of chronic malnutrition and wasting which refers to low weight for height and is a marker of acute malnutrition, examples include marasmus and kwashiorkor. Underweight is low weight for height and is a combination of both stunting and wasting. Understanding and preventing malnutrition is crucial because it not only exposes the child to opportunistic infections but also has negative effects on the physical and mental development of the child.

Good nutrition throughout the life cycle is a prerequisite to good health, which adds quality to life and is at the core of a strong and productive society. However, the triple burden of malnutrition in Kenya is characterized by the coexistence of: (i) undernutrition as manifested by stunting, wasting and underweight; (ii) micronutrient deficiencies; and (iii) overweight and obesity, including diet-related non-communicable diseases (DRNCD). Comparison of KDHS data over time indicates an overall improvement in the child nutrition status in Kenya. The current levels of child undernutrition illustrate the continuing challenges for reduction of child hunger and undernutrition which have long-term effects on human capital development in the country.

Figure 2: Trends in nutrition status of children (in percentages)



Source of Data: KNBS 2015

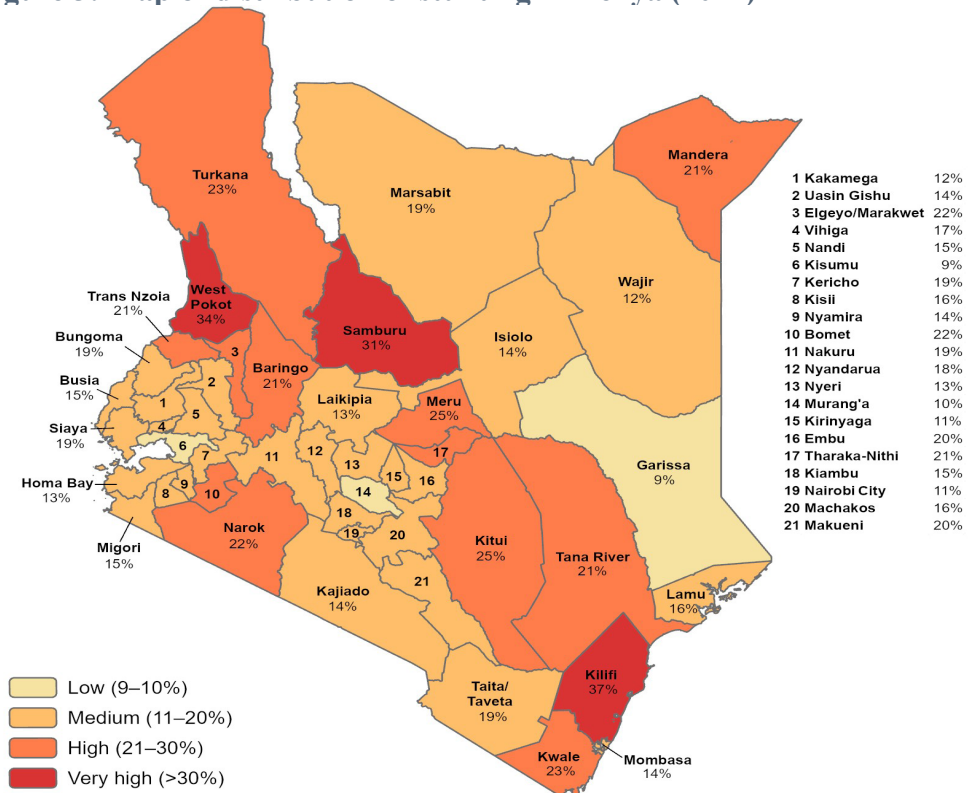
Figure 2 shows status of health outcomes in the last two decades, which show an overall decline in the recent years. The status is associated with the following factors: poor agricultural performance and food distribution at the macro level and micronutrient deficiency at the level of individuals.

Further, studies have shown that food served to children in Kenya has multiple micronutrient deficiencies, placing children at risk of poor growth regardless of the quantities of food provided by the agriculture sector. These explain at the individual level the levels of health outcomes during the period (Bwibo and Neumann, 2003; Matanda et al., 2014).

The impact of food security initiatives such as the Kenya Special programme is reflected by the periods with increasing health outcomes (2006) (FAO, 2007). However, studies have shown that foods used to complement breastfeeding in Kenya are of low nutritive value (Bwibo an Neumann., 2003). The most preferred porridge is made of composite flours causing negative nutrient-nutrient interactions and also causing mal-absorption due to the child’s immature gut. Such foods are also high in anti-nutrients such as phytates and tannins that bind available nutrients and thus reduce bioavailability (Matanda et al., 2014). The trend indicates that much remains to be done for the country to realize its Vision 2030 nutrition targets of reducing stunting to 14.7% (43.4% reduction from the figure in 2014), proportion of underweight children to 8.4% (23.6% reduction from the figure in 2014) and 2% for wasted children.

Stunting decreased from 26% in 2014 to 16% in 2022, However, there are wide variations in stunting across counties. The highest percentages are in Kilifi, West Pokot, and Samburu (37%, 34% and 31% respectively) and the lowest in Kisumu and Garissa (9% each) (Figure 3).

Figure 3: Map of distribution of stunting in Kenya (2022)



Source: KNBS and ICF, 2023

Further, other inputs affect the growth of a child. These include maternal healthcare services and child healthcare services such as access to immunization services, exclusive breastfeeding, antenatal visits and skill deliveries among others. The importance and status of these health inputs are discussed in the following paragraphs.

A child aged 12 months and below who has received all the World Health Organization (WHO)-recommended basic vaccines is considered to be fully immunized. The WHO recommended doses include one dose of Bacille Calmette-Guérin (BCG), three doses each of DPT-HiB-Hepatitis B (diphtheria-tetanus-pertussis-Haemophilus influenzae type B, hepatitis B), three doses of polio and one dose of measles vaccine (Mutua, 2016)). A child who has missed at least one dose of these recommended vaccines is considered not fully immunized. Full immunization of children reduces risks of mortality and financial burdens in the form of health care for sick children. Although immunization is among the most successful RMNCAH (Reproductive maternal, newborn, child and adolescent health) interventions in Kenya and across the globe, the effects of the Covid-19 pandemic strained health systems. This resulted in 23 million children missing out on vaccination in 2020, a number exceeding the 2019 numbers by 3.7 million and becoming the highest number since 2009 (WHO, 2021). This translated to a decline in global immunization coverage to 83% in 2020 from 86% in 2019.

Poor child development leads to high mortality rates which also have an impact on national productivity. WHO (2018) indicates that in Kenya, 31% of the under-five mortality rate is attributed to diarrhoea. In 1990, several countries in sub-Saharan Africa had higher childhood mortality rates in urban areas than in rural areas (Cairncross and Valdmanis, 2006). The high mortality rate among children under the age of 5 years in urban areas was linked to diarrhoea due to unsafe drinking water, poor sanitation and unhygienic conditions (Cairncross and Valdmanis, 2006). Environmental risk factors cause about 20% of infant and child deaths stemming from unsafe water, sanitation and hygiene. The Millennium Development Goal (MDG) 4 target was to reduce child mortality: “to reduce child mortality by two-thirds, from 87 children of every 1,000 dying before age five in 1990 to 29 of every 1,000 in 2015”.

Further, children require a safe, reliable, affordable and conducive environment for good health (Hunter *et al*), 2010). Good nutrition and food security are critical to tackling underweight, wasting and stunting. A recent study on the Cost of Hunger in Kenya showed that KES373.9 billion (or US\$4.2 billion) was lost in 2014 as a result of child undernutrition. This is equivalent to 6.9% of the gross domestic product (GDP) (Government of Kenya, 2019).

Provision of safe water, sanitation and hygienic conditions is essential to preventing and protecting human health during any infectious disease outbreaks. Of specific interest to this study is SDG 3 goal on access to good health and early investment in education for improved human capital. Therefore, investing adequately in the early years of life among all children in all households would contribute immeasurably to the

health of children under the age of 5 years. This paper therefore contributes to existing literature by looking at the status of the basic needs of households with children under 2 years in Kenya and the effect this has had on child mortality. In addition t, the paper compares the status in the 47 counties in Kenya, with the knowledge that as much as nationally the rate of stunting, wasting and underweight has been improving over the last 15years, these levels are higher in some counties than in others.

2.1.2 Essential healthcare services for a child under 1,000 days of Life

This section discusses the basic needs and services during the first 1,000 days of life.

Maternal health care: Maternal health refers to a woman's health during pregnancy, childbirth and the first 28 days after delivery. A healthy mother delivers a healthy child and the poor health of a mother is likely to have an effect on the child's health. Maternal healthcare has remained a major public health concern across the globe and more so in low and middle income countries. Globally, about 289,000 maternal deaths, 2.6 million stillbirths and 2.7 million neonatal deaths are recorded each year (Lang'at et al., 2019).

Child healthcare: This begins from the moment the child is born and continues to adulthood. WHO noted that the high mortality rates during the first 5 years of life was attributed to preventable infectious diseases and nutrition related illnesses. The potential solution is to focus on primary prevention at community level to reduce the morbidity and mortality of children under 5 years old. This involves mobilizing mothers to seek early antenatal care, increasing hospital deliveries, exclusive breast feeding, knowledge sharing on diets and immunization.

Mobilization of mothers to seek early antenatal care: During the antenatal care visits, community health workers are able to advise on nutrition, do basic investigations and give supplements early. This has the potential to reduce early childhood complications, such as malnutrition and reduced brain development due to low iodine levels among others.

Increasing hospital deliveries: This reduces complications related to childbirth, such as perinatal asphyxia and foetal stillbirths. It also reduces maternal mortality secondary to birth-related complications, such as postpartum haemorrhage.

Enhancing exclusive breastfeeding for the first 6 months of life: WHO has developed 10 steps of Baby Friendly Hospital Initiatives to encourage breastfeeding while the mother is still in hospital but the initiative does not have follow-up when the mother goes home. Therefore, there is a need to come up with initiatives to educate and enhance breastfeeding while the mother is at home. This should include the women who prefer formula milk to breast milk and women who wean their children early.

Increasing knowledge on the proper weaning diet: Children face malnutrition during weaning due to reduced access and availability of a well-balanced diet. In addition, some mothers are unaware of what constitutes a proper diet and hence give starchy foods only, such as porridge, leading to increased numbers of children with

marasmus and kwashiorkor. This not only affects the physical but also the mental development of the children. Malnutrition during infancy and early childhood leads to impairment of cognitive development leading to permanent cognitive deficits which affect learning and memory. These individuals are less likely to reach full potential in the workforce hence diminished productivity at individual and society level resulting to low human capital.,

Immunization: This enhances the child's immunity in preparation for interactions with the pathogens involved.

Early diagnosis and treatment of common childhood illnesses such as pneumonia, gastroenteritis among others. This leads to prevention of long term complications and facilitates optimal childhood development hence a healthier, more educated and productive population, thereby enhancing human capital and fostering sustainable socio-economic development

2.2 Relationship between child health inputs and the child health outcomes

To explore this relationship between child health inputs and outcomes, and its consequent effects, most studies have adopted parametric or semi-parametric models and approaches. For example, Daniel (2020) conducted a study to evaluate the effects of spatial variation on the under-five mortality rate in Kenya using data from KDHS 2014 (KDHS, 2015). During the survey, information was collected on children born 5 years before the data collection time, demographic indicators related to the mother aged 15–49 years and child, and various social and economic attributes. The study used two models to compare the results: the Cox proportional hazards (no frailty) and the proportional hazard spatial frailty model. The spatial Cox proportional hazard model was identified as the best-fit model. The study established a hazard ratio of $\exp(-0.1304) = 0.877$, with the probability of survival of female being higher by 12.23% than of male children. This implied that male children are at higher risk of death. The study also established that the counties with the highest hazard of death were Laikipia, Nyandarua, Nyeri, Kiambu and Makueni. The counties in western Kenya and Nyanza had the lowest hazard of death in Kenya.

Johnson et al. (2018) conducted a seven-year study on children under-five in Mali for starting in 2011. The objective was to measure early access to care and the under-five mortality rate over the course of the Proactive community case management (ProCCM) intervention in peri-urban areas in the country. The study used a cluster-based population-weighted sampling methodology of 400 households from a population of 77,132 individuals. Cross-sectional household surveys were conducted at baseline and at 12, 24, 36, 48, 60, 72 and 84 months later in the intervention area. The under-five mortality rate was calculated using a Cox proportional hazard survival regression. The study measured the percentage of children initiating effective antimalarial treatment within 24 hours of symptom onset and the percentage of children reported to be

febrile within the previous 2 weeks. During the intervention, the rate of early effective antimalarial treatment of children 0–59 months more than doubled, from 14.7% in 2008 to 35.3% in 2015 (OR 3.198, $P < 0.0001$). The prevalence of febrile illness among children under 5 years declined after 7 years of the intervention from 39.7% at baseline to 22.6% in 2015 (OR 0.448, $P < 0.0001$). Communities where ProCCM was implemented achieved an under-five mortality rate at or below 28 per 1,000 during the period. In 2015, under-five mortality was 7 per 1,000 (HR 0.039, $P < 0.0001$).

Muriithi and Muriithi (2015) studied children under five between 2007 and 2008 to determine infant and child mortality in Kenya. A two-stage cluster sampling design was used to collect data from KDHS 2008/2009 (Muriithi and Muriithi, 2015). The Cox regression survival analysis was used to compute the relative risk of the socio-economic and demographic variables on infant and child mortality. Childhood mortality was analysed in two age periods: mortality from birth to the age of 12 months, referred to as “infant mortality” and mortality from 12 months to 60 months, referred to as “child mortality”. The study revealed that socio-economic and demographic factors affect both infant and child mortality. The relative risks were higher for infant mortality than for child mortality. The place of birth had the greatest impact on infant mortality. The study revealed that the number of live births in 2004–2008 was 5,878, with under-5 deaths at 277. Of these deaths, 234 occurred during infancy (0–12 months) and 43 during childhood (13–60 months). The study recommended policy makers and programme managers in the child health sector to formulate appropriate strategies to improve the situation of children younger than 5 years old in Kenya, by creating awareness of these factors and improving on them.

Gender also plays a key role on the status of children anthropometric profile. Boys tend to suffer more from malnutrition than girls, and parent’s level of education, use of health services, location, household and community characteristics play a key role in determining children’s nutrition status (Kabubo-Mariara et al., 2009; Behrman and Skoufias, 2004).

Noori et al. (2021) conducted a study in the Burkina Faso on children under five between 2009 and 2013 to evaluate child mortality risk factors. The study tracked children registered in the Nanoro Health and Demographic Surveillance System (HDSS) from 2009 to 2013 using a population of 54,781. The number of children under-15 years old was 23,851 and the study sampled 8,000 children under 5 from Nanoro health district. The study covered 24 villages and different weather seasons to reflect malaria-related mortalities. Cox regression modelling and hazard ratios were used to analyse HDSS data, including economic status, seasonal factors and maternal health to evaluate child mortality risk factors. The results revealed that people living in homes 40–60 minutes from an inpatient facility was associated with a lower (1.52) hazard of under-5 mortality compared to those living more than 60 minutes travel time associated with 1.74 possibility of greater mortality hazard, but lower possibility

of hazard for those living in homes less than 20 minutes from an inpatient facility. No such association was found for outpatient facilities. The wet season (July–November) was associated with 1.28 (95% CI: 1.07, 1.53) higher under-five mortality than the dry season (December–June), likely reflecting the malaria season.

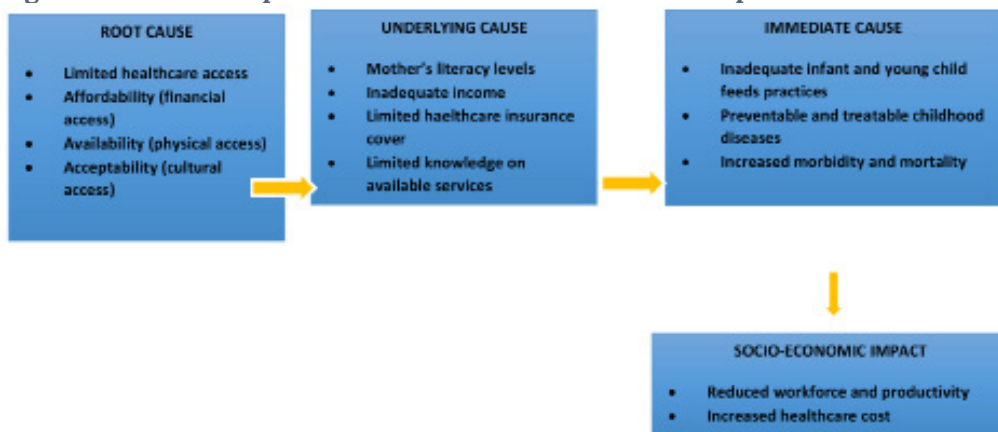
Kadobera et al. (2012) conducted a study in Tanzania on children under five between 2005 and 2007 to measure all live births of children that occurred between 2005 and 2007 from the Ifakara Health and Demographic Surveillance System. The study used a population of 28,823 under-5 children from the rural areas of Tanzania. Both Euclidean and networked distances from the household to the nearest health facility were calculated using geographical information system methods. Cox proportional hazard regression models were used to investigate the effect of distance from home to the nearest health facility on child mortality. The study revealed that children who lived in homes with radius distance >5 km experienced about 17% increased mortality risk (HR=1.17; 95% CI 1.02–1.38) compared to those who lived <5 km radius distance to the nearest health facility. Death of a mother (HR=5.87; 95% CI 4.11–8.40), death of preceding sibling (HR=1.9; 95% CI 1.37–2.65) and twin birth (HR=2.9; 95% CI 2.27–3.74) were the strongest independent predictors of child mortality.

Finally, Byass et al. (2008), in their study in the rural areas of Ethiopia, followed all live births from 1987 until the child's 18th birthday. They collected information on vital events initially monthly and then quarterly and analysed data using Cox regression modelling. The results showed that the risk of dying was not significantly greater for children living >5 km of a health facility (HR 1.27 95% CI 0.89–1.84).

2.3 Relationship between child health and human capital outcomes

Increased child morbidity and mortality rates are related to inadequate infant and child feeding practices. Children also get preventable and treatable childhood illnesses which, if not diagnosed and treated early, lead to increased hospital stays, long-term complications of the illnesses and, for some, death. It is therefore important to understand the underlying causes of these eventualities (Figure 6).

Figure 4: Relationship between child health and human capital outcomes



Source: Authors' conceptualization

Access to health care is not only limited to physical access but has two other dimensions: financial access and cultural access. Financial access: Every year 1 million Kenyans fall below the poverty line due to health-related expenditures. The country has the National Health Insurance Fund but only 20% of the population have access to medical coverage (World Bank 2014). The government therefore introduced a free maternity programme in 2013 that was later renamed the *Linda Mama* programme in 2017. This had a mixed effect on the number of mothers delivering in healthcare facilities and eventually following up on post-natal care (Orangi et al., 2021). It is therefore important to not only increase healthcare coverage but also remove other barriers to access.

Cultural access to healthcare services influences household decisions on where to seek these services. It includes family roles, personal beliefs and assumptions, core values and family values. Various initiatives have been implemented by the Kenya Government to reduce child maternal and child morbidity and mortality rates but the country is yet to meet the targets due to individual and cultural roles and beliefs. Tasker and Harman (2020) implemented a pilot study in Myanmar and Nigeria on the need to invest in a child's early years. Their study aimed to improve nutritional outcomes for mothers and children by giving monthly cash transfers for nutritional

support until the child turned 2 years old. In addition, regular social and behavioural change communication activities were conducted regularly to increase knowledge and change nutrition and hygiene behaviour. After 2 years of programme delivery, there was a 5.4% reduction in the proportion of stunted children in Myanmar and a 5.8% reduction in Nigeria, compared to the control group which was given cash only. The study concluded that regular social and behavioural change communication (SBCC) had a large impact in reducing stunting rates. However, to date no studies have been done to see the impact of SBCC in Kenya.

Hoddinott et al. (2013) presented a framework for understanding the economic rationale for investing in stunting reduction. The study created a framework with six life cycle stages: first 1,000 days; subsequent early childhood; late childhood; adolescence; adulthood; and old age. It outlined the economic rationale for investments that reduce stunting by generating estimated costs of a set of nutritional investments. The study revealed that the nutrition specific interventions are cost-effective in generating and sustaining broad-based wealth and that policy makers should prioritize scaling up these nutrition-based interventions.

Orangi et al. (2021) implemented a study aimed to assess the impact of free maternity healthcare services introduced in 2013 (revised to the *Linda Mama* programme in 2017). Data were collected from 5,419 public and 305 private and faith-based organizations to analyse facility deliveries, antenatal and post-natal visits between 2012 and 2019. The findings revealed that following the 2013 policy introduction, there was a 19.6% increase in normal deliveries and a 28.9% increase in caesarean deliveries in public facilities. After revision to *Linda Mama* programme in 2017 there was a level decrease then increase in post-natal care visits and a 1.1% decrease in caesarean section deliveries in public hospitals. The study concluded that with the mixed effects of increasing financial access to maternal health services, investigations are warranted to determine other accessibility barriers and health service delivery challenges.

3. Methodology

3.1 Theoretical Framework

This study was based on the Human Capital Theory, which is about the idea of humans increasing their productivity and efficiency through a greater focus on health, education and training. The theory advocates that individuals are more productive through investments in training and education, making them easily employable and helping them attract higher incomes. The theory makes an assumption that the marginal labour productivity which translates to higher level of income is predetermined by education (Marginson, 2019). However, according to Marginson, (2019), the theory fails to elucidate how education increases productivity or that inequalities exist in wages.

Smith (1776) set the stage for the study of human capital. He assumed that since education offers satisfaction to the consumer and serves as an input to human resource development required for social and economic transformation, it is therefore referred to as a capital good and consumer. The emphasis on education as a capital good is associated to the notion of human capital, which underscores that the growth of skills is a vital aspect in production activities. Although the theory does not use the phrase human capital, it identifies the acquired and useful abilities of individuals as a fundamental source of wealth and economic progress of a country. Woodhall (1997) stated that investment in human capital through formal education is considered equally or even more worthy than that of physical capital.

Therefore, child education and health care are vital to improvement of human capital and eventually improvement of economic outputs of the nation (Becker, 1993)

The conclusion that can be drawn from the literature on the relationship between children's health and the economy is that children's health is a potentially valuable economic investment. The literature shows that making greater investments in children's health results in better education and more productive adults; sets in motion favourable demographic changes; and shows that safeguarding health during childhood is more important than at any other age because poor health during childhood is likely to permanently impair them over the course of their life.

3.2 Research design

This study adopted a quantitative research design to establish the link between comprehensive investment in the first 1,000 days of life and health outcomes among children under the age of 2 years in Kenya. In addition, the study incorporated a review of literature and descriptive statistics to establish the basic needs and health services that a child or a household with a child under five years old age requires. This involved reviewing the basic needs acquired by children in Kenya relative to the recommended WHO basic needs thresholds.

The basic needs and services at first 1,000 days of life reviewed were: maternal healthcare; child healthcare; mobilization of mothers to seek early antenatal care; increasing hospital deliveries; enhancing exclusive breastfeeding for the first 6 months of life; increasing knowledge on the proper weaning diet; immunization; and early diagnosis and treatment of common childhood illnesses. Further, the role played by access to basic needs and services at first 1,000 days of life in promoting health is best assessed by mapping the needs and sources of the services. Such mapping could also reveal the relationship between prevalence of common diseases like diarrhoea and child and infant mortality, and whether provision of basic children needs has an effect on eradication of the diseases and child mortality while improving a country's human capital in the long term. The outcomes for the basic needs were assessed by considering both infant and child mortality rates.

3.3 Cox proportional hazard model

This study used the Cox proportional hazard model which is useful in assessing the impact of lifetime-related factors. In the model, the continuous random variable represents the lifetime of an individual (t) and the vector of explanatory variables related to (X), when X is given under the proportional hazard hypothesis. Therefore, let x_1, x_2, \dots, x_p be the values of p covariates X_1, X_2, \dots, X_p . According to the Cox regression model (Cox, 1972), the hazard function is given as follows:

$$h(t, X) = h_0(t)\Psi(X)$$

where $\Psi(X) = \exp(\sum_{i=1}^p \beta_i x_i)$, $\beta = (\beta_1, \beta_2, \dots, \beta_p)$ is a $1 \times p$ vector of regression parameters; and $h_0(t)$ is the baseline hazard function at that time.

In the model, there are two unknown components, the regression parameter β and the baseline hazard function $h_0(t)$. The model component $h_0(t)$ is called the baseline hazard function.

Assumption of the Cox regression mode: The proportional hazards assumption states that the hazard ratio is constant over time or the hazard for an individual is proportional to the hazard for any other individual.

In its simplest form, the proportional hazard model can be given as

$$h_i(t) = e^{\sum_{i=1}^p \beta_i X_i} h_0(t)$$

where $h_i(t)$ is the hazard at time t of the i^{th} individual; $h_0(t)$ is the baseline hazard at time t ; X_i is a vector of covariate values corresponding to the i^{th} individual; and β is a vector of coefficients to be estimated when the model is fit.

Let $X_i = 0$. Then, the hazard function of the i^{th} individual is the baseline hazard function. Secondly, dividing both sides by $h_0(t)$ gives:

$$\frac{h_i(t)}{h_0(t)} = e^{\sum_{i=1}^p \beta_i X_i}$$

This equation shows where the term proportional comes from. In the equation, each individual, $e^{X_i\beta}$ is constant across time. Furthermore, for every value of t , the i^{th} individual's hazard function is a constant proportion of the baseline hazard. Therefore, each individual's hazard function is parallel to the $h_0(t)$. Moreover, the i^{th} individual's survival function is a constant power of the baseline survival function, that is:

$$S_i(t, X) = [S_0(t)]^{e^{X_i\beta}}$$

For proportional hazard function of β 's can be interpreted as time invariant shifters of the hazard function. Because of this property, the result can be interpreted as factors that affect risk relative to the baseline risk where $S_0(t)$ is the essential life function t (Cox, 1972).

The childhood mortality (dependent variable) was analysed in two age periods: mortality from birth to 12 months, which is indicated by infant mortality; and the mortality from the 12 months to 60 months, indicated by child mortality. In both cases, the dependent variable is the risk of death occurring in an age interval, in a period such as from birth to age one in a year.

STATA software was used to estimate the coefficients and hazard ratios. The unit of analysis was at the individual level. The findings were presented using tables and figures appropriately.

A hazard ratio greater than 1 indicates that the hazard of event or death is higher; less than one indicates a decrease in the risk; and equal to one indicates no different effect. Diagnostic statistics indicate that there is no multicollinearity as variance inflation factors are below 5 (see Appendix 1).

3.4 Linear Probability Model (LPM)

The study adopted the Linear Probability Model (LPM) to estimate the probability of a child dying within 1,000 days of birth, given a list of maternal and child health indicators. This model was suitable for estimating the probability of child mortalities since the model enables generation of coefficient estimates which are easy to interpret and often the effects are close enough. However, the model is associated with weaknesses of having probabilities above 1 or above 0 and errors being heteroskedastic. Nonetheless, recent studies have indicated linear regression as the optimal strategy to estimate causal effects of treatments on binary outcomes (Gomila, 2021). Further, the Gomilla (2021) study gave evidence using the Neyman–Rubin Causal Model to ascertain that estimated coefficients are unbiased.

Estimating the LPM using ordinary linear squares (OLS) allows for direct interpretation of the treatment effect in terms of the percentage point change in the probability to observe $Y_i = 1$. Therefore, to estimate the probability of a binary outcome (the child mortalities) given a set of explanatory variables such as maternal and child health indicators, the study derive model by assuming a linear regression model which is given as:

$$Y_i = \beta_0 + \beta_1 X_i + \varepsilon_i \quad (1)$$

Where Y_i is the dependent variable in a given time; X_i is independent variable over a time period; β_1 is the estimated coefficient; and ε_i error term.

The OLS model assumes that error term distributes normally with mean of zero, given as:

$$E(\varepsilon_i/X_i) = 0 \quad (2)$$

Equation 2 implies that the expected value of the error term given the value of explanatory variables is zero. Therefore, the conditional expectation of the error term given the values of X_i (independent variables) can be equated as:

$$E(\varepsilon_i/X_i) = E(\beta_0 + \beta_1 X_i + \varepsilon_i/X_i) = \beta_0 + \beta_1 X_i \quad (3)$$

This means that the expected value of the dependent variable given for a given value of X_i can be predicted by the regression equation without the need for the error term.

Given that the dependent variable in our study was binary, it is important to note that the expected value of a binary variable can be expressed as follows, as supported by literature:

$$E[Y] = 1 * \Pr(Y = 1) + 0 * \Pr(Y = 0) = \Pr(y = 1) \quad (4)$$

Equation 4 represents the expected value of a binary variable Y , which takes only two possible values (0 or 1) as described below. The equation consists of two parts:

- a) $1 * Pr(Y = 1)$: This represents the expected value of Y given that it takes the value of 1. In other words, it is the probability of Y being 1 multiplied by the value of 1, which simplifies to just the probability of Y being 1.
- b) $0 * Pr(Y = 0)$: This represents the expected value of Y given that it takes the value of 0. In other words, it is the probability of Y being 0 multiplied by the value of 0, which simplifies to just 0.

Adding these two parts together gives the expected value of Y :

$$E[Y] = Pr(Y = 1) + 0 \tag{5}$$

Therefore, the equation simplifies to $E[Y] = Pr(Y=1)$, which means that the expected value of Y is equal to the probability of Y being equal to 1. In other words, the equation suggests that if we know the probability of Y being equal to 1, we can predict the expected value of Y .

Therefore, to understand the relationship between the binary variable (child mortality) and the predictable variables (maternal and child health indicators) the study adopted the following equation:

$$E(Y/X) = Pr(Y = 1/X) \tag{6}$$

$$E(Y/X = x) = Pr(Y = 1/X = x) = \text{Probability that } (Y = 1) \text{ given } x$$

Equation 6 implies that the expected value of Y , given a specific value of X , is equivalent to the probability of Y being equal to 1, given the same value of X . That is the binary \hat{Y} is the predicted probability that Y_i is equal to 1, given X variable(s).

Further, to estimate the coefficient in the linear probability model, the following equation was adopted:

$$\beta_1 = \frac{Pr(Y=1/X=x+\Delta x) - Pr(Y=1/X=x)}{\Delta x} \tag{7}$$

That is, β_1 is the change in probability that $(Y = 1)$ for a given Δx . Therefore, the predicted value then becomes a probability, which is derived as:

$$Pr(Y = 1/X) = f(\beta_0 + \beta_1 X_1 \dots \beta_i X_i + \varepsilon_i) \tag{8}$$

Further, since our study had several independent variables, we adopted the multiple regression model and modified it to suit the binary model as follows:

$$E(Y_i/X_{1i}, \dots, X_{ki}) = Pr(Y_i = 1/X_{1i}, \dots, X_{ki}) \tag{9}$$

$$Pr(Y = 1/X_{1i}, \dots, X_{ki}) = f(\beta_0 + \beta_1 X_1 \dots \beta_k X_{ki} + \varepsilon_i) \quad (10)$$

Where:

$Pr(Y = 1/X_{1i}, \dots, X_{ki})$ is the conditional probability of child mortalities given the values of the health indicators X_1, X_2, \dots, X_k ; β_0 is the intercept or constant term; $\beta_1, \beta_2, \dots, \beta_k$ are the coefficients for the health indicators X_1, X_2, \dots, X_k respectively; X_1, X_2, \dots, X_k are the values of the health indicators for a given child; and ε_i is the error term, which represents unobserved factors that may affect child mortalities but are not included in the model.

The conditional expectation equals the probability that $(Y_1 = 1)$ conditional on X_{1i}, \dots, X_{ki} :

$$E(Y_i/X_{1i}, \dots, X_{ki}) = Pr(Y_i = 1/X_{1i}, \dots, X_{ki}) = \beta_0 + \beta_1 X_1 \dots \beta_k X_{ki} \quad (11)$$

The population coefficient β_j equals the change in the probability that $Y_1 = 1$ associated with a unit change in X_j .

$$\frac{\partial Pr(Y_i = 1/X_{1i}, \dots, X_{ki})}{\Delta X_j} = \beta_j \quad (12)$$

Therefore, the coefficient estimates in Equation 12 were used to indicate the association between child mortalities given the child and maternal health indicators. The assumption considered in the model is that the requirement for continuous clinical studies such as antenatal and post-natal care visits supersede the mother's medical condition. Therefore, the probability of risk of death occurring will be associated to lack of basic healthcare needs, holding other secondary factors constant.

Childhood mortality (dependent variable) was analysed in two age periods as previously mentioned (0–12 months and 12–60 months). In both cases, the dependent variable is the risk of death occurring in an age interval, in a period such as from birth to age one in a year.

The independent variables were:

- i. Maternal and child healthcare indicators (place of birth, assisted delivery, antenatal visits)
- ii. Child basic healthcare inputs (exclusive breastfeeding, immunization visits)
- iii. Nutrition-related outcomes for under-5 years (child stunting, wasting, underweight)
- iv. Health morbidity outputs (maternal morbidity, gestational diabetes)

The dependent variables were:

- i. Infant mortality: Probability of dying between birth and first birthday.
- ii. Child mortality: Probability of dying between the exact age of one year and the fifth birthday.
- iii. Child morbidity: Probability of a child falling sick from diarrhoea between the age of zero and the second birthday.

The dependent variable(s) represent(s) households with children who were born alive but died in the period 2015–2016. The study considered childhood mortality rates in the two age periods using the Kenya Integrated Household Budget Survey (KIHBS) 2015–2016 data. Child morbidity through diarrhoea is experienced by children between birth and 2 years. The variable takes the value zero if the household did not have any children dying after birth and one if the household had an incidence of children dying after birth.

STATA software was used to estimate the coefficients and hazard ratios. The unit of analysis was at the individual level. The findings were presented using tables and figures appropriately.

3.5 Study data

This study used the data set from (KNBS and ICY 2023). The main aim of the 2022 KDHS was to provide current data on basic socio-demographic, nutrition and health indicators. Specifically, the survey collected information on fertility levels and contraceptive prevalence; childhood mortality; maternal and child health; Early Childhood Development Index (ECDI); anthropometric measures for children, women and men; children's nutrition; woman's dietary diversity; knowledge and behaviour related to transmission of HIV and other sexually transmitted diseases; non-communicable diseases and other health issues; extent and pattern of domestic violence; and female genital cutting.

This was achieved by developing a nationally representative sample of 42,300 households, comprising all the women aged 15–49 residing in a household or who slept in the households the night before the survey and all men aged 15–54 residing in a household or who slept in the households the night before the survey. In addition, anthropometry (weight and height measurement) was taken for all eligible men, women and all children under 5 years. The 2022 KDHS was designed to provide reliable estimates at the national level, for rural and urban areas separately and, for some indicators, at the county level for all the 47 counties.

Sample Frame

The sample for the 2022 KDHS was drawn from the Kenya Household Master Sample Frame (K-HMSF). The frame is based on the 2019 Kenya Population and Housing Census (KPHC) data where a total of 129,067 enumeration areas (EAs) were developed. Of these EAs, 10,000 were selected with probability proportional to size to create the K-HMSF. The 10,000 EAs were randomized into 4 equal subsamples. The 2022 KDHS sample was drawn from subsample one of the frame. Based on the Constitution of Kenya, 2010, each of the 47 counties in the country was stratified into rural and urban strata, resulting in 92 strata since Nairobi City and Mombasa counties are purely urban.

Sample Design and Implementation

The 2022 KDHS used a two-stage stratified sample design whereby in the first stage, 1,692 clusters were selected from the K-HMSF using the equal probability systematic sampling method (EPSSM). The clusters were selected independently in each sampling stratum. Household listing was carried out in all of the selected clusters. The resultant list of households served as a sampling frame for the second stage of selection, where 25 households were selected from each cluster. However, after the household listing procedure, some clusters had fewer than 25 households, hence, all of the households from these clusters were selected into the sample. This resulted in 42,022 households being sampled for the 2022 KDHS. Interviews were conducted only in the pre-selected households and clusters; no replacement of the pre-selected units was allowed during the survey data collection stages

This study focussed on children born 5 years before the survey. The data set was divided into modules for men, women and children. However, key characteristics from other modules are contained in all the modules, that is, the module for children contains characteristics of the mothers and household heads. After considering those born 5 years before the survey, this study focussed on 20,920 births of which 17,076 (81.6%) were aged between 13 and 60 months while 3,844 (18.4%) are aged below 1 year. Under each category we focussed on mortality.

3.6 Definition/description and measurement of variables

The descriptive variable is household mortality, which was derived from male and female children born alive who died. The main explanatory/independent variables of interest for this study captured where the child was delivered, who assisted in delivery of the child, among others. Table 2 presents the definition of key variables used in the study.

Table 2: Definition of key variables

Dependent variable	Measurement
Child mortality in a household (0–12 months)	0 = no; 1 = yes
Child mortality in a household (13–60 months) or 1–5 years	0 = no; 1 = yes
Individual characteristics	Measurement
Sex of child	0 = female; 1 = male
Child is a twin	1 = yes; 0 = no
Order at birth	1 = firstborn; 0 = no
Household characteristics	Measurement
Access to improved water	0 = No; 1 = Yes
Access to improved toilet	1 = flush; 2 = pit latrine. 3 = other type of facility
Household size	Number of members in a household
Sex of household head	0 = female; 1 = male
Place of residence	1 = rural; 0 = urban
Highest level of education of mother	1 = no education 2 = primary 3 = secondary 4 = tertiary
Mothers self-reported health status	1 = very good 2 = good 3 = moderate 4 = bad 5 = very bad

Wealth Index	Poorest = 1 Poorer = 2 Middle = 3 Richer = 4 Richest = 5
Child basic healthcare	
Assisted delivery	1 = yes; 0 = no
Place of delivery	1 = home 2 = government facility 3 = other facility (Private and mission)

3.7 Descriptive statistics

Table 3 presents the descriptive statistics for the KDHS 2022 data focusing on child mortality, child characteristics and household characteristics. According to the survey, 96.5% of the children born were still alive and most were aged between 13 and 60 months (99.6%); of those younger than 1 year, 84.5% were still alive. This indicates that infant mortality is higher than child mortality. In terms of key characteristics, the average age of the mothers was 29 years. In terms of residence, 35% lived in urban areas, of whom 24% had access to improved water. On average, each household had six members with at least two being children under five. Most (70%) of the household heads were male with an average age of 39 years. Each female interviewed had, on average, given birth to three children. The findings indicate that 75.8% of the children were firstborns, with a small (about 2%) of twins. In terms of gender, the results indicate that there was fair distribution between male and female as 51% were male indicating 49% were female.

In terms of assistance during delivery, 56% indicated that they were assisted. Assistance ranged from doctors (42%), nurse/midwife/clinical officer (58%), traditional birth attendants (12%) or relatives/friend (6%).

Table 3: Descriptive statistics on children mortality, child characteristics and the household characteristics

	Under 12 months	13–60 months	Total
Child is alive (1 = yes, 0 = no)	0.845 (0.362)	0.996 (0.0667)	0.965 (0.184)
Respondent's current age (years)	27.55 (6.620)	29.69 (6.652)	29.29 (6.697)
Type of place of residence (0 = urban, 1 = rural)	0.341 (0.474)	0.357 (0.479)	0.354 (0.478)
Improved water (1 = yes, 0 = no)	0.225 (0.417)	0.239 (0.426)	0.236 (0.425)

Number of household members	5.874 (2.652)	5.783 (2.642)	5.800 (2.644)
Number of children five and under in household	1.696 (0.937)	1.592 (0.919)	1.611 (0.923)
Sex of household head (0 = female, 1 = male)	0.723 (0.447)	0.694 (0.461)	0.699 (0.459)
Age of household head (years)	39.51 (13.94)	39.26 (12.88)	39.31 (13.08)
Total children ever born	3.263 (2.245)	3.467 (2.353)	3.430 (2.335)
Child order at birth (1 = first born, 0 = otherwise)	0.750 (0.433)	0.760 (0.427)	0.758 (0.428)
Child twin (1 = yes, 0 = no)	0.0229 (0.150)	0.0144 (0.119)	0.0160 (0.125)
Sex of child (0=female, 1=male)	0.526 (0.499)	0.506 (0.500)	0.510 (0.500)
Assisted delivery (1=yes, 0=no)	0.927 (0.260)	0.479 (0.500)	0.561 (0.496)
Assistance: doctor (1=yes, 0=no)	0.423 (0.494)	0.413 (0.492)	0.416 (0.493)
Assistance: nurse/midwife/clinical officer (1 = yes, 0 = no)	0.592 (0.491)	0.581 (0.493)	0.584 (0.493)
Assistance: traditional birth attendant (1 = yes, 0 = no)	0.117 (0.321)	0.122 (0.327)	0.120 (0.325)
Assistance: relative/friend (1 = yes, 0 = no)	0.0626 (0.242)	0.0590 (0.236)	0.0601 (0.238)
Assistance: other (1 = yes, 0 = no)	0.000554 (0.0235)	0.000240 (0.0155)	0.000335 (0.0183)
Assistance: no one assisted (1 = yes, 0 = no)	0.0125 (0.111)	0.0185 (0.135)	0.0167 (0.128)

Table 4 presents descriptive statistics for categorical variables. According to the results, 35% of the mothers had primary education, 28% had secondary education, 14% had higher education and 22% had no education. In terms of sanitation facilities, 54% used pit latrines, 25% used flush toilets and 20% used other forms which range from bucket to bush. Mother's health is a crucial determinant of a child's well-being. From the results, over 80% of the mothers rated their health as good to very good with a few mothers indicating bad health. In terms of wealth, 32% were classified as poorest, 17% as poorer, 17% as middle, 19% as richer while 15% were classified as richest. In terms of marital status, 75% were married and the other 25% indicated that they were either never in union, living with partner, widowed, divorced or no longer living together/separated. In regard to place of birth of the child, 11% indicated they delivered at home, 36% in a government health facility, 7% in a private facility and 46% indicated others.

Table 4: Descriptive statistics on children mortality, child characteristics and the household characteristics

	Under 12 months	13–60 months	Total
Education level of mother			
No education	20.84	23.00	22.61
Primary	32.83	35.24	34.80
Secondary	32.28	27.51	28.39
Higher	14.05	14.24	14.21
Toilet facility type			
Flush/vip(Ventilated Improved Pit)	25.13	26.05	25.88
Pit latrine	53.77	53.54	53.58
Other	21.10	20.41	20.54
Self-reported health of the mother			
Very good	23.57	22.92	23.04
Good	60.20	57.45	57.96
Moderate	14.39	17.21	16.69
Bad	1.74	2.28	2.18
Very bad	0.10	0.13	0.12
Wealth Index			
Poorest	32.08	31.93	31.96
Poorer	16.75	16.70	16.71
Middle	17.46	17.12	17.18
Richer	19.85	19.26	19.37
Richest	13.87	14.99	14.78
Marital status			
Never in union	10.98	7.23	7.92
Married	73.78	75.16	74.91
Living with partner	8.58	7.34	7.57
Widowed	1.33	2.00	1.87
Divorced	0.86	1.53	1.41
No longer living together/separated	4.47	6.73	6.32
Place of birth			
Home	17.40	9.68	11.10
Government facility	60.67	30.66	36.17
Private facility	10.61	5.77	6.66
Other	11.32	53.89	46.07

Test of equality of survival distribution for the different categorical covariates

Table 5 presents the result of log-rank test of equality of survival distribution for the different categorical covariates. The log-rank test is used to test the null hypothesis that there is no difference between the populations in the probability of an event (here a death) at any time point. The results indicate that child being a twin, highest level

of education for the mother and the self-reported health status exhibit a significant difference in the survival experience among their categories at 5% significance. This means that the hazard of child mortality for these covariates varies significantly from group to group.

Table 5: Result of log-rank test of equality of survival distribution for the different categorical covariates

Covariates	Chi-square	df	p-value
Sex of child	0.00	1	0.9979
Sex of household head	0.37	1	0.5440
Child is a twin	7.67	1	0.0056
Child order at birth	0.02	1	0.8971
Type of place of residence	0.00	1	0.9698
Highest educational level	8.77	3	0.0325
Toilet type	1.21	2	0.5461
Self-reported health status	16.21	4	0.0027
Wealth Index	0.67	4	0.9545
Current marital status	4.76	5	0.4459
Place of birth child	6.59	3	0.0861
Improved water	1.58	1	0.2092
Assisted delivery	0.01	1	0.9248
Assistance: doctor	0.02	1	0.6408
Assistance: nurse/midwife/clinical officer	3.69	1	0.0547
Assistance: traditional birth attendant	3.04	1	0.0813
Assistance: relative/friend	0.00	1	0.9642
Assistance: other	0.04	1	0.8376
No assistance	0.17	1	0.6794

4. Empirical results

4.1 Cox proportional hazard Results

Table 6 displays the Cox proportional hazard results for the full sample, children younger than 1 year and those aged between 13 and 60 months. The results indicate that for the full sample, children born as twins are 2.723 times more likely to die before their fifth birthday than those born single, however, there are no significant results for the differentiated sample (less than 1-year-old and between 13 and 60 months). In terms of child order at birth, firstborns were 0.677 times (32.3%) less likely to die before their fifth birthday and 0.56 times (44%) less likely to die before their first birthday than those born after. The findings also indicate that an increase in the household size by 1 individual reduces the likelihood of death by 30%, 22.9% and 31.1 % for the full sample, for children aged less than 1 year and for children aged between 13 and 60 months respectively.

In regard to gender of the household head, children from male-headed households were 1.644 times (64.4%) more likely to die before their fifth birthday than children from female-headed households. In terms of wealth quintile, children younger than 1 year from the richest quintile were 2.224 times (122.3 %) more likely to die than those from the poorest wealth quintile, and children age between 13 and 60 months from the middle quintile were 0.373 times (62.7%) less likely to die than those from the poorest wealth quintile.

An increase in the number of children ever born increases the likelihood of a child dying by 36.6% for the full sample, 24.6% for the children aged less than 1 year and 37.9% for the children aged between 13 and 60 months. Likelihood of mortality for children whose mothers reported moderate health was 70% more than those who reported very good health for the full sample and 51.1% more for those aged less than 1 year. Children younger than 1 year for mothers who were assisted during delivery were 90.3% less likely to die than those whose parents were assisted during delivery. In relation to the place of delivery, children who were delivered at a government health facility were 38.4% less likely to die than those who were born at home, and children who were delivered at a private health facility were 59.4% less likely to die than those who were born at home.

Table 6: Cox proportional hazard results for the full sample, children aged less than 1 year and those aged between 13 and 60 months

	Full sample	Less than 1 year	13–60 months
Gender (Ref=Female)	1.000	1.000	1.000
Male	1.007 (0.054)	1.142 (0.855)	0.751 (-1.159)
Child is a twin (Ref=No)	1.000	1.000	1.000
Yes	2.723*** (2.908)	1.142 (0.347)	0.000 (-0.000)
Child order at birth (Ref=Otherwise)	1.000	1.000	1.000
Firstborn	0.677** (-2.111)	0.560*** (-2.607)	0.773 (-0.706)
Household size	0.701*** (-8.063)	0.771*** (-5.065)	0.689*** (-4.408)
Gender of the household head (Ref=Female)	1.000	1.000	1.000
Male	1.644*** (2.829)	1.965*** (3.082)	1.211 (0.610)
Residence (Ref=Urban)	1.000	1.000	1.000
Rural	1.017 (0.091)	0.742 (-1.307)	1.077 (0.209)
Education of the mother (Ref=no education)	1.000	1.000	1.000
Primary	1.339 (1.378)	0.911 (-0.353)	1.313 (0.714)
Secondary	1.193 (0.683)	0.880 (-0.421)	1.221 (0.410)
Higher	0.913 (-0.278)	0.603 (-1.332)	0.986 (-0.022)
Wealth Index (Ref=Poorest)	1.000	1.000	1.000
Poorer	1.065 (0.301)	1.168 (0.600)	0.817 (-0.549)
Middle	0.981 (-0.083)	1.240 (0.758)	0.373** (-1.971)
Richer	1.091 (0.331)	1.537 (1.285)	0.806 (-0.445)
Richest	1.347 (0.886)	2.224 (1.935)	0.595 (-0.729)
Total children ever born	1.366*** (7.596)	1.246*** (4.168)	1.379*** (4.263)
Marital status of mother (Ref=never in union)	1.000	1.000	1.000
Married	0.654 (-1.413)	0.857 (-0.430)	1.136 (0.167)
Living with partner	0.822 (-0.557)	0.714 (-0.797)	2.131 (0.930)
Widowed	1.011 (0.023)	1.461 (0.688)	0.547 (-0.482)
Divorced	1.093 (0.155)	2.326 (1.067)	2.638 (0.947)

No longer living together/separated	0.854 (-0.425)	1.820 (1.287)	1.690 (0.628)
Mother's self-reported health status (Ref=very good)	1.000	1.000	1.000
Good	1.103 (0.567)	1.186 (0.834)	1.183 (0.484)
Moderate	1.700*** (2.690)	1.515* (1.717)	1.720 (1.368)
Bad	1.489 (0.969)	1.573 (0.733)	2.766* (1.706)
Very bad	0.000 (-0.000)	0.000 (-0.000)	0.000 (-0.000)
Assisted Delivery (Ref=No)	1.000	1.000	1.000
Yes	1.126 (0.363)	0.097*** (-9.396)	2.055 (1.175)
Water sources(Improved=No)	1.000	1.000	1.000
Yes	0.766 (-1.525)	0.929 (-0.361)	0.634 (-1.227)
Type of toilet (Ref=Flush/vip)	1.000	1.000	1.000
Pit latrine	1.083 (0.416)	1.071 (0.299)	1.171 (0.402)
Other	0.888 (-0.448)	1.146 (0.411)	0.756 (-0.538)
Place of birth (Ref=Home)	1.000	1.000	1.000
Government facility	0.616** (-2.207)	1.029 (0.102)	0.556 (-1.245)
Private facility	0.406** (-2.382)	0.835 (-0.432)	0.000 (-0.000)
Other	0.636 (-1.327)	2.445*** (3.246)	1.358 (0.451)
Observations	18387	3382	15005

Notes: t statistics in parentheses; * p < 0.1, ** p < 0.05, *** p < 0.01

The results obtained from the Cox proportional hazard analysis provide crucial understanding into the factors influencing child mortality with a special focus on under 1 year old and those aged between 13 and 60 months. The results provide a significant link between different socio-demographic aspects and the probability of a child dying before reaching 5 years old. In particular, the research found that twins had a 2.723 times higher risk of mortality than single births. This discovery aligns with that from previous studies (Gebretsadik and Gabreyohannes, 2016; Fikru, et al., 2019; Limaso et al., 2020; Zewudie et al., 2020) that also reported elevated mortality rates among twins. Interestingly, when the sample was divided by age, the connection between twin births and increased mortality was no longer significant among children under 1 year old and those aged between 13 and 60 months. These outcomes show the complexity of factors influencing child mortality at different stages of development.

In respect to birth order, the study contradicts existing literature, such as Muriithi and Muriithi (2015) who found that birth order does not have an effect on mortality and Zewudie et al. (2020) who found that mortality was higher among firstborns than

that of children born later. These results therefore provide mixed results on the effect of birth order child survival.

Household characteristics like size, gender of the household head and wealth quintile demonstrated diverse impacts on child mortality. The study revealed an interesting finding regarding household size, where an increase in household size was linked to increased mortality risks for children across all age groups. This corroborates what Zewudie et al. (2020) and Gebretsadik and Gabreyohannes (2016) found that larger households pose a risk for child mortality. The unclear impact of household size necessitates deeper exploration into the mechanisms and contexts in which larger households might positively influence child survival.

Additionally, the link between the gender of the household head and child mortality showed that children in male-headed households faced a 1.644 times higher risk of mortality before their fifth birthday than those in female-headed households. These findings challenge traditional perspectives suggesting that the gender of the household head might significantly influence child health outcomes, warranting further investigation and potential policy implications.

The disparities in mortality risks across wealth quintiles emphasize the intricate relationship between socio-economic status and child survival. Particularly notable was the increased likelihood of mortality among children from the richest quintile in the age group under 1 year, contrary to findings from other studies (see, for example, Fikru et al., 2019) indicating no mortality risks among the different categories of the households.

The number of children ever born, maternal health, assistance during delivery and place of delivery also emerged as significant factors influencing child mortality. The increased risk of mortality with higher parity aligns with results from established literature (Ayele et al., 2017). Maternal health, particularly reporting moderate health status, was linked to increased child mortality. Moreover, the place of delivery had a significant impact on child mortality, with births at government and private health facilities showing reduced mortality risks compared to home deliveries. These findings contradict those of previous research that found that those born at home were slightly more likely to die than those born in a facility (Muriithi and Muriithi, 2015), emphasizing the importance of healthcare infrastructure in reducing child mortality.

4.2 Inferential statistics on correlates of child mortality

Table 7 presents the logistic regression results for the probability of the child being alive. According to the results, respondent's age has a statistically positive effect on probability of survival at all levels. Education, though considered essential, does not have any significant effect on survival. Additionally, access to sanitation provides interesting results where using other toilet facilities compared to flush toilets indicated a significant and positive effect on survival rate of the child. The findings further indicate that survival of children in households with many members is significant and positive, most importantly when the household has children under 5 years old.

In relation to Wealth Index, it was positively significant for children aged between 13 and 60 months in the middle quartile compared to the poorest. Children born to mothers who have many children had a lower probability of survival. Children of those mothers who were no longer living together had a lower probability of survival than those who were never in any union. The findings indicate that twins had a lower survival rate than children born alone. In terms of place of delivery, children born in health facilities (government or private) had a higher probability of survival than those born at home. Assisted delivery increased the probability of survival for children under 1 year.

Table 7: Logit and margins results—Combined

Sample	Child is alive		Child is alive		Child is alive	
	Less than 1 year	13–60 months	13–60 months	Full sample	Full sample	Full sample
Respondent's age	0.075*** (7.379)	0.002*** (7.268)	0.062*** (4.047)	0.004*** (4.071)	0.029 (0.956)	0.000 (0.951)
Type of residence	-0.003 (-0.025)	-0.000 (-0.025)	-0.157 (-0.869)	-0.011 (-0.869)	0.084 (0.230)	0.000 (0.230)
Education level (Ref=No education)						
Primary	-0.051 (-0.370)	-0.002 (-0.374)	0.040 (0.186)	0.003 (0.185)	-0.048 (-0.126)	-0.000 (-0.127)
Secondary	0.036 (0.215)	0.001 (0.214)	0.149 (0.613)	0.011 (0.603)	-0.016 (-0.033)	-0.000 (-0.033)
Higher	0.167 (0.793)	0.005 (0.799)	0.328 (1.060)	0.022 (1.058)	0.168 (0.252)	0.001 (0.259)
Improved water	0.006 (0.050)	0.000 (0.050)	-0.033 (-0.203)	-0.002 (-0.203)	0.367 (0.980)	0.002 (0.974)
Toilet type (Ref=Flush/vip)						
Pit latrine	0.045 (0.376)	0.002 (0.373)	0.171 (0.959)	0.013 (0.943)	-0.140 (-0.356)	-0.001 (-0.370)
Other	0.497*** (3.065)	0.014*** (3.044)	0.665*** (2.739)	0.043*** (2.769)	0.532 (1.059)	0.002 (0.989)

Household size	0.149*** (5.828)	0.005*** (5.781)	0.119*** (3.212)	0.008*** (3.221)	0.127 (1.562)	0.001 (1.539)
Number of children under 5	1.408*** (20.628)	0.044*** (18.160)	1.899*** (17.471)	0.131*** (18.858)	1.384*** (6.512)	0.007*** (5.225)
Sex of household head	-0.325*** (-2.964)	-0.010*** (-2.956)	-0.422*** (-2.643)	-0.029*** (-2.647)	-0.144 (-0.446)	-0.001 (-0.446)
Age of household head (years)	-0.005 (-1.333)	-0.000 (-1.333)	-0.001 (-0.167)	-0.000 (-0.167)	0.020 (1.445)	0.000 (1.425)
Health of the mother (Ref=Very good)						
Good	-0.381*** (-3.241)	-0.010*** (-3.504)	-0.704*** (-4.041)	-0.043*** (-4.439)	-0.118 (-0.337)	-0.000 (-0.347)
Moderate	-0.519*** (-3.707)	-0.015*** (-3.669)	-0.837*** (-3.867)	-0.054*** (-3.768)	-0.448 (-1.118)	-0.002 (-1.118)
Bad	-1.024*** (-4.343)	-0.037*** (-3.266)	-1.384*** (-3.335)	-0.102*** (-2.598)	-1.038* (-1.713)	-0.007 (-1.242)
Very bad	-0.265 (-0.251)	-0.007 (-0.226)	-0.325 (-0.094)	-0.018 (-0.087)		
Wealth Index (Ref=Poorest)						
Poorer	0.114 (0.835)	0.004 (0.835)	0.219 (1.022)	0.016 (1.020)	0.362 (0.982)	0.002 (0.972)
Middle	0.226 (1.531)	0.007 (1.527)	0.304 (1.373)	0.021 (1.360)	1.251** (2.504)	0.005** (2.458)
Richer	0.113 (0.682)	0.004 (0.683)	0.366 (1.417)	0.025 (1.409)	0.482 (0.994)	0.003 (1.000)
Richest	0.009 (0.043)	0.000 (0.043)	0.057 (0.173)	0.004 (0.174)	0.767 (1.086)	0.004 (1.229)
Total children ever born	-0.438*** (-13.465)	-0.014*** (-12.832)	-0.541*** (-9.850)	-0.037*** (-10.147)	-0.347*** (-3.859)	-0.002*** (-3.541)
Marital Status (ref=Never in union)						
Married	0.006 (0.034)	0.000 (0.034)	0.172 (0.686)	0.012 (0.666)	-0.533 (-0.679)	-0.002 (-0.851)
Living with partner	-0.035 (-0.162)	-0.001 (-0.162)	0.484 (1.538)	0.032 (1.513)	-1.045 (-1.257)	-0.005 (-1.488)
Widowed	-0.129 (-0.407)	-0.004 (-0.397)	0.253 (0.474)	0.017 (0.493)	0.408 (0.321)	0.001 (0.330)
Divorced	-0.343 (-0.987)	-0.012 (-0.905)	-0.698 (-1.198)	-0.060 (-1.067)	-1.163 (-1.122)	-0.006 (-0.907)
No longer living together/separated	-0.081 (-0.369)	-0.003 (-0.369)	-0.847*** (-2.599)	-0.076** (-2.470)	-0.703 (-0.832)	-0.003 (-0.897)
Child order at birth	0.198 (1.594)	0.006 (1.592)	0.455** (2.479)	0.031** (2.477)	0.110 (0.282)	0.001 (0.282)
Child twin	-1.989*** (-9.783)	-0.062*** (-9.567)	-2.341*** (-6.487)	-0.161*** (-6.575)		
Sex of child	-0.096 (-1.155)	-0.003 (-1.154)	-0.122 (-0.983)	-0.008 (-0.983)	0.259 (1.038)	0.001 (1.031)
Place of delivery (Home)						
Government facility	0.398*** (2.717)	0.014** (2.485)	0.062 (0.305)	0.004 (0.302)	0.700 (1.473)	0.003 (1.220)

Private facility	0.967*** (3.841)	0.028*** (4.085)	0.555* (1.816)	0.035* (1.840)		
Other	0.371 (1.620)	0.014 (1.586)	-0.897*** (-3.494)	-0.080*** (-3.321)	-0.225 (-0.353)	-0.001 (-0.360)
Assisted delivery	-0.003 (-0.012)	-0.000 (-0.012)	3.952*** (13.853)	0.272*** (14.982)	-0.241 (-0.419)	-0.001 (-0.418)
Constant	0.160 (0.391)		-4.726*** (-7.757)		2.631** (1.978)	
ll	-2.43e+03		-914.6177		-371.5158	
Observations	18849	18849	3844	3844	13808	13808

Notes: t statistics in parentheses; * p < 0.1, ** p < 0.05, *** p < 0.01

In conclusion, the findings of this study provide nuanced insights into the various determinants of child mortality. Addressing these factors that influence child survival is crucial in designing targeted interventions and policies to reduce the risk of child mortality and improve overall child health outcomes.

5. Conclusion and implications for policy

The purpose of this study was to estimate the risks and determinants of child mortality among 1-year-olds and those aged between 13 to 60 months. Using the Cox regression hazard model applied on the (KNBS and ICY 2023) data, the study found out that twins have higher risk of mortality than do single births. In terms of child order at birth, firstborns were less likely to die before their fifth birthday than those born after. The findings also indicate that an increase in the household size by 1 individual reduces the likelihood of death for children aged less than 1 year and for children aged between 13 and 60 months. In regard to gender of the household head, children from male-headed households were more likely to die before their fifth birthday than were children from female-headed households.

An increase in the number of children ever born increases the likelihood of a child dying. Likelihood of mortality for children whose mothers reported moderate health was more than for those who reported very good health. Children less than 1 year of mothers who were assisted during delivery were less likely to die than those whose parents were assisted during delivery. In relation to the place of delivery, children who were delivered at a government health facility were less likely to die than those who were born at home

Consequently, provision of civic education to pregnant and new mothers on the risk facing their newborns is important to alleviate or reduce child and infant mortality. The findings will therefore inform the government and other stakeholders policies and interventions in planning for health care interventions both at national and county level to guide integration of social and health policies for counties of higher hazard risks of child mortality being given special attention compared to those with lower hazard risk of child mortality.

Notes

- 1 The government is in the process of revamping the National Health Insurance Fund and transforming into the Social Health Insurance Fund in 2023.

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