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Time to Death and Its Predictors Among Preterm Neonates Admitted to Neonatal Intensive Care Unit at Public Hospitals of Harari Region and Dire Dawa City Administration, Eastern Ethiopia

MSc Thesis

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I hereby certify that I have read and evaluated the thesis entitled Time to death and its Predictors Among Preterm Neonates Admitted to Neonatal Intensive Care Unit at Public Hospitals of Harari Region and Dire Dawa City Administration, Eastern Ethiopia: retrospective cohort study prepared under my guidance by Boru Abera Ebsa. I recommend that it be submitted as fulfilling the thesis requirement.

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As members of the Examining Board of the Final MSc Open Defense, we certify that we have read and evaluated the thesis prepared by Boru Abera Ebsa examined the candidate. We recommend that the thesis be accepted as fulfilling the thesis requirements for the master's degree in Maternity and Neonatal Nursing.

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By signing below, I confirm that this thesis is entirely my own work. I have adhered to all ethical and academic standards throughout its preparation, including data collection, analysis, and writing. All sources and scholarly contributions used in this thesis have been properly acknowledged through citation.

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BIOGRAPHICAL SKETCH

I was born in Meki town in 1996 GC, in East Shewa Zone, Oromia Regional State, Ethiopia. I completed my primary education at Gemodeglagela Primary School in Dugda District. I attended my secondary and preparatory education at Oda Bokota School. After finishing my preparatory studies, I joined Haramaya University in the 2017/18 academic year. I received my first degree, a Bachelor of Science (BSc) in Midwifery, from Haramaya University on March 11, 2021. I have been serving as an assistant lecturer at Haramaya University since April 2021.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

AHR	Adjusted Hazard Ratio
AMANHI	Alliance for Maternal and Newborn Health Improvement
AOR	Adjusted Odd Ratio
APGAR	Appearance, Pulse, Grimace, Activity, Respiration
APH	Antepartum Hemorrhage
CPAP	Continuous Positive Airway Pressure
EMDHS	Ethiopia Mini-Demographic Health Survey
GA	Gestational Age
HFCSUH	Hiwot Fana Comprehensive Specialized University Hospital
KMC	Kangaroo Mother Care
LBW	Low Birth Weight
NICU	Neonatal Intensive Care Unit
NMR	Neonatal Mortality Rate
PNA	Perinatal Asphyxia
RDS	Respiratory Distress Syndrome
SDG	Sustainable Development Goals
UNICEF	United nation International Children's Emergency Fund
VLBW	Very Low Birth Weight
WHO	World Health Organization

ABSTRACT

Background: The neonatal period is the most vulnerable time for an infant's survival, particularly for preterm neonates. Complications related to preterm birth are among the leading causes of death in neonates. Many of these complications are preventable with available resources and intensive intervention. However, preterm birth remains a major cause of admission, mortality, and long-term consequences, underscoring the need for further research to assess outcome variability and survival disparities across different populations and settings.

Objective: To determine time to death and its predictors among preterm neonates admitted to neonatal intensive care units at public hospitals in the Harari region and Dire Dawa city administration, Eastern Ethiopia, from November 1, 2021 to October 30, 2024.

Methods: The hospital-based retrospective cohort study was conducted among preterm neonates admitted to the neonatal intensive care unit at public hospitals of the Harari region and Dire Dawa administration, Eastern Ethiopia. A simple random sampling technique was used, and data were extracted from neonates' medical records and registration formats using a structured checklist prepared in English. Descriptive statistics, life table, Kaplan-Meier curves, and Log-rank test were used to estimate and compare survival time. Predictors of mortality were identified using the Cox proportional hazard model.

Results: Out of 612 preterm neonates, 205 (33.50%) died with an incidence rate of 52.76 (95% CI: 46.01 to 60.50) deaths per 1000 preterm neonate-days with median survival time of 18 days. As multivariable cox-regression result, ≥ 4 antenatal care contact (AHR: 0.56 (95% CI: 0.36 – 0.89)), receiving KMC (AHR: 0.16 (95% CI: 0.09 - 0.27), 5^{th} minute APGAR score <7 (AHR: 1.80 (95% CI: 1.22 - 2.66)), PNA (AHR: 1.55 (95 CI: 1.08 - 2.22)), resuscitation with bag and mask at birth (AHR: 1.59 (95% CI: 1.10 - 2.29)), RDS (AHR: 1.75 (95% CI: 1.22-2.51)), born in non-cephalic presentation (AHR:1.68 (95% CI: 1.12 - 2.53)), and neonatal sepsis (AHR: 1.58 (95% CI: 1.09 - 2.28)) were identified as significant predictors of preterm neonates mortality.

Conclusion: The cumulative incidence of preterm neonatal mortality was high in this study. Adequate ANC and kangaroo mother care significantly improved preterm survival, while low APGAR score, resuscitation with bag and mask, neonatal sepsis, PNA, and RDS were major predictors of preterm neonatal death. Emphasis should be placed on strengthening antenatal and perinatal care, along with early detection and management of identified neonatal complications.

Keywords: Survival status, Preterm neonate, Preterm mortality, Ethiopia

1. INTRODUCTION

1.1 Background

Preterm birth is defined as a live birth born before completed 37 weeks of pregnancy or less than 259 days from the first date of the woman's last normal menstrual period (WHO, 2023, Chawanpaiboon et al., 2019). Preterm birth is classified as very preterm (28 to < 32 weeks), moderate preterm (32 to <34 weeks), and late preterm (34 to <37 completed weeks) based on gestational age (WHO, 2023, Vogel et al., 2016). The majority of preterm births occur spontaneously, while others are caused by medical conditions like infections or other pregnancy complications that require early labor induction or cesarean delivery (WHO, 2023).

The preterm birth rate was reduced from 10.6% in 2014 to 9.9% in 2020 globally, and 15% of all preterm births occurred at <32 weeks of gestation (Chawanpaiboon et al., 2019, Ohuma et al., 2023). In 2020, of all preterm births in the world, over 50% occurred in eight countries, with the highest in India and followed by Pakistan, Nigeria, China, Ethiopia, Bangladesh, the Democratic Republic of the Congo, and the USA (Ohuma et al., 2023). Southern Asia and sub-Saharan Africa contributed to approximately 65% of all preterm births globally in 2020 (Ohuma et al., 2023). The majority of preterm births and related mortality occur in low- and middle-income countries, and their burden is high in sub-Saharan Africa and South Asia (Walani, 2020).

A healthy pregnancy is an initial step towards improving the survival rate of preterm neonates and preventing their problems. Antenatal care is the key intervention in preventing preterm delivery (WHO, 2023). In order to improve the survival rate of preterm neonates, the WHO implemented several strategies. These included expanding access to high-quality prenatal care, enforcing KMC for all preterm newborns, improving skilled birth attendance, promoting early breastfeeding initiation, antenatal corticosteroid, using CPAP and medications like caffeine for breathing problems, and involving and empowering families in the routine care of preterm infants (Darmstadt et al., 2023, WHO, 2023, Griffin et al., 2019).

The Ethiopian government has also developed the Health Sector Transformation Plan-II, 2021–2024/25, in addition to the WHO's strategies. This plan involves the expansion of the NICU, the implementation of neonatal health packages and a neonatal care corner, community-based newborn care (CBNC), and a quality improvement program aimed at reducing neonatal deaths at the institutional and community levels by managing major neonatal complications (Aynalem et al., 2021, EMoH, 2021, MoHE, 2021).

1.2 Statement of Problems

The neonatal period is the most vulnerable time for an infant's survival, with 2.3 million newborn deaths recorded globally in 2022 and a neonatal mortality rate of 17 per 1,000 live births (WHO, 2024, UNICEF, 2024). In 2020, an estimated 13.4 million newborns were born preterm (9.9% of all births)(Ohuma et al., 2023, WHO, 2023). Preterm birth is also the leading cause of death in children under five, accounting for 1 million deaths, which is 35% of neonatal deaths and 18% of under-five deaths worldwide (Walani, 2020, WHO, 2023).

Preterm birth remains a global health challenge, significantly contributing to neonatal mortality across diverse settings. In the USA, a retrospective review from 1995 to 2020 reported the preterm birth rate of 12.7%, with a mortality rate of 22.35 per 1000 preterm births (Venkatesan et al., 2023). In China, regional disparities were observed, with preterm-related neonatal deaths accounting for 51.3% in eastern and 44.5% in western regions (Yu et al., 2021). India, a major contributor to the global burden, accounts for 330,000 (almost 33%) of all preterm birth-related deaths worldwide (Walani, 2020). A systematic analysis in 2015 further revealed that 27.5% of India's neonatal deaths were due to preterm birth (Liu et al., 2019).

The 2022 WHO report identified Sub-Saharan Africa as having the highest NMR (27 per 1000 live births) (WHO, 2024). According to the AMANHI, 46% of neonatal mortality was due to preterm birth, with 40% of these occurring in sub-Saharan Africa (AMANHI, 2022). A retrospective review reported a preterm neonatal mortality rate of 27.6% in Ghana (Agbeno et al., 2021) and 18.7% in Nigeria (Michael et al., 2021). In South Africa and Kenya, preterm birth complications were the major cause of neonatal mortality, in South Africa (36%), and the second major cause in Kenya (28%)(Masaba and Mmusi-Phetoe, 2020).

Preterm mortality in East Africa remains unacceptably high, with Uganda reporting a rate of 31.6% (Egesa et al., 2020). In Ethiopia, the prevalence of preterm birth is 10.48% (Muchie et al., 2020) and the country ranks among the top five globally for both preterm births and newborn deaths (Ohuma et al., 2023, WHO, 2020). Ethiopia's national NMR (33 per 1000 live births) in 2019, exceeds the regional averages of Sub-Saharan Africa and Central and Southern Asia (EMDHS, 2019, EMoH, 2021, WHO, 2024). And also, regional variations show preterm neonatal mortality rate ranging from 22.7% to 36.1% (Muhe et al., 2019, Tamene et al., 2020). As a study done in eastern Ethiopia, preterm complications also account for 28.8% of neonatal deaths (Desalew et al., 2020).

Preterm birth has lasting impacts, including neurodevelopmental delays, sensory and cognitive impairments, and behavioral issues in newborns (Henderson et al., 2016, Chen et al., 2022). It also affects mothers by limiting early bonding, increasing postpartum health issues, and reducing positive emotions toward the newborn (Henderson et al., 2016). Economically, preterm births lead to medical and caregiving costs, special education needs, lost work time, increased debt, and reduced productivity associated with the morbidity (Waitzman et al., 2021).

Different studies have identified diverse and multifactorial predictors of preterm neonatal mortality. A study conducted in Uganda reported birth asphyxia, very preterm births, RDS, hypothermia, lack of KMC, delayed breastfeeding, and inadequate ANC (Tibaijuka et al., 2021). In Ethiopia, studies in Mizan Tepi, Gondar, and Tikur Anbessa hospitals identified predictors such as non-cephalic presentation, VLBW, low APGAR score, neonatal sepsis, GA, jaundice, hypoglycemia, maternal diabetes, home delivery, sex of neonate, rural residency, and lack of KMC (Bereka et al., 2021, Yismaw et al., 2019, Aynalem et al., 2021).

Ethiopia's current NMR remains significantly high, falling short of the HSTP-II target of 21 per 1,000 live births by 2024/25 (EMoH, 2021) and the uncertainty towards the achievement of Sustainable Development Goal target of 12 per 1,000 live births by 2030, underscoring the urgent need for context-specific evidence to guide intervention (WHO, 2024, UNICEF, 2024). Despite implementation strategies and interventions, preterm mortality remains continuously high. However, studies on the survival status and predictors of mortality among preterm neonates remain limited, particularly in the current study area. Most studies are predominantly focused on the northern, southwestern, and central regions, leaving a significant geographic gap. The study highlights that outcomes can vary based on geographical location, times, and healthcare facilities, emphasizing the need for further research. This study also has a larger sample size in relative to previous studies conducted on a similar topic, and the inconsistent results in previous studies lead to further investigations. Additionally, previous research stresses the importance of gathering more evidence on the survival gap and its predictors in preterm neonates across diverse populations, including the community in which this study is conducted. Therefore, this study aims to assess the survival status and predictors of mortality among preterm neonates admitted to the NICU at public hospitals in the Harar region and the Dire Dawa City Administration, Eastern Ethiopia.

1.3 Significance of the Study

The evidence generated from this study has helped public hospitals in the Harari region and Dire Dawa administrations to understand the survival gap and common predictors of mortality among preterm neonates, and addresses preterm neonatal death. Moreover, the result of this study is helping stakeholders engaged in neonatal health programs, such as Harari regional health bureaus, Dire Dawa administration health bureaus, and non-governmental organizations working on neonatal interventional programs, make evidence-based decisions about the interventions they are running. Specifically, it is important to ensure that the necessary resources and programs for improving neonatal survival are employed. For health professionals, it helps to improve their knowledge regarding common factors related to preterm neonatal mortality. In addition, the findings of this study will be used as a reference for other researchers, particularly in the study areas, to do further research on the related topic, and the results of this study will be used for a systematic review.

1.4 Objectives

1.4.1 General objective

To determine time to death and its predictors among preterm neonates admitted to neonatal intensive care units at public hospitals in the Harari region and Dire Dawa city administration, Eastern Ethiopia, from November 1, 2021 to October 31, 2024.

1.4.2 Specific objectives

1. To determine time to death among preterm neonates admitted to neonatal intensive care units at public hospitals in the Harari region and Dire Dawa city administration, Eastern Ethiopia, November 1, 2021 to October 31, 2024.
2. To identify predictors of mortality among preterm neonates admitted to neonatal intensive care units at public hospitals in the Harari region and Dire Dawa city administration, Eastern Ethiopia, from November 1, 2021 to October 31, 2024.

2. LITERATURE REVIEW

2.1 Mortality of Preterm Neonates

A single-center study conducted in China from 2006 to 2016 showed that the overall preterm mortality rate was 5.01% (280/5585) (Yan et al., 2018). A prospective cohort study conducted in India and Pakistan revealed that the overall preterm neonatal mortality rate was 23.3% among those, the majority were in Pakistan (475 (33.4%) out of 1421, whereas in India (329 (16.2%) out of 2025 preterm neonates (Tikmani et al., 2024).

A prospective cohort study in the Busoga region of Uganda showed that 8% of preterm neonates died, with a mortality rate of 3.9 per 1000 person days and a median survival time of 17 days (Opio et al., 2019). In contrast, the same another study conducted in the south-western part of the country revealed the preterm neonatal mortality was 19.8% (95% C.I.: 16.7–23.5) at 28 days from birth (Tibaijuka et al., 2021). Also, a cross-sectional study in Kenya revealed that the preterm neonatal mortality rate was 18.4%, which was consistent with a study in western Uganda (Mwangi et al., 2022).

In Ethiopia, the survival status of preterm neonates varied nationwide. According to a multicenter study conducted in Ethiopian public hospitals, the preterm survival rate was 71.1% (95% CI: 66.7, 75.1). The preterm neonate survival probability of surviving at the end of the first 24 hours and the first week was 86.3% and 56.4%, respectively, which indicates a decrease in the survival probability as the age of preterm neonates increases (Hailemeskel et al., 2023).

A retrospective follow-up study at Gondar Comprehensive Specialized Hospital revealed the proportion of preterm neonatal mortality was 28.8% (95% CI 25.1, 32.9), with an overall median length of hospital stay of 7 days (Yismaw et al., 2019). Likewise, the same study done in the Tigray region revealed that the proportion of preterm neonatal mortality was 32.1% with an incidence rate of 36.6 (95% CI: 31.6–42.4) per 1,000 person days (Girma et al., 2023). Furthermore, a study in Gondar revealed that 85.23% of preterm neonates died during the early neonatal period, whereas 11.4% of them died within the first 24 hours of life(Yismaw et al., 2019). Also, other retrospective follow-up studies conducted in the Gonder and Tigray regions showed that the cumulative survival probability of preterm neonates at the end of the first day and 28 days decreased from 96.71% to 57.14% and 90.5% to 56.4%, respectively (Yismaw et al., 2019, Girma et al., 2023).

Another retrospective cohort study in Mizan Tepi Teaching Hospital, South West Ethiopia, showed preterm neonatal death was 35%, with an incidence of mortality of 62.15 (54.09–71.41) deaths per 1000 person-days and a median survival time of 15 days (Bereka et al., 2021). In another similar study done in West Guji and Borena Zone public hospitals in southern Ethiopia, preterm mortality was 25.5% (95% CI: 22–29), with an incidence of mortality of 47.7 (95% CI: 40.2–56.7) deaths per 1000 person-day, which was lower than that in south-west Ethiopia (Huka et al., 2023). Besides, findings in southern Ethiopia expose that the cumulative survival probability of preterm neonates at the first and 28 days was 80.1% and 45.6%, respectively, which indicates a decrease in the survival probability of preterm newborns as the neonatal period is advanced (Huka et al., 2023).

Moreover, a prospective cohort study conducted at selected public hospitals in Addis Ababa city revealed that the preterm neonatal mortality rate was 34.9%, which was consistent with findings in Mizan Tepi hospital. The incidence rate was 36.4/1000 (CI: 0.031–0.044) person-day, and the median survival time to death was 6 days (Birhanu et al., 2022). Additionally, this study showed that cumulative failure of preterm neonates at the end of the 1^{st} day, 3^{rd} day, 7^{th} day, and 28^{th} day of hospital stay was 3.6%, 15.9%, 33.9% and 45.5% respectively. So, the length of hospital stay increases the hazard of death in preterm neonates (Birhanu et al., 2022).

In the same way, prospective follow-up research done in Bench Sheko, Sheka, and Keffa Zones, Southwest Ethiopia, informs that 32.57% of preterm neonates died during the study period, with an incidence rate of 61.69 (95% CI: 53.7 to 70.86) deaths per 1000 person-day and a mean survival time of 17.46 (95% CI: 16.34 to 18.98) days (Mihretu et al., 2024). One cross-sectional study conducted at Felege Hiwot Specialized Hospital in Bahir Dar revealed that out of admitted preterm babies, 36.1% died, while 49.1% were improved and discharged during the study period (Tamene et al., 2020).

2.2 Predictors of Time to Death Among Preterm Neonates

It is better to preview and explore factors that independently affect preterm neonates' survival status, which were attributable to death according to their predictors as follows:

2.2.1 Socio-demographic characteristics

Marital status

A multicenter prospective follow-up conducted in Ethiopian public hospitals showed that the survival time of preterm newborns whose mothers were not in unions was reduced by a factor of 0.49 compared to preterm newborns whose mothers were married (Hailemeskel et al., 2023). Additionally, a cross-sectional study performed at the Teaching Hospitals of Addis Ababa University found that preterm newborns born to married mothers have a four times higher chance of survival compared to their counterparts (AOR 3.9, 95% CI 1.2–12) (Dagnachew and Yigeremu, 2019).

Maternal residency

A retrospective cohort study conducted at Tikur Anbesa Specialized Hospital revealed that preterm neonatal deaths were 1.45 (AHR: 1.45 (95% CI: 1.1, 4.8)) times higher among mothers who reside in rural areas compared to those who reside in urban (Aynalem et al., 2021).

Maternal age

A prospective cohort study conducted at Fort Portal Regional Referral Hospital in Western Uganda found that preterm neonates born to mothers aged ≥ 35 years were 4.5 (AOR: 4.5; 95% CI: 1.35–15.31) times more likely to die compared to those born to mothers aged between 25–34 years (Egesa et al., 2020). Similarly, a cross-sectional study conducted at the University Teaching Hospital of Butare in Rwanda reported that preterm newborns born to mothers aged between 30-34 years had the highest survival rate (35.9%) compared to other maternal age groups (Habimana et al., 2023).

Neonate sex

A multicenter study conducted in Ethiopian public hospitals found that Kaplan-Meier curve estimation showed that male infants have a lower probability of survival compared to female infants (Hailemeskel et al., 2023). Also, a retrospective cohort study conducted at Tikur Anbesa Specialized Hospital and at Debretabor General Hospital, Northwest Ethiopia, revealed that male preterm neonates were 51% [AHR: 1.51; 95% CI: 1.06, 2.13] and 38% [AHR: 1.38; 95% CI: 1.01, 1.90] at increased hazard of death compared to female preterm neonates, respectively (Aynalem et al., 2021, Sinshaw et al., 2019). Contrarily, a prospective follow-up study at government hospitals in Bench Sheko, Sheka, and Keffa Zones, Southwest Ethiopia, showed male preterm babies had a 34% increase in survival time compared to female babies (AHR = 0.66, 95% CI: 0.47, 0.94) (Mihretu et al., 2024).

2.2.2 Obstetrics and gynecological-related factors

Antenatal care follow-up

A prospective cohort study conducted in South Western Uganda showed that preterm babies born to mothers with late ANC bookings in the 2nd trimester and 3rd trimester had 1.81 times [AHR: 1.81; 95% CI: 1.03–3.64] and 2.52 times [AHR: 2.52; 95% CI: 1.11–7.11] higher hazard of mortality compared with those booked in the 1st trimester, respectively (Tibaijuka et al., 2021). These studies also showed that preterm babies born to mothers with no ANC follow-up had a nearly 4-fold increased hazard of death compared to those who attended 3–4 ANC visits (AHR, 3.56; 95% CI: 1.51 to 8.43) (Tibaijuka et al., 2021).

Furthermore, retrospective cohort studies conducted in Mizan Tepi Teaching Hospital and in Yabello and Bule Hora Public Hospitals of Oromia region, southern Ethiopia found that preterm newborns born from mothers who had no antenatal care had a 2-fold (AHR = 1.9, 95% CI: 1.29−3.01) and a 7-fold (AHR = 7.1, 95% CI: 4–12.65) at increased risk of death compared to mothers who had at least one antenatal care during index pregnancy, respectively (Bereka et al., 2021, Huka et al., 2023). Another retrospective study at public hospitals in Northwest Ethiopia also showed preterm neonates born to mothers who had ANC follow-up had a 46% lower chance of death than those who hadn't (AHR: 0.544 [0.3475, 0.853]) (Yehuala and Teka, 2015). Similarly, a cross-sectional study in Rwanda found that preterm newborns with mothers who had attended at least four antenatal visits had a 57.0% increase in survival rate compared to those with <4 visits (Habimana et al., 2023).

Antepartum Hemorrhage (APH)

A prospective cohort study in Addis Ababa also showed preterm neonates born to mothers with antepartum hemorrhage had a three-fold increased hazard of death compared to their counterparts (AHR: 3.1, CI: 1.4–6.6) (Birhanu et al., 2022). Similarly, a cross-sectional study done at Kenyatta National Hospital in Kenya also supported the above finding in that preterm neonates delivered from mothers who had a history of APH were four times more likely to die (AOR = 4.252, 95% CI 1.470 to 12.297) (Mwangi et al., 2022).

Gravidity and Parity

A retrospective study in the Guji and Borana zones of southern Ethiopia revealed preterm neonates born to primipara mothers had a 2-fold increase in the hazard of mortality compared to those born to multipara (AHR: 2.3, 95%CI: 1.16–4.43) (Huka et al., 2023). Additionally, a multicenter prospective study in Ethiopian public hospitals revealed that the survival time of preterm neonates born to multipara mothers was increased by a factor of 1.4 compared to those from nulliparous mothers (β = 0.35; 95% CI: 0.01, 0.69) (Hailemeskel et al., 2023). But, a multicenter prospective study at public hospitals in South Gondar revealed that premature infants born to mothers with a gravidity of 6–10 were at a two-fold higher risk of death compared to those infants born to primigravida mothers [AHR: 2.22, 95% CI (1.0597, 4.629)] (Yehuala and Teka, 2015).

Mode of delivery

In a retrospective study in Mizan Tepi town, South West Ethiopia, preterm newborns who were delivered vaginally had 78% advanced hazards of mortality as compared to those delivered through cesarean section delivery (AHR 1.78, 95% CI 1.05–3.08) (Bereka et al., 2021). Also, a prospective cohort study conducted in South Western Uganda supports the above findings in that vaginal breech delivery three times increases the hazard of death compared with those delivered by Caesarean (AHR, 3.04; 95 CI 1.37 - 5.18) (Tibaijuka et al., 2021).

Type of pregnancy

A retrospective follow-up study conducted on survival and its predictors among preterm neonates in Gondar city, indicated type of pregnancy (singleton) was 2 times increase risk of death in preterm neonates compared to multiple pregnancy (AHR = 2.35 (1.58, 3.50) (Yismaw et al., 2019).

Preeclampsia/Eclampsia

A prospective follow-up study conducted in Nigist Eleni Memorial Comprehensive Specialized Hospital, Hossana town, southern Ethiopia, showed that preterm neonates delivered from mothers who had Eclampsia were three-fold at risk of death (AHR: 3.03, 95% CI: 1.52, 9.09) (Tirore et al., 2024). Similarly, a retrospective cohort study done at Debretabor General Hospital, Northwest Ethiopia, showed preterm neonates born to mothers with preeclampsia/eclampsia were nearly twice more hazard to die as preterm neonates born to mothers without preeclampsia/eclampsia [AHR: 1.95, 95% CI: 1.13, 3.36] (Sinshaw et al., 2019). And also, a study conducted in five selected hospitals in Ethiopia showed that pre-eclampsia and eclampsia contributed to 20.6% of preterm deaths (Muhe et al., 2019).

Antenatal steroid use

A retrospective cohort study conducted at Jimma University Medical Center (JUMC) revealed that preterm neonates born to mothers who used antenatal steroids during their current pregnancy had a 45% lower hazard of death compared to neonates born to mothers who didn't use antenatal steroids [AHR = 0.55; 95% CI: 0.34, 0.90] (Temesgen et al., 2021).

Place of delivery

Retrospective cohort research conducted in Gondar city revealed that preterm neonates who were delivered at home had 2.3 times higher hazards of dying as compared to those who were delivered in the hospital (AHR = 2.29; 95%CI (1.05, 4.98)) (Yismaw et al., 2019). Likewise, a cross-sectional study conducted at Felege Hiwot specialized hospital in Bahir Dar city revealed preterm babies who were born at home were twice as likely to die compared to those delivered at health care institutions [AHR: 2.08, 95% CI (1.26, 3.434)] (Tamene et al., 2020).

2.2.3 Maternal medical conditions

HIV status and Diabetes Mellitus

A prospective cohort study in Uganda showed preterm neonates born to HIV-positive mothers had a five-fold higher hazard of mortality compared to HIV-negative mothers (AHR: 4.9, 95%CI: 1.1–22.2) (Opio et al., 2019). In another retrospective study in Northwest Ethiopia, preterm neonates born to HIV-positive mothers had 2-fold higher hazards of mortality compared to those with HIV-negative mothers [1.03724, 3.1351] (Yehuala and Teka, 2015). The same study conducted at Tikur Anbesa Specialized Hospital found that preterm babies born to mothers with diabetes mellitus were twice as likely to die compared to those with no diabetes mellitus (AHR: 2.29; 95% CI: 1.43–3.65) (Aynalem et al., 2021).

2.2.4 Neonatal-related factors

Preterm birth complications were the leading cause of neonatal death in all regions of the world which accounting for 35.7% neonatal mortality (Oza et al., 2014). Predictor variables are discussed as follows:

Kangaroo Mother Care Usage

A prospective cohort study conducted in the South Western and Busoga regions of Uganda revealed that preterm newborns who did not receive kangaroo mother care had a nearly 10 times (AHR, 9.50; 95% CI: 5.37 to 16.78) and 6 times (AHR: 6.4, 95% CI: 1.7–24.5) higher risk of mortality compared to those who used KMC, respectively (Tibaijuka et al., 2021, Opio et al., 2019). In addition, similar studies conducted in Addis Ababa, the capital of Ethiopia, were in line with studies done in Uganda, in which preterm neonates who did not use KMC had a nearly six-fold increased hazard of mortality compared to those who used it (AHR: 5.8, 95% CI: 2.37–14.33) (Birhanu et al., 2022).

Other studies conducted in different areas of Ethiopia came up with a consistent report, like retrospective follow up studies in Southern and South West Ethiopia, which showed that preterm babies who didn't use KMC had 9 times (AHR: 9.3, 95% CI: 4.36–19.9) and 1.5 times (AHR: 1.45, 95% CI: 1.06–1.98) more hazards of death than those who used it respectively (Huka et al., 2023, Bereka et al., 2021). The same study in Gondar city also revealed that using KMC reduces the hazard of mortality by 76% (AHR = 0.24, 95%CI (0.11, 0.52))(Yismaw et al., 2019). Consistently, a retrospective cohort study conducted in the Tigray region showed that using KMC reduced the hazard of preterm death by 86% (AHR = 0.14; 95% CI 0.08–0.24) (Girma et al., 2023). Furthermore, a prospective follow-up study conducted in Nigist Eleni Hospital, Hossana town, south-west Ethiopia, showed that not using KMC increases the hazard of death twice in preterm neonates (AHR: 2.26, 95% CI: 1.04, 4.90) (Tirore et al., 2024).

Fetal Presentation

A multicenter prospective follow-up study at public hospitals in the South Gondar zone revealed that the survival time for preterm neonates born with non-cephalic presentation had accelerated by a factor of 0.29 compared to those born with cephalic presentation (Hailemeskel et al., 2023). Similarly, a retrospective cohort study conducted in Mizan Tepi, south-west Ethiopia, revealed that the hazard rate of mortality was nearly two times higher in non-cephalic presentation compared to cephalic presentation (AHR: 1.8, 95% CI 1.04–3.06) (Bereka et al., 2021).

APGAR score

A retrospective cohort study in Mizan Tepi town, South West Ethiopia, in line with the above findings, found that a preterm neonate who had a fifth-minute APGAR score <7 was 2 times more likely the hazard of death (AHR: 1.87, 95% CI: 1.31–2.68) (Bereka et al., 2021). And also, the same study conducted in Tikur Anbessa Specialized Hospital, Addis Ababa, showed preterm newborns whose 1st and 5th minute APGAR score < 7 were 3 times (AHR: 3.1, 95% CI (1.79,5.05)) and nearly 2 times (AHR: 1.81, 95% CI (1.32,4.78)) more at risk of death than those whose APGAR score was ≥ 7 (Aynalem et al., 2021). Additionally, a cross-sectional study conducted over 5 years at the University Teaching Hospital in Jos, Nigeria, revealed that preterm neonates with a 5-minute APGAR score <7 were three times more likely to die (AOR = 2.59, 95% CI = 1.4–4.7) (Michael et al., 2021).

Respiratory Distress Syndrome

According to a prospective follow-up study conducted in western Uganda, preterm neonates who had respiratory distress syndrome (RDS) were 2.5 times at increased risk of death (AHR, 2.50; 95% CI: 1.11 to 5.64) (Tibaijuka et al., 2021). Similarly, a retrospective follow-up study conducted in the Tigray region, northern Ethiopia, and Mizan Tepi hospital, south-west Ethiopia, showed that preterm neonates who had RDS had 2 times (AHR = 2.04 (1.48–2.82) and 1.74 times (AHR: 1.74, 95%CI: 1.28–2.36) higher chance of mortality, respectively (Girma et al., 2023, Bereka et al., 2021). Another similar study conducted in Gondar also revealed that preterm neonates diagnosed with hyaline membrane disease have a three-times higher hazard of mortality (AHR = 3.21, 95% CI 1.96, 5.25) (Yismaw et al., 2019). Likewise, a retrospective cohort study conducted in Tikur Anbessa Specialized Hospital, Addis Ababa, showed preterm newborns who had respiratory distress were 54% at higher risk of death (AHR: 1.54 (95% CI: 1.03–2.31) (Aynalem et al., 2021).

Birth Weight

According to a retrospective cohort study in Mizan Tepi town, VLBW (1500–2499 g) and low birth weight (1000–1499 g) had 2.67 times (AHR: 2.67, 95%CI: 1.29–5.53) and 2.24 times (AHR: 2.24, 95%CI: 1.15–4.39) higher chance of death compared to those with ≥ 2500g respectively (Bereka et al., 2021). Apart from this, one cross-sectional study conducted in Nigeria showed preterm neonates with birth weight <1000 g were 3 times (AOR 3.35, 95% CI=1.4–7.9) more likely to be at increased risk of mortality, but those who had birth weight between 1500 g and 2499 g were 29% (AOR: 0.71; 95% CI=0.5–0.9) less likely to die compared to those with ≥2500 g birth weight (Michael et al., 2021).

Gestational Age

A prospective study in South Western Uganda showed neonates with very preterm births had a three-times (AHR, 3.17; 95% CI: 1.24 to 8.13) increased hazard of death compared to those with late preterm births (Tibaijuka et al., 2021). And also, retrospective studies conducted in Gondar, northwest Ethiopia, and in the Tigray region of Northern Ethiopia revealed that as the gestational age increased in 1 week, the death rate decreased by 18% (AHR = 0.82; 95% CI: 0.74–0.91) and 15% (AHR = 0.85; 95% CI: 0.80–0.90), respectively (Yismaw et al., 2019, Girma et al., 2023). Another descriptive finding conducted in the Teaching Hospitals of Addis

Ababa University supported the above findings in that the preterm survival rate increases as GA nears term, reaching zero at 28 weeks and 98.8% at 36 weeks (Dagnachew and Yigeremu, 2019). Additionally, preterm neonates who were small for gestational age at birth had a 65% (AHR = 1.65 (1.12, 2.43) higher chance of death compared with those appropriate for gestational age, as a study in Gondar revealed (Yismaw et al., 2019). Similarly, the survival time for preterm neonates born at a gestational age of > 34 weeks was accelerated by a factor of 2.8 compared to neonates born with a gestational age of fewer than 32 weeks, as findings from a public hospital in Northwest Ethiopia showed (Hailemeskel et al., 2023).

Resuscitation at birth

According to a retrospective study done at public hospitals in southern Ethiopia, preterm newborns resuscitated at birth were 2 times more likely to die compared to their counterparts (AHR: 2.1, 95% CI: 0.28–0.77) (Huka et al., 2023). Likewise, a cross-sectional study done in the Teaching Hospitals of Addis Ababa University supports the above finding in that newborns resuscitated after delivery are 70% less likely to survive than those who don't (AOR-0.3, 95% CI 0.12-0.6) (Dagnachew and Yigeremu, 2019). A consistent study in Kenya showed preterm newborns resuscitated at birth were 54 times at risk of death (AOR: 54.406, 6.807–434.851) (Mwangi et al., 2022).

Perinatal asphyxia (PNA)

A prospective study done in Uganda found, preterm neonates who had birth asphyxia had a 15-fold higher risk of death than those who didn't (AHR: 14.80; 95% CI: 5.21 to 42.02) (Tibaijuka et al., 2021). Correspondingly, a retrospective follow-up study done at the University of Gondar comprehensive specialized hospital and the comprehensive specialized hospital of Tigray region revealed that preterm newborns who had a PNA 55% (AHR = 1.55 (1.09, 2.20) and 2 times (AHR = 2.13 (1.32–3.47) increased the hazard of mortality compared to those who hadn't respectively (Yismaw et al., 2019, Girma et al., 2023).

Hypothermia

One study done in southern Uganda revealed that preterm newborns who had hypothermia at the time of admission had a 2 times higher risk of death than those who didn't (AHR, 1.98; 95% CI: 1.18 to 3.33) (Tibaijuka et al., 2021). The above finding was supported by a study done in five selected hospitals in Ethiopia, as evidenced by the fact that hypothermia contributed to 69.4% of all preterm deaths (Muhe et al., 2019). Similarly, a study done at Mizan Tepi Teaching

Hospital revealed that preterm newborns who had hypothermia had a 36% increased hazard of death than those who did not (AHR = 1.36, 95% CI (1–1.84)) (Bereka et al., 2021).

Neonatal sepsis

As one retrospective cohort study done at Tikur Anbessa Specialized Hospital in Addis Ababa revealed, preterm neonates who had sepsis had a 62% increased hazard of death compared to those who had no sepsis (AHR:1.62 (95% CI: 1.11,2.37)(Aynalem et al., 2021). Consistent research conducted at Jimma University Medical Center (JUMC) in Southwest Ethiopia revealed preterm neonates diagnosed with neonatal sepsis were 71% at increased hazards of mortality compared to their counterparts [AHR = 1.71, 95% CI: 1.18, 2.49] (Temesgen et al., 2021).

Jaundice

A retrospective follow-up study conducted in Gonder and Bahir Dar city, Northern Ethiopia, revealed that preterm neonates who had jaundice were 1.62 times (AHR = 1.62, 95% CI: 1.12, 2.54) and three times [AHR = 3.25, 95% CI: 2.14, 7.24] more likely to die than preterm neonates who had no jaundice, respectively (Yismaw et al., 2019, Belay et al., 2022). But a cross-sectional study done at Felege Hiwot specialized hospital in Bahir Dar City revealed that preterm neonates who had hyperbilirubinemia had a 41.9% lower risk of death than those who hadn't [AHR: 0.581, 95% CI: (0.436, 0.775)] (Tamene et al., 2020).

Hypoglycemia

A retrospective follow-up study conducted in Gonder revealed that preterm neonates who were diagnosed with hypoglycemia at admission had a nearly two-fold higher hazard of death than those who hadn't (AHR = 1.75, 95% CI (1.21, 2.54)) (Yismaw et al., 2019).

Preterm neonates Anemia

A prospective follow-up study conducted at government hospitals in Bench Sheko, Sheka, and Keffa Zone, Southwest Ethiopia, showed preterm neonates who had anemia had a 6.2 times higher hazard of death as compared with those who had no anemia (AHR = 6.2, 95% CI: 2.34 to 16.43) (Mihretu et al., 2024). Similarly, a retrospective study done at the University of Gondar Hospital in Northwest Ethiopia revealed that preterm neonates who had anemia had a 7.05 times higher hazard of death [AHR 7.053, 95% CI (2.5758, 19.31)] (Yehuala and Teka, 2015).

2.3 Conceptual Framework

A conceptual framework is developed by reviewing different literature. It shows different interrelated concepts of predictor mortality among preterm neonates. The diagram illustrates that preterm neonatal survival status has been associated with different factors, such as the following:

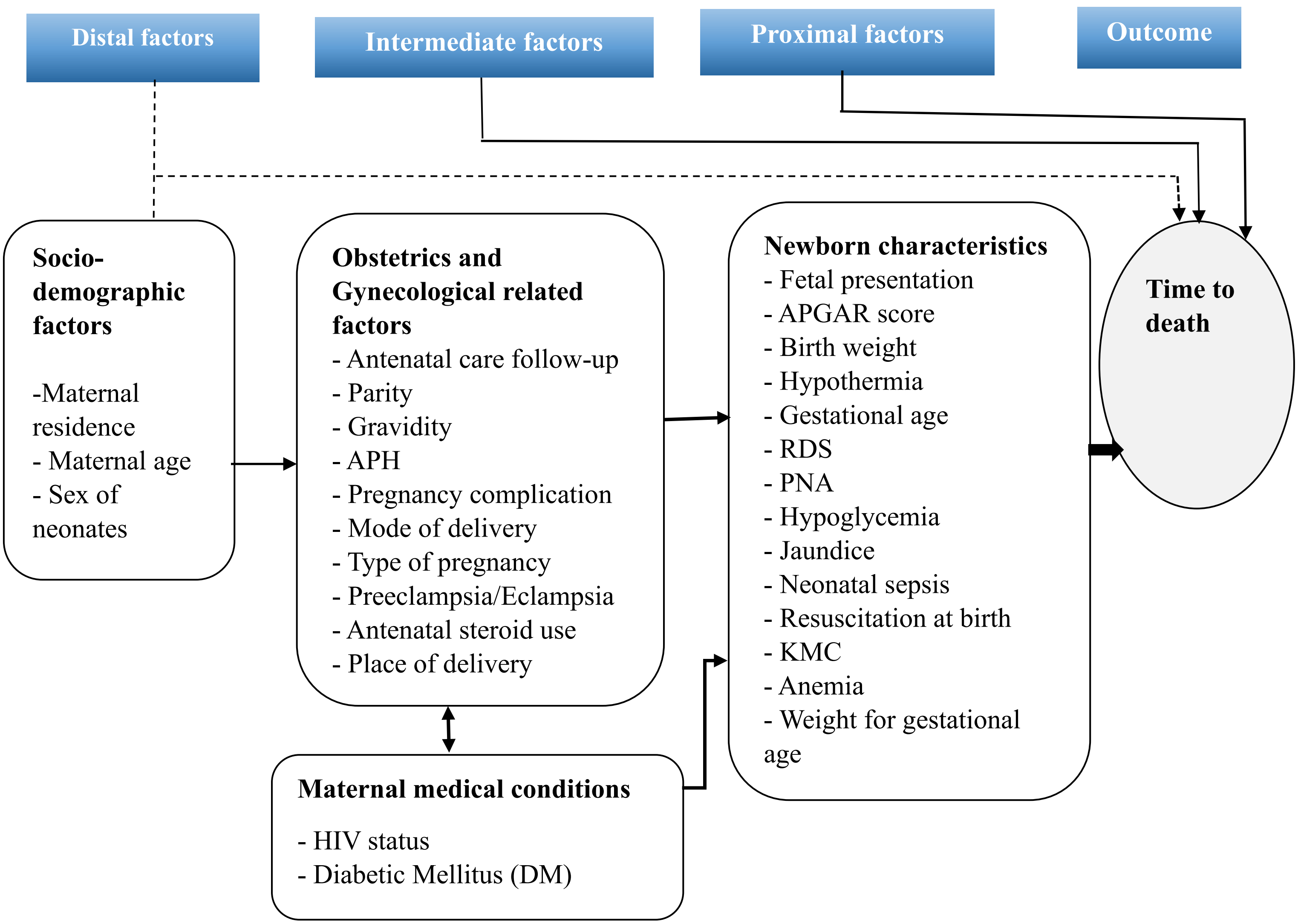

Figure 1: Conceptual Framework describing predictors of mortality among preterm neonates admitted to neonatal intensive care units of Public Hospitals in the Harari Region and Dire Dawa City Administration, Eastern Ethiopia.

Source: Constructed by the investigator based on a review of different literature.

3. METHODS AND MATERIALS

3.1. Study Area and Study Period

This study was conducted among preterm neonates who were admitted to the NICU at public hospitals in the Harari region and Dire Dawa administration from November 1, 2021 to October 31, 2024, and the preterm neonates' medical charts and registers were reviewed from January 1 to 31, 2025.

The Harari region is one of the regional states in Ethiopia and has an estimated population of 283,000, of which males and females are 143,000 and 140,000, respectively (ESS, 2023). The capital city of the Harari region is Harar, an ancient city located on a hilltop in the eastern part of Ethiopia, approximately 526 kilometers away from the capital city of Addis Ababa. Harari region has two public hospitals, Hiwot Fana Compressive Specialized University Hospital (HFCSUH) and Jugal General Hospital (JGH). Additionally, one military hospital, one private hospital, eight health centers (4 urban and 4 rural), 19 health posts, and 10 private clinics. HFCSUH and JGH are selected for this study based on preterm neonatal care provision. According to data from HFCSUH, out of 1,394 total neonates admitted to the NICU per year, 363 (26.04%) were preterm neonates. The hospital has 16 neonatal nurses and 8 pediatricians. The hospital also has 25 beds in the NICU ward, and on average, 31 preterm neonates are admitted per month. As data from Jugal General Hospital, out of 228 total neonates admitted to the NICU per year, 58 (25.4%) were preterm neonates. The hospital also has 6 neonatal nurses, 1 general practitioner (GP), and 2 pediatricians. The hospital has 4 beds in the NICU ward, and on average, 5 preterm neonates are admitted per month.

Dire Dawa city administration is located 515 kilometers northeast of the capital of Addis Ababa, Ethiopia. The city is one of the two chartered cities in Ethiopia. The projected total population in the city is estimated to be 551,000, of which 278,000 were male and 273,000 were female (ESS, 2023). The city is divided into nine kebeles (administrative districts). There are 2 governmental and 4 private hospitals, 15 health centers, 32 health posts, and 2 clinics in the city (Tolera et al., 2022). Dilchora Referral Hospital and Sabian General Hospital are selected for this study. According to data from Dilchora Referral Hospital, out of 717 total neonates admitted to the NICU per year, 96 (13.4%) were preterm neonates. The hospital has 10 nurses, 1 general practitioner (GP), and 3 pediatricians. The hospital has 16 beds in the NICU ward, and on average, 8 preterm neonates are admitted per month. The data from Sabina General Hospital, out of 536 total neonates admitted to the NICU per year, 82 (15.3%) were preterm neonates. The hospital has 12 neonatal nurses, 2 general practitioners (GPs), and 2 pediatricians. The hospital has 21 beds in the NICU ward, and on average, 7 preterm neonates are admitted per month.

3.2 Study Design

The hospital-based retrospective cohort study was conducted.

3.3 Population

3.3.1 Source Population

The source population was all preterm neonates admitted to the NICU at public hospitals in the Harar region and the Dire Dawa administration.

3.3.2 Study population

All randomly selected preterm neonates who were admitted to the NICU at public hospitals in the Harar region and the Dire Dawa administration from November 1, 2021, to October 31, 2024.

3.4 Inclusion and Exclusion Criteria

3.4.1 Inclusion Criteria

All preterm neonates who were admitted to the NICU at a public hospital in the Harar region and the Dire Dawa city administration from November 1, 2021, to October 31, 2024.

3.4.2 Exclusion Criteria

A preterm neonate's medical card with incomplete records of date of admission, date of discharge, gestational age, and unknown status was excluded.

3.5 Sample Size Determination

3.5.1 Sample size determination for the first objective

The sample size was determined by considering different covariates as exposure variables to estimate survival probabilities. The sample size needed for this objective was calculated by considering, survival probability of preterm neonates in the non-exposed or control/reference group and the survival probability of preterm neonates in the exposed group or experimental/comparison group based on previous literature for each variable. And also, the 10% (0.01) proportion of withdrawals or incomplete records, 80% power, and 0.05 significance level are considered. The total number of events (deaths) required to be observed in a study was also calculated using the log-rank test of the Freedman formula as follows:

$$E = \frac{1}{R}\left(Z\frac{\alpha}{2} + Z\beta\right)^2 \left(\frac{R(HR)+1}{HR-1}\right)^2,$$

And then the total sample size required to observe the total number of events (E) is calculated as: $n = \frac{E}{P(E)}$, where:

- ✓ **E** = the total number of events (deaths)
- ✓ **R** = the allocation ratio of the experimental group to the control group
- ✓ **Zα/2** = the critical value of the standard normal distribution (α = 0.05)
- ✓ **Zβ** = the critical value of the standard normal distribution corresponding to the desired
- ✓ **HR** = the difference between the survival probabilities or hazard ratios of the two groups
- ✓ **n** = total sample size required for the study
- ✓ **P(E)** = proportion of participants expected to experience the event

Generally, the total number of events (deaths) and sample size required for this objective were calculated using the log-rank test of STATA software version 17.0, as shown in Table 1 below.

Table 1: Sample size determination for time to death and its predictors among preterm neonates admitted to neonatal intensive care units at public hospitals in Harar region and Dire Dawa city administration, Eastern Ethiopia, 2024.

S. No	Exposure variable		Survival probability of preterm neonates	Estimated number of events	Sample size with 10% of incomplete records	References
1	Neonatal sepsis	No (non-exposed)	0.785	**116**	**466**	(Toma et al., 2021)
		Yes (exposed)	0.662			
2	Maternal Residency	Urban (non-exposed)	0.76	79	270	(Aynalem et al., 2021)
		Rural (exposed)	0.59			
3	Type of presentation	Cephalic (non-exposed)	0.66	94	240	(Bereka et al., 2021)
		Non-cephalic (exposed	0.47			
4	KMC usage	No (exposed)	0.560	81	256	(Bereka et al., 2021)
		Yes (non-exposed)	0.738			
5	RDS	Yes (exposed)	0. 685	60	278	(Toma et al., 2021)
		No (non-exposed)	0.838			

Therefore, the maximum sample size is **466** with **116** events for this objective, taking neonatal sepsis as the exposure variable, as shown in Table 1 above.

3.5.2 Sample size determination for the second objective

For this objective sample size was determined by considering predictors significantly associated with time to death of preterm neonates taken from previous studies and calculated using Stata software or using the Schoenfeld formula as follows:

$$\boldsymbol{E} = \frac{\left(\boldsymbol{Z}\frac{\boldsymbol{\alpha}}{2} + \boldsymbol{Z\beta}\right)^2}{\boldsymbol{P}(1-\boldsymbol{P})(\boldsymbol{lnHR})^2}\ , \qquad \boldsymbol{n} = \frac{\boldsymbol{E}}{\boldsymbol{P}(\boldsymbol{E})}$$

Where;

- ✓ E = number of required events (deaths)
- ✓ n = total sample size required for the study
- ✓ HR = hazard ratio of selected covariates
- ✓ P = Proportion of subjects in the exposed groups
- ✓ P(E) = probability of an event from a previous study
- ✓ lnHR = natural logarithm of hazard ratio
- ✓ $Z\alpha/2$ = critical value of the standard normal distribution at $\alpha/2$ significance level
- ✓ $Z\beta$ = critical value of the standard normal distribution at β significance level

Therefore, the required sample size for this objective is determined by using the STATA statistical package (sample size for Cox PH regression), version 17.0, by considering assumptions such as the hazard ratio (HR) for selected covariates from previous studies in Ethiopia, a variability (SD) of 0.5, a probability of failure (death) from the previous study, a significance level (alpha) of 0.05, and a power 80%. Additionally, a 10% proportion of withdrawals or incomplete records was considered. The detailed summary of the sample size calculation for this objective study is as follows in ***Table 2*** below.

Table 2: Sample size determination for time to death and its predictors among preterm neonates admitted to neonatal intensive care units at public hospitals in Harar region and Dire Dawa city administration, Eastern Ethiopia, 2024.

S. No	Variable	Failure probability in %	Adjusted hazard ratio (AHR) of the variable	Estimated sample size with probability of incomplete data at 10% (0.01)	Estimated number of events	References
1	Bag and mask resuscitation at birth	25.5	2.1	249	58	(Huka et al., 2023)
2	Jaundice	28.8	1.62	521	135	(Yismaw et al., 2019)
3	Neonatal sepsis	29.7	1.62	505	135	(Birhanu et al., 2022)
4	Weight for gestational age at birth	28.8	1.65	483	126	(Yismaw et al., 2019)
5	Respiratory distress syndrome (RDS)	29.7	1.54	**630**	**169**	(Aynalem et al., 2021)

Finally, respiratory distress syndrome (RDS) was selected out of 5 covariates from a study done in Tikur Anbessa Specialized Hospital, Addis Ababa, from the second objective sample size calculation, because it gives a maximum sample size of **630** (Aynalem et al., 2021). Therefore, based on the two objectives, the maximum sample size for this study was **630**.

3.6 Sampling Procedure/Technique

Public hospitals in the Harari region and the Dire Dawa administration were selected based on their service provision for preterm neonatal care. The preterm neonates' medical cards were identified by their MRN using the NICU register as a sampling frame. The total sample size was allocated proportionally to each hospital by reviewing the number of preterm neonates admitted to the NICU in the past three years (from November 1, 2021, to October 31, 2024). And then, an Excel-generated simple random sampling technique was employed to select 630 participants for the study from each hospital. The medical records of preterm neonates attached to selected MRNs were reviewed, and those records that met the eligibility criteria were included in this study.

The following diagram illustrates the proportional allocation of the required sample size among selected public hospitals of the Harari region and the Dire Dawa city administration.

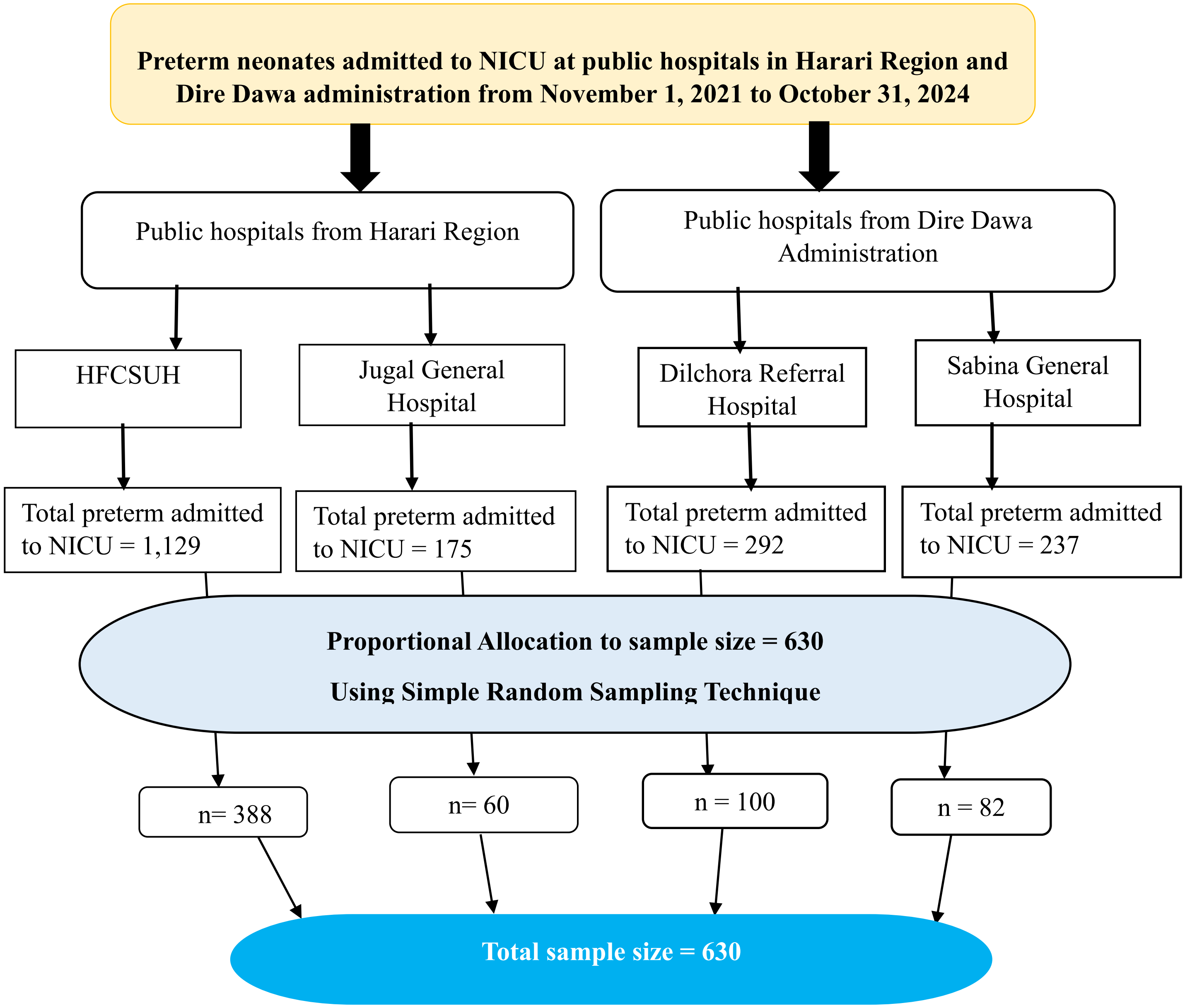

Figure 2: Schematic presentation of sampling procedure/technique among preterm neonates admitted to NICU at the public hospital of Harari region and Dire Dawa administration.

3.7 Data Collection Methods

3.7.1 Data Collection Instruments

The data collection checklist consists of information on socio-demographic characteristics, obstetrics and gynecological related factors, maternal medical conditions, preterm neonatal status, and preterm neonates related characteristics. The data extraction checklist was adapted by reviewing different literature from similar studies (Yismaw et al., 2019, Huka et al., 2023, Aynalem et al., 2021, Bereka et al., 2021, Temesgen et al., 2021, Mihretu et al., 2024) and modified with preterm neonates' medical cards and NICU register books.

3.7.2 Data Collectors and Supervisors

Two BSc Midwives data collectors were recruited for data extraction from the neonate's medical card and logbook, and one BSc Midwife supervisor was recruited. Two days of theoretical and practical training were given about the objective of the study and how to extract appropriate data for data collectors and supervisors by the principal investigator before the actual data collection, with close daily monitoring and supervision at the data collection site.

3.7.3 Procedure of Data Collection

Before actual data collection, the records were reviewed, and preterm neonatal cards were identified by their corresponding medical record numbers. Then, the data were extracted from each preterm neonate's medical records and health management information system (HMIS) registration format, using a structured checklist prepared in English from those preterm neonates' medical records that fulfilled the inclusion criteria.

3.8 Variables

3.8.1 Dependent Variable

Survival status of preterm neonates

3.8.2 Independent Variables

Socio-demographic characteristics: maternal residency, maternal age, and neonate sex.

Obstetrics and Gynecological Related Factors: Antenatal care follow-up, preeclampsia, eclampsia, APH, gravidity and parity, mode of delivery, type of pregnancy (singleton or multiple pregnancy), place of delivery, complication during last pregnancy, and antenatal steroid use.

Maternal medical conditions: HIV status and Diabetic Mellitus (DM)

Preterm neonate-related characteristics: gestational age, birth weight, weight for gestational age, APGAR score, PNA, RDS, KMC, resuscitation at birth, neonatal sepsis, hypothermia, hypoglycemia, jaundice, fetal presentation, and anemia.

3.9 Operational Definitions

Survival status: the outcome of preterm neonates, either death or censored.

Censored: preterm neonates those alive beyond 28 days after birth, discharged with parental refusal, discharged with improvement, and referred to other health institutions.

Follow-up time: starting from the date of admission up to 28 days of life.

Time to death: is the time in days from admission to NICU until death/transfer/discharge of neonates in the first 28 days of life.

Event: the death of preterm neonates after admission to the NICU.

Time scale: the survival time measured in days.

Preterm neonatal sepsis: defined as clinical signs and symptoms with the presence of risk factors, lab tests or diagnosed by a physician as the presence of sepsis.

3.10 Data Quality Control

For data collectors and supervisors, training was given on the objective of the study and each component of the structured checklists. After the training was given, a pretest was conducted on 5% of the total sample size using neonates' medical records and register books at Hiwot Fana Comprehensive Specialized Hospital during a period outside the main study, and then corrections were made accordingly before the actual data collection. The principal investigator and supervisor were checked on the spot and reviewed all data extraction checklists to ensure the completeness and consistency of the information collected, and action was taken accordingly.

3.11 Methods of Data Processing and Analysis

The collected data were cleaned, exported from the Kobo toolbox to Microsoft Excel, then exported into STATA version 17.0 software and analyzed.

The Kaplan–Meier curve was used to estimate median survival time, cumulative probability of survival, and failure to compare survival differences between the different covariates. The log-rank test was also carried out to compare statistical survival differences between categories of different explanatory variables. A life table was used to estimate the cumulative probability of survival at different time intervals.

A bivariable analysis using crude hazard ratios was conducted to identify candidate variables ($p < 0.25$) for inclusion in the multivariable Cox regression to identify predictors of preterm neonatal death. The proportional hazards assumption was assessed with the Schoenfeld residuals test (global test) and the Cox-Snell residual plot was assessed to check overall model fitness graphically.

The Cox proportional hazard model was used to determine the important predictors of time to death among preterm neonates. The Hazard Ratios (HR) with 95% Confidence Intervals (CI) were used to assess the relationship between predictors associated with the occurrence of preterm neonatal death. Statistical significance was declared at p-value < 0.05.

3.12 Ethical Considerations

Ethical clearance was obtained from the Institutional Health Research Ethical Review Committee (IHRERC) of Haramaya University, College of Health and Medical Sciences (Ref. No. IHRERC/227/2024). After approval, an official letter was written from Haramaya University, College of Health and Medical Sciences, to the director of HFCSUH, Jugal General Hospital, and the Dire Dawa Administration health bureau. Informed, voluntary, written, and signed consent was obtained from the head of each hospital. Neonates' confidentiality was maintained through anonymous data collection.

3.13 Information Dissemination

The findings of this study will be submitted to the College of Health and Medical Sciences at Haramaya University. Also be disseminated to Hiwot Fana Comprehensive Specialized University Hospital, Jugal General Hospital, Dilchora Referral Hospital, and Sabina General Hospital. Similarly, it will be disseminated to the Harari Regional Health Bureau and the Dire Dawa administration city. Anyone who needs to know the specific time at which there is a risk of preterm death, and other stakeholders, can use this study's findings. Furthermore, the results of this study will be submitted to a selected peer-reviewed journal for publication.

4. RESULTS

4.1 Socio-demographic characteristics

In the final analysis, 612 (97.14%) medical records of preterm neonates meeting the inclusion criteria were reviewed, whereas 18 (2.86%) records were excluded due to incomplete data. Out of incomplete cards, 6 had no date of admission, 7 had no date of discharge, and 5 were not available during card review. Out of 612 reviewed preterm neonate cards majority, 379 (61.93 %), were from Hiwot Fana Comprehensive Specialized Hospital, 58 (9.48 %) were from Jugal General Hospital, 96 (15.69 %) were from Dilchora Referral Hospital, and 79 (12.91%) were from Sabian General Hospital. The average maternal ages were 26.90 years with a standard deviation of ±5.50 years. More than two-thirds, 488 (79.74%) of the maternal ages were between 20-34 years. Slightly more than half, 315 (51.47%), of preterm neonates were male, and also more than half, 339 (55.39%) of the mothers resided in rural areas ***(Table 3).***

Table 3: Socio-demographic characteristics of mothers of preterm neonates admitted to the NICU of public hospitals in the Harari region and Dire Dawa administration from November 1, 2021, to October 31, 2024 (n=612).

Characteristics		**Frequency**	**Percentage (%)**
Hospital	HFCSUH	379	61.93
	Jugal General Hospital	58	9.48
	Dilchora Referral Hospital	96	15.69
	Sabian General Hospital	79	12.91
Maternal Age	15 - < 20 years	51	8.33
	20-34 years	488	79.74
	≥ 35 years	74	11.93
Maternal residence	Urban	273	44.61
	Rural	339	55.39
Sex of neonates	Male	315	51.47
	Female	297	48.53

4.2 Obstetrics and Gynecological Related Factors

Out of 612 mothers of preterm neonates, more than three-fourths, 474 (77.45%) had ANC follow-up, and among those, 298 (62.87%) had less than four ANC contacts. Two hundred seventy-four (44.77%) preterm neonates were delivered from multipara mothers. In more than two-thirds, 427 (69.77%) of mothers, the labor started spontaneously. Five hundred six (82.68%) of neonates were born from single pregnancies, and the majority, 242 (88.56%) of preterm neonates, were born at the hospital. Four hundred thirty-seven (71.41%) of preterm neonates were delivered through spontaneous vaginal delivery, and two-thirds (66.67%) of labor lasted from four hours to eighteen hours, and a median duration of labor was 6 hours. Nearly one-fourth, 140 (22.88%) of preterm births were delivered from preeclamptic mothers, and two hundred seventeen (35.46%) mothers experienced preterm premature rupture of membrane. One hundred seventy-nine (29.25%) mothers were taking corticosteroid drugs before delivery (***Table 4***).

Table 4: Obstetrics and Gynecological Related Factors of mothers among preterm neonates admitted to the NICU of public hospitals in the Harari region and Dire Dawa administration from November 1, 2021 to October 31, 2024 (n=612).

Characteristics		**Frequency**	**Percentage**
ANC follow-up	Yes	474	77.45
	No	138	22.55
ANC follow-up in numbers (n=474)	<4	298	62.87
	≥4	176	37.13
Gravidity	Primigravida	191	31.21
	Multigravida	280	45.75
	Grand multigravida	141	23.04
Parity	Primipara	212	34.64
	Multipara (2-4)	274	44.77
	Grand multipara (≥ 5 births)	126	20.59
Bad obstetrics history	Yes	62	10.13
	No	550	89.87
Type of pregnancy	Singleton	506	82.68
	Multiple	106	17.32
Onset of labor	Spontaneous	427	69.77
	Elective/emergency C/S	112	18.30
	Induced	73	11.93
Place of birth	Hospital	542	88.56
	Health center	59	9.64
	Home delivery	11	1.80
Mode of delivery	SVD	444	72.55
	Caesarean section	168	27.45
Duration of labor in hours	< 4	150	24.51
	4-18	408	66.67
	>18	54	8.82

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Preeclampsia	**Yes**	**140**	**22.88**
	No	472	77.12
Eclampsia	Yes	41	6.70
	No	571	93.30
Antepartum hemorrhage (APH)	Yes	94	15.36
	No	518	84.64
APH causes	Abruptio placenta	64	68.09
	Placenta previa	30	31.91
PPROM	Yes	217	35.46
	No	395	64.54
Polyhydramnios	Yes	14	2.29
	No	598	97.71
Oligohydramnios	Yes	13	2.12
	No	599	97.88
Chorioamnionitis	Yes	6	0.98
	No	606	99.02
Antenatal steroid use	Yes	179	29.25
	No	433	70.75

4.3 Maternal Medical Related Condition

Out of the preterm neonates' mothers included in this study seven (1.14%) mothers had Diabetic Mellitus. Likewise, among mothers of preterm neonates, 61 (9.97%) of them were had anemia, and twelve (1.96%) of preterm neonates were born to HIV positive mothers (***table 5***).

Table 5: Maternal medical conditions of preterm neonates admitted to NICU at public hospitals of Harari region and Dire Dawa administration from November 1, 2021 to October 31, 2024 (n=612).

Characteristics		**Frequency**	**Percentage**
Diabetic Mellitus	Yes	7	1.14
	No	605	98.86
Maternal hypertension	Yes	12	1.96
	No	600	98.04
Anemia	Yes	61	9.97
	No	551	90.03
Mother's HIV status	Reactive	12	1.96
	Non-reactive	600	98.04

4.4 Neonatal Related Characteristics

Out of 612 preterm neonates 147 (24.02%) were very preterm (28 to < 32 weeks), 183 (29.90%) moderate preterm (32 to <34 completed weeks), and 282 (46.08%) were late preterm (34 to <37 completed weeks), based on gestational age they were born after conception. Nearly two-thirds

(395, 64.54%) of preterm neonates were low birth weight (1500g – 2499g), and 170 (27.78%) of them were very low birth weight (1000g - 1499g). The average birth weight of preterm neonates was 1693.86g (SD±430.10g).

The majority, 432 (70.59%) of preterm neonates were classified as appropriate weight for gestational age at birth. Four hundred forty-seven (73.04%) of preterm neonates had a 5-minute APGAR score of more than or equal to seven (≥7). Nearly one-third, 185 (30.23%) of preterm neonates were resuscitated with bag and mask at birth. One hundred sixteen (18.95%) of preterm neonates had normal body temperatures (≥ 36.5 °C) measured within one hour of admission.

Ninety-six of (15.69%) neonates were developed peri-natal asphyxia (PNA) during the study time. Half, 309 (50.49%) of preterm neonates were diagnosed with respiratory distress syndrome (RDS) among those included in the study, and three-fourths, 468 (76.47%) of preterm neonates were diagnosed with hypothermia. Three hundred ninety (63.73%) newborns were diagnosed with neonatal sepsis among preterm neonates admitted during the study period. Based presentation of newborns at birth, 523 (85.46%) of them presented with cephalic presentation. Among all newborns included in this study, 236 (38.56%) received kangaroo mother care, and more than half, 352 (57.52%) of neonates received continuous positive airway pressure (CPAP) during the admission period (***Table 6***).

Table 6: Neonatal-related characteristics among preterm neonates admitted to the NICU of public hospitals in the Harari region and Dire Dawa administration from November 1, 2021 to October 31, 2024 (n = 612).

Characteristics		**Frequency**	**Percentage**
Gestational age in weeks	28 to < 32 completed weeks	147	24.02
	32 to <34 completed weeks	183	29.90
	34 to <37 completed weeks	282	46.08
Weight of neonate at birth (gm)	ELBW < 1000)	20	3.27
	VLBW (1000-1499)	170	27.78
	LBW (1500-2499)	395	64.54
	NBW (≥2500)	27	4.41
Weight for gestational age at birth	Appropriate	432	70.59
	Small	180	29.41
APGAR score at 1st minute	<7	305	49.84
	≥7	307	50.16

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APGAR score at 5th minute	<7	165	26.96
	≥7	447	73.04
Bag and mask resuscitation at birth	Yes	185	30.23
	No	427	69.77
Newborns temperature within 1 hour of admission	≤33°C	31	5.07
	33.1-35 °C	231	37.75
	35.1-36.4 °C	234	38.24
	≥36.5 °C	116	18.95
Newborn diagnosed with Perinatal asphyxia (PNA)	Yes	96	15.69
	No	516	84.31
Newborn diagnosed with respiratory distress syndrome	Yes	309	50.49
	No	303	49.51
Hypothermia diagnosed at admission	Yes	468	76.47
	No	144	23.53
Hypoglycemia diagnosed at admission	Yes	66	10.78
	No	546	89.22
Jaundice	Yes	112	18.30
	No	500	81.70
Newborn diagnosed with sepsis	Yes	390	63.73
	No	222	36.27
Congenital anomalies	Yes	22	3.53
	No	590	96.41
Newborn diagnosed with Anemia	Yes	18	2.94
	No	594	97.06
Type of presentation	Cephalic	523	85.46
	Non-cephalic	89	14.54
Types of cephalic presentation (n=523)	Vertex	474	90.63
	Non-vertex	49	9.37
Neonates diagnosed with NEC	Yes	48	7.84
	No	564	92.16
The newborn received kangaroo mother care	Yes	236	38.56
	No	376	61.44
Neonate received continuous positive airway pressure (nCPAP)	Yes	352	57.52
	No	260	42.48
Neonate received phototherapy	Yes	86	14.05
	No	526	85.95
Newborn heated with a radiant warmer	Yes	437	71.41
	No	175	28.59

4.5 Major predictors contributed to preterm neonatal mortality

The findings of this study revealed that multiple comorbidities were observed among deceased preterm neonates, significantly contributing to the overall burden of morbidity, resulting in preterm neonate mortality. The major causes of death among preterm neonates were hypothermia (25.65%), neonatal sepsis (25.04%), and respiratory distress syndrome (23.50%), together accounting for the majority of reported mortality (***Figure 3).***

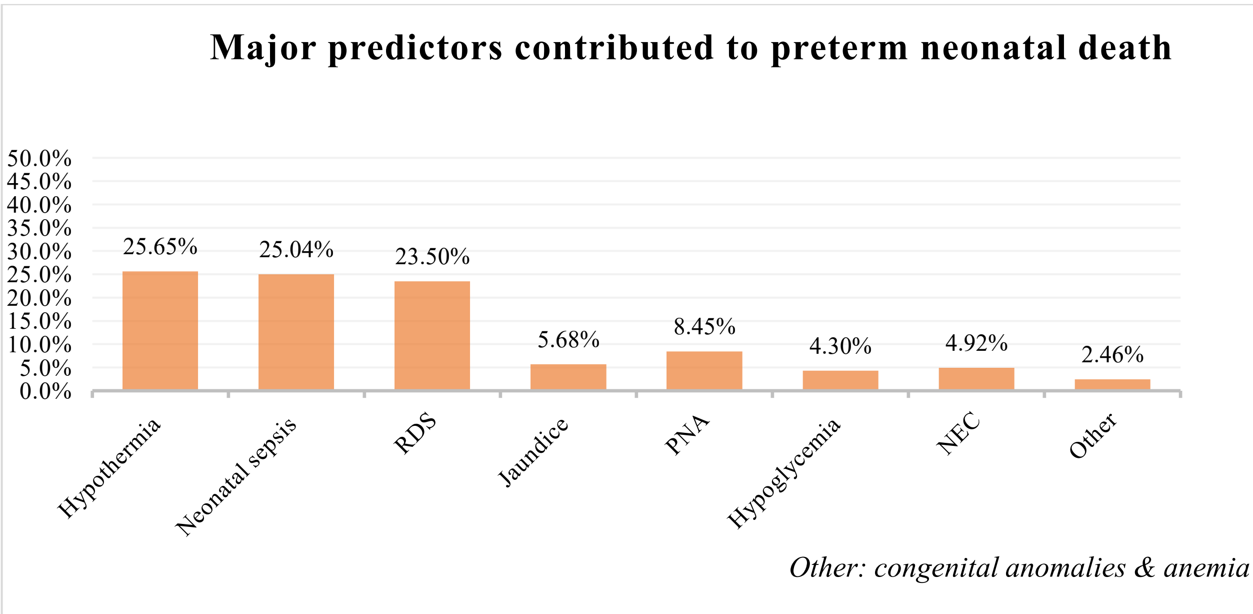


Figure 3: Major predictors contributing to preterm neonatal death among total morbidities in preterm neonates admitted to the NICU of public hospitals in the Harari region and Dire Dawa administration from November 1, 2021, to October 31, 2024.

4.6 Survival Status of Preterm Neonate

Among those admitted preterm neonates, 205 (33.50%) (95% CI: (29.76 - 37.39)) died, 342 (55.88%) were discharged to home (survived), 47 (7.68%) had loss to follow up (discharged against medical advice), 8 (1.31%) were referred to other health institutions, and 10 (1.63%) had survived more than 28 days (***Figure 4***).

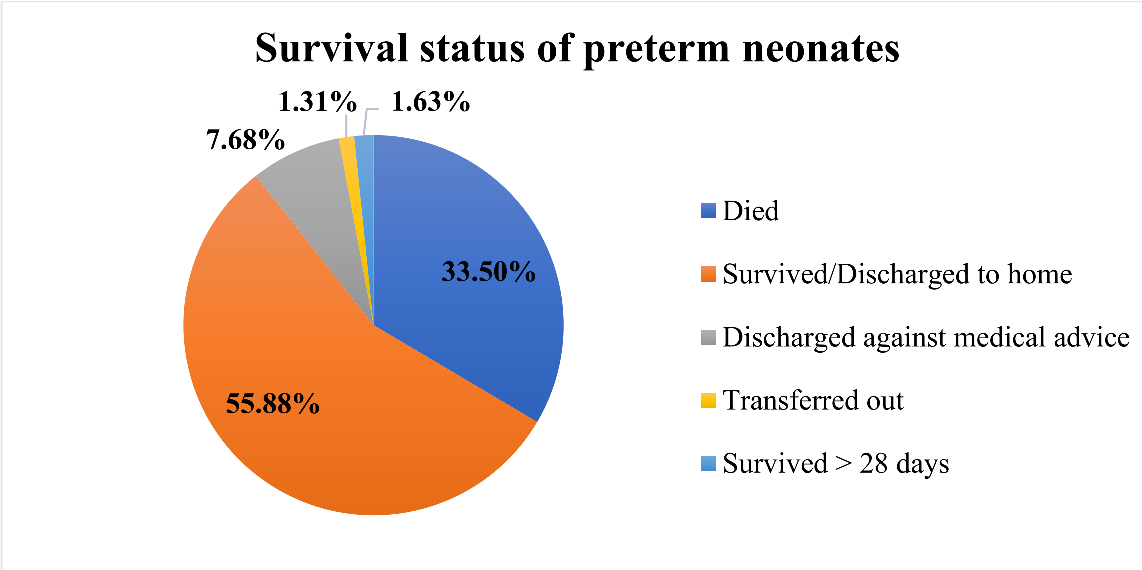


Figure 4: The overall survival status of preterm neonates admitted to the NICU of public hospitals in the Harari region and Dire Dawa administration from November 1, 2021 to October 31, 2024.

The overall incidence rate was 52.76 (95% CI: 46.01 to 60.50) deaths per 1000 neonate-days, with a total time at risk of 612 preterm neonates of 3,885.35 neonate-days. The overall median survival time was 18 days, and the median length of hospital stay for preterm neonates was 4 days (interquartile range: 7 [2, 9] days).

The Kaplan-Meier survival function estimate revealed that among all preterm neonatal deaths, 65 (31.71%) occurred on the first day of the follow-up period. The cumulative survival probabilities at the end of follow up periods of 1 day, 3 days, 7 days and 28 days were 89.16% (95% CI: 86.39 - 91.40), 76.17% (95% CI: 72.40 - 79.51), 64.45% (95% CI: 59.92 - 68.59) and 44.38% (95% CI: 35.84 - 52.57) respectively ***(Table 7)***.

Table 7: Survival probability from life table among preterm neonates admitted to the NICU of public hospitals in the Harari region and Dire Dawa administration from November 1, 2021 to October 31, 2024 (n=612).

Length of hospital stay (days)	Total at the beginning	Death	Censored	Survival probability (%)	95% Confidence interval
(0-4]	612	135	123	75.48	(71.66 – 78.86)
(4-8]	354	46	128	63.50	(58.94 – 67.70)
(8-12]	180	10	76	59.03	(53.99 – 63.72)
(12-16]	94	7	39	53.49	(47.41 – 59.18)
(16-20]	48	5	14	46.96	(39.36 – 54.19)
(20-24]	29	1	7	43.35	(34.86 – 51.53)
(24-28]	31	0	21	43.35	(34.86 – 51.53)

Kaplan-Meier survival graph and log-rank test were used to compare the hazard of death between preterm neonates with the different predictors of mortality. The Kaplan-Meier curve illustrates the probabilities of survival and failure over time, indicating that these probabilities change over time **(Figure 5).**

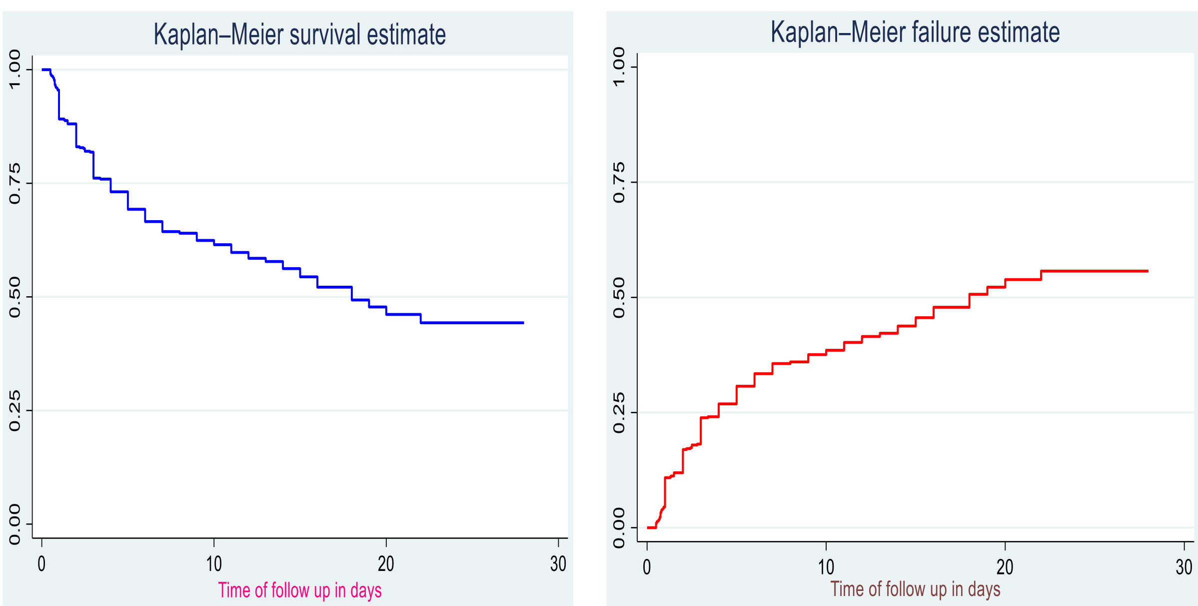


Figure 5: Overall Kaplan-Meier survival and failure estimate graphs among preterm neonates admitted to the NICU of public hospitals in the Harari region and Dire Dawa administration from November 1, 2021 to October 31, 2024.

The Nelson-Aalen cumulative hazard estimates the accumulated risk of death among preterm neonates admitted to NICUs at public hospitals in the Harari region and Dire Dawa administration, up to the end of 28 days **(Figure 6).**

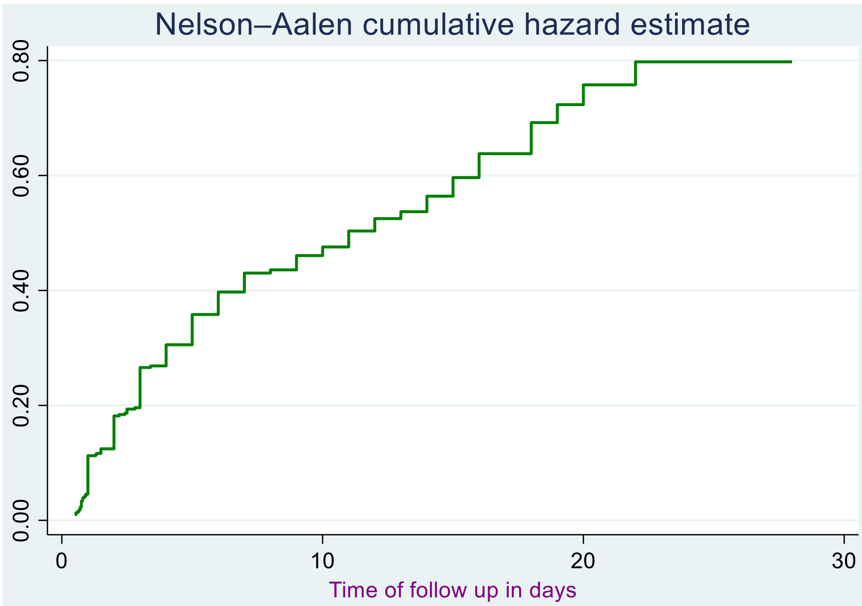
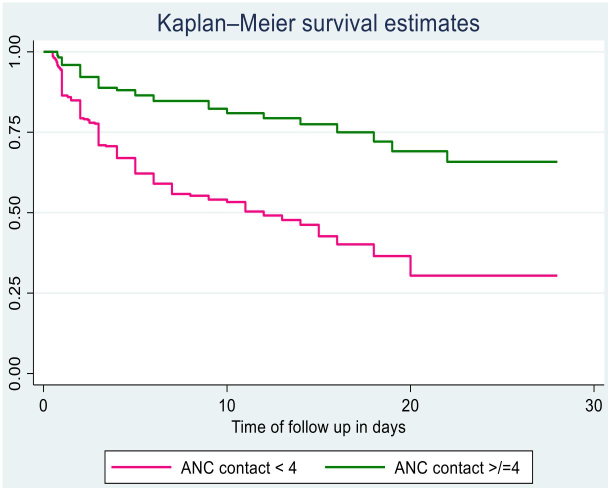
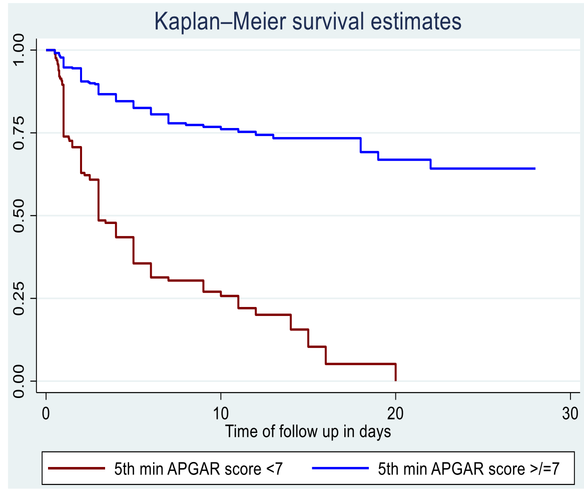
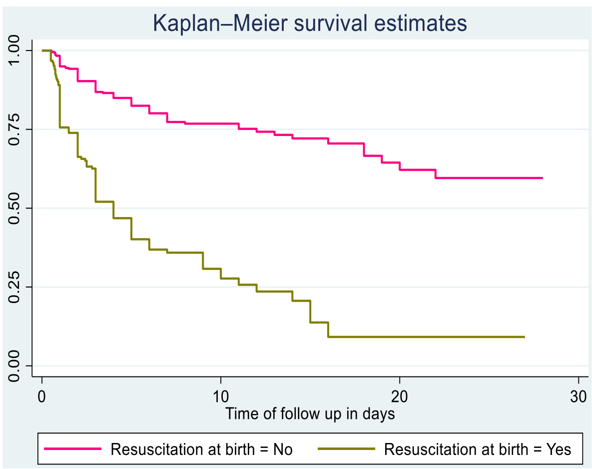


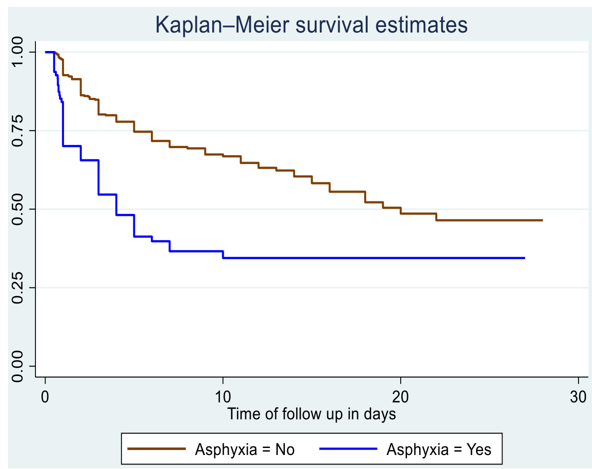
Figure 6: The overall Nelson-Aalen cumulative hazard estimate among preterm neonates admitted to the NICU of public hospitals in the Harari region and Dire Dawa administration from November 1, 2021 to October 31, 2024.

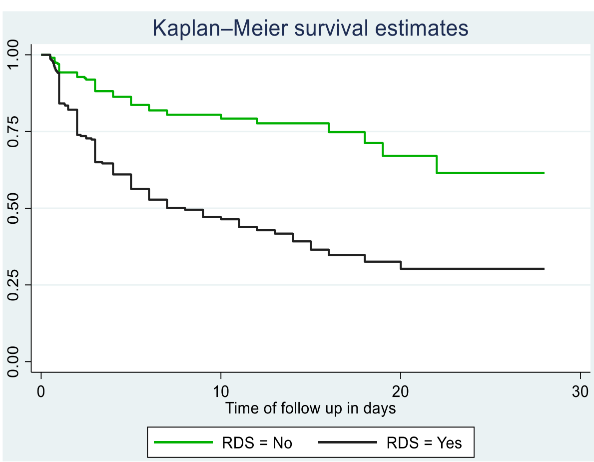
The log-rank test was used for comparisons of survival time differences between different groups of categorical covariates. In this study, in preterm neonates, the log-rank test was statistically significant which shows the differences between groups in ANC follow up frequency ≥ 4 (Pr>X2 = 0.0000), 5th minute APGAR score < 7 (Pr>X2 = 0.0000), resuscitation with bag and mask at birth (Pr>X2 = 0.0000), PNA (Pr>X2 = 0.0000), RDS (Pr>X2 = 0.0000), neonatal sepsis (Pr>chi2 = 0.0001), non-cephalic presentation during birth (Pr>X2 = 0.0184) and using KMC (Pr>X2 = 0.0000), as compared to their counterparts (**figure 7**).

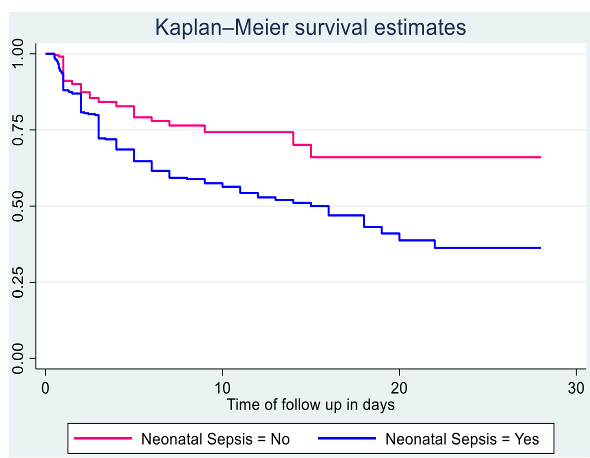

Kaplan–Meier survival estimates
0.00 0.25 0.50 0.75 1.00
0 10 20 30
Time of follow up in days
ANC contact < 4
ANC contact >/=4

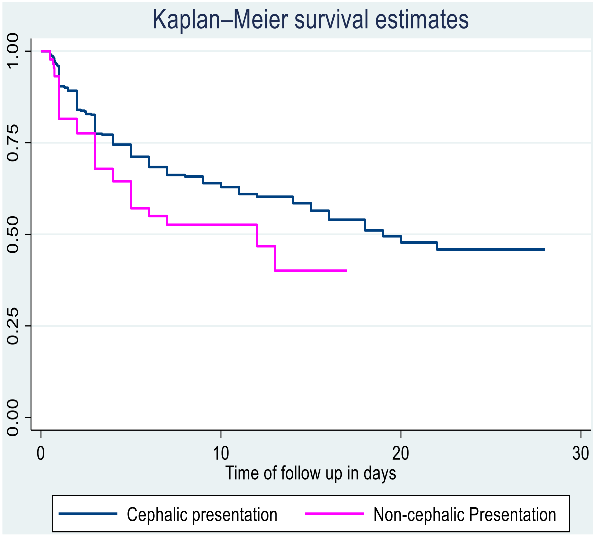

Kaplan–Meier survival estimates
0.00 0.25 0.50 0.75 1.00
0 10 20 30
Time of follow up in days
5th min APGAR score <7
5th min APGAR score >/=7


Kaplan–Meier survival estimates
0.00 0.25 0.50 0.75 1.00
0 10 20 30
Time of follow up in days
Resuscitation at birth = No
Resuscitation at birth = Yes


Kaplan–Meier survival estimates
0.00 0.25 0.50 0.75 1.00
0 10 20 30
Time of follow up in days
Asphyxia = No
Asphyxia = Yes


Kaplan–Meier survival estimates
0.00 0.25 0.50 0.75 1.00
0 10 20 30
Time of follow up in days
RDS = No
RDS = Yes


Kaplan–Meier survival estimates
0.00 0.25 0.50 0.75 1.00
0 10 20 30
Time of follow up in days
Neonatal Sepsis = No
Neonatal Sepsis = Yes



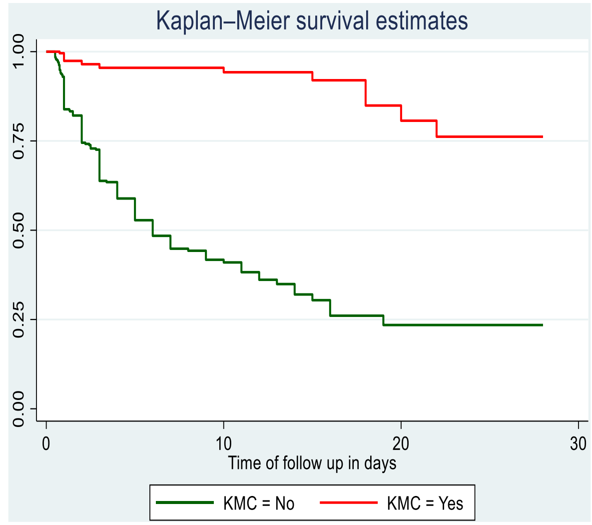


Figure 7: Kaplan-Meier survival curve compares the difference in survival time among exposed and unexposed preterm neonates admitted to the NICU of public hospitals in the Harari region and Dire Dawa administration from November 1, 2021, to October 31, 2024.

Cox proportional hazards assumption test and model fitness test

The assumption of cox-proportional hazards was assessed using the Schoenfeld residual test and the global test for the overall model PH assumption test, which was insignificant (Prob>X2 = 0.6401), indicating that the proportional hazard assumption of Cox-proportional hazards regression was met. The model fitness was checked graphically by using the Cox-Snell residual, and the graph showed that the hazard function followed the line closely at 45 °, which confirms that the final model was a good fit ***(Figure 8).***

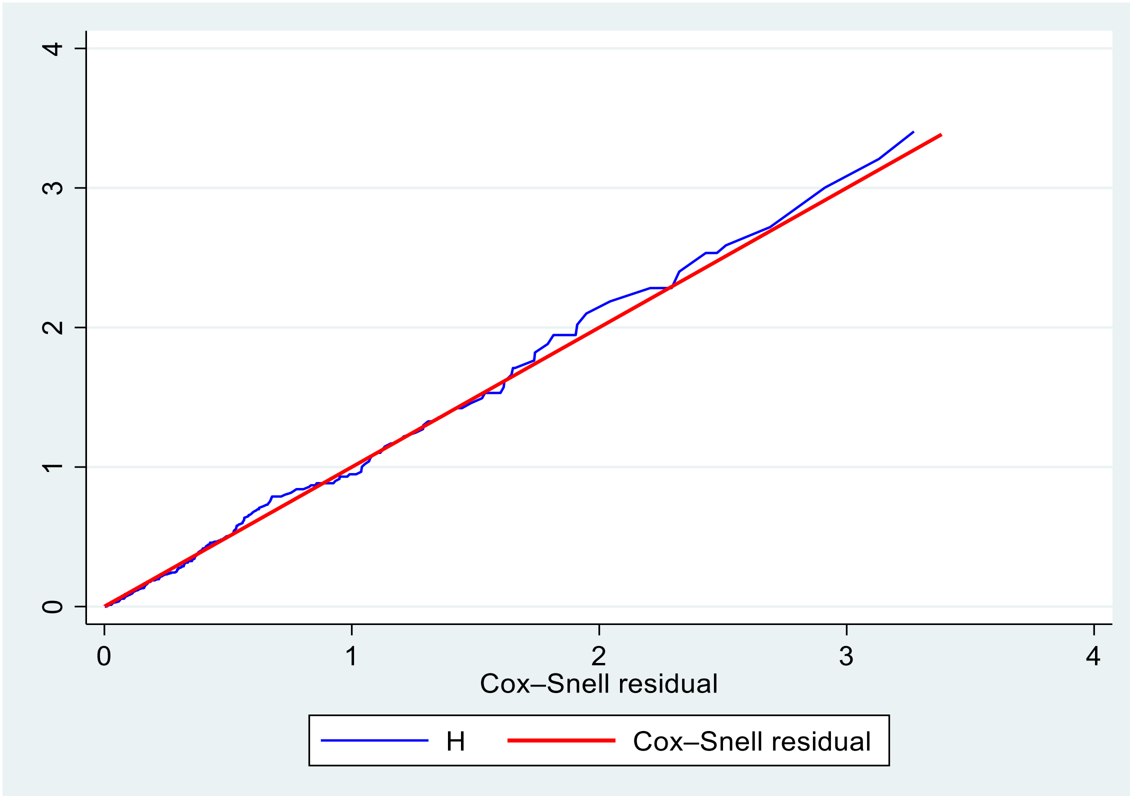


Figure 8: Cox-Snell residual for assessing the goodness-of-fit of the Cox proportional hazards model among preterm neonates admitted to the NICU of public hospitals in the Harari region and Dire Dawa administration from November 1, 2021 to October 31, 2024.

4.7 Predictors of Time to Death Among Preterm Neonates

As bivariable Cox-PH regression at <5% significance level the having ANC follow up, frequency of ANC contacts ≥ 4, grand multipara, having eclampsia, taking antenatal steroid, gestational age between 28 to < 32 and 32- < 34 weeks, <1000gm weight of neonate, small weight for gestational age at birth, APGAR score at 1st and 5th minute < 7, diagnosed hypothermia with at admission, bag and mask resuscitation at birth, having perinatal asphyxia, having respiratory distress syndrome, having neonatal sepsis, non-cephalic presentation, neonates diagnosed with NEC, kangaroo mother care usage, and receiving CPAP were significantly predictors of mortality among preterm neonates compared to their counterparts ***(Table 8).***

Table 8: Bivariable Cox-proportional hazard regression analysis among preterm neonates admitted to the NICU of public hospitals in the Harari region and Dire Dawa administration from November 1, 2021 to October 31, 2024 (n=612).

Variables	**Categories**	**Survival status**		**CHR 95% CI**	**p-value**
		Censored n = 407	**Death n = 205**		
Maternal age in years	15 -< 20	36	15	0.91 (0.54 - 1.55)	0.739
	20 - 34	315	173	1	1
	≥ 35	56	17	0.61 (0.37 – 1.00)	0.050
ANC follow-up	Yes	334	140	0.56(0.41 - 0.75) ***	0.0001
	No	73	65	1	1
ANC contacts	< 4contacts	264	173	1	1
	≥ 4contacts	143	32	0.33(0.22 - 0.48) ***	0.0001
Parity	Primipara	136	76	1	1
	Multipara	176	98	0.93 (0.69 - 1.25)	0.629
	Grand multipara	95	31	0.61(0.40 - 0.93) *	0.020
Bad obstetrics history	Yes	34	28	1.28(0.86 - 1.91)	0.224
	No	373	177	1	1
Chorioamnionitis	Yes	4	2	2.44(0.60 – 9.84)	0.211
	No	403	203	1	1
Preeclampsia	Yes	85	55	1.31 (0.97 - 1.78)	0.152
	No	322	150	1	1
Eclampsia	Yes	21	20	1.63 (1.03 - 2.59) *	0.038
	No	386	185	1	1
Antenatal Steroid used	Yes	131	48	0.66 (0.47 - 0.91) *	0.011
	No	276	157	1	1
Maternal anemia	Yes	39	22	1.41 (0.91 - 2.20)	0.126
	No	368	183	1	1
Mothers with HIV	Reactive	4	8	2.02(0.99 - 4.02)	0.052
	Non-reactive	403	197	1	1
Gestational age in weeks	28 to < 32	62	85	3.17(2.27 - 4.44) ***	0.0001
	32 to <34	121	62	1.63(1.14 - 2.33) **	0.008
	34 to <37	224	58	1	1
Weight of neonate (gm)	<1000	4	16	3.72 (1.46 - 9.55) **	0.006
	1000-1499	76	94	2.24 (0.98 - 5.12)	0.056
	1500-2499	306	89	0.84 (0.37 - 1.92)	0.675
	≥2500	21	6	1	1
Weight for gestational age at birth	Appropriate	312	120	1	1
	Small	95	85	1.71(1.29 - 2.26) ***	0.0001
APGAR score at 1st minute	<7	146	159	4.60(3.31 - 6.40) ***	0.0001
	≥7	261	46	1	1
APGAR score at 5th minute	<7	48	117	5.28(3.98 – 7.00) ***	0.0001
	≥7	359	88	1	1

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Resuscitation at birth	Yes	68	117	4.55(3.42 – 6.03) ***	0.0001
	No	339(79.39)	88	1	1
PNA	Yes	41	55	2.48(1.82 - 3.38) ***	0.0001
	No	366	150	1	1
RDS	Yes	156	153	3.16(2.31 - 4.33) ***	0.0001
	No	251	52	1	1
Hypothermia diagnosed at admission	Yes	301	167	1.53 (1.07 – 2.17) *	0.019
	No	106	38	1	1
Hypoglycemia diagnosed at admission	Yes	38	28	1.30 (0.87 - 1.93)	0.200
	No	369	177	1	1
Jaundice	Yes	75	37	0.77 (0.54 - 1.10)	0.147
	No	332	168	1	1
Neonatal sepsis	Yes	227	163	1.9 (1.36 - 2.69) ***	0.0001
	No	180	42	1	1
Type of presentation	Cephalic	353	170	1	1
	Non-cephalic	54	35	1.53 (1.06 - 2.21) *	0.022
Neonates diagnosed with NEC	Yes	16	32	2.10(1.42 - 3.02) ***	0.0001
	No	391	173	1	1
Kangaroo mother care use	Yes	220	16	0.09(0.05 - 0.15) ***	0.0001
	No	187	189	1	1
CPAP	Yes	212	140	1.58 (1.18 - 2.12) **	0.002
	No	195	65	1	1

Note: CHR = Crude Hazard Ratio, CI= Confidence Interval, 1 = Reference group
p-value <0.05(*), p-value <0.01 (**), and p-value <0.001 (***)

Findings from multivariable Cox-Proportional hazard regression revealed that the hazard of death among preterm neonates delivered from mothers with ≥ 4 ANC contacts was 44% (AHR: 0.56 (95% CI: 0.36 - 0.89)) lower than those born from <4 ANC contacts. The hazards of death among preterm neonates with APGAR score at 5th minute <7 were 1.80 (AHR: 1.80 (95% CI: (1.22 - 2.66)) times higher than those with APGAR score at 5th minute ≥7. Preterm neonates who were resuscitated with bag and mask at birth had 1.59 (AHR: 1.59 (95% CI: 1.10 - 2.29)) times higher risk of mortality compared to those who were not resuscitated. The risk of death of preterm neonates with perinatal asphyxia (PNA) was 1.55 (AHR: 1.55 (95% CI: (1.08 - 2.22)) times higher than compared of those who had no PNA.

Similarly, preterm neonates diagnosed with respiratory distress syndrome (RDS) had a 75% (AHR: 1.75 (95% CI: (1.22 - 2.51)) higher risk of mortality compared to those without RDS. Preterm neonates with non-cephalic presentation at birth had 1.68 (AHR: 1.68 (95% CI: 1.12 - 2.53)) times higher risk of death compared to those with cephalic presentation. The hazard of death of preterm neonates with neonatal sepsis was 1.58 (AHR: 1.58 (95% CI: (1.09 - 2.28)) times higher than compared of those without sepsis. Likewise, preterm neonates who received Kangaroo Mother Care (KMC) had an 84% (AHR: 0.16 (95% CI: (0.09 - 0.27)) lower risk of death compared to those who did not receive KMC (***Table 9***).

Table 9: Multivariable Cox-Proportional Hazard Regression analysis among preterm neonates admitted to the NICU of public hospitals in the Harari region and Dire Dawa administration from November 1, 2021 to October 31, 2024 (n=612).

Variables	**Categories**	**Survival status**		**AHR 95% CI**
		Censored (n, %) n = 407	**Death (n, %) n = 205**	
Maternal age in years	15 - < 20	36 (70.59)	15 (29.41)	0.96(0.55 – 1.70)
	20 - 34	315(64.55)	173 (35.45)	1
	≥ 35	56 (76.71)	17 (23.29)	1.07(0.57 - 1.96)
ANC follow up	Yes	334(70.46)	140 (29.54)	1.04(0.75 - 1.45)
	No	73 (52.90)	65 (47.10)	1
ANC contacts	< 4contacts	264(60.41)	173 (39.59)	1
	≥ 4contacts	143(81.71)	32 (18.29)	0.56(0.36 - 0.89) *
Parity	Primipara	136 (64.15)	76 (35.85)	1
	Multipara	176(64.23)	98 (35.77)	0.84(0.59 - 1.19)
	Grand multipara	95 (75.40)	31 (24.80)	0.74 (0.43 - 1.29)
Bad obstetrics history	Yes	34 (54.84)	28 (45.16)	1.02(0.65 - 1.58)
	No	373(67.82)	177 (32.18)	1
Chorioamnionitis	Yes	4(66.67)	2(33.33)	1.09(0.25 - 4.89)
	No	403(66.50)	203 (33.50)	1
Preeclampsia	Yes	85(60.71)	55 (39.29)	1.04 (0.72 - 1.51)
	No	322(68.22)	150(31.78)	1
Eclampsia	Yes	21 (51.22)	20(48.78)	1.08(0.64 - 1.82)
	No	386(67.60)	185 (32.40)	1
Steroid used	Yes	131(73.18)	48 (26.82)	0.75(0.52 - 1.09)
	No	276(63.74)	157 (36.26)	1
Maternal anemia	Yes	39(63.93)	22 (36.07)	1.13(0.69 - 1.86)
	No	368(66.79)	183 (33.21)	1
Mothers with HIV	Reactive	4 (33.33)	8 (66.67)	2.15(0.94 - 4.95)
	Non-reactive	403(67.17)	197 (32.83)	1
Gestational age in weeks	28 to < 32	62(42.18)	85 (57.82)	1.42 (0.88 - 2.29)
	32 to <34	121(66.12)	62 (33.88)	1.23(0.81 - 1.86)
	34 to <37	224(79.43)	58 (20.57)	1
Weight of neonate (gm)	<1000	4(20)	16(80)	1.25(0.38 – 4.08)
	1000-1499	76(44.71)	94 (55.29)	1.00(0.37 - 2.68)

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	1500-2499	306(77.47)	89 (22.53)	0.68(0.28 - 1.66)
	≥2500	21 (77.78)	6(22.22)	1
Weight for gestational age at birth	Appropriate	312(72.22)	120 (27.78)	1
	Small	95 (52.78)	85 (47.22)	0.72(0.49 - 1.06)
APGAR score at 1st minute	<7	146(47.87)	159 (52.13)	1.43(0.91 - 2.25)
	≥7	261 (85.02)	46 (14.98)	1
APGAR score at 5th minute	<7	48(29.09)	117 (70.91)	1.80(1.22 - 2.66) **
	≥7	359 (80.31)	88 (19.69)	1
Resuscitation at birth	Yes	68(36.76)	117 (63.24)	1.59(1.10 - 2.29) *
	No	339(79.39)	88 (20.61)	1
PNA	Yes	41 (42.71)	55 (57.29)	1.55(1.08 - 2.22) *
	No	366 (70.93)	150(29.07)	1
RDS	Yes	156 (50.49)	153 (49.51)	1.75(1.22 - 2.51) **
	No	251(82.84)	52 (17.16)	1
Hypothermia diagnosed at admission	Yes	301(64.32)	167 (35.68)	0.98 (0.67 - 1.44)
	No	106(73.61)	38 (26.39)	1
Hypoglycemia diagnosed at admission	Yes	38 (57.58)	28 (42.42)	1.27(0.81 – 2.01)
	No	369(67.58)	177 (32.42)	1
Jaundice	Yes	75(66.96)	37 (33.04)	0.86(0.58 - 1.28)
	No	332(66.40)	168 (33.60)	1
Neonatal sepsis	Yes	227(58.21)	163 (41.79)	1.58 (1.09 - 2.28) *
	No	180(81.08)	42(18.92)	1
Type of presentation	Cephalic	353(67.50)	170(32.50)	1
	Non-cephalic	54(60.67)	35(39.33)	1.68(1.12 - 2.53) *
Neonates diagnosed with NEC	Yes	16(33.33)	32(66.67)	1.24(0.80 - 1.92)
	No	391(69.33)	173(30.67)	1
Kangaroo mother care usage	Yes	220(93.22)	16 (6.78)	0.16(0.09 -0.27) ***
	No	187(49.73)	189(50.27)	1
CPAP	Yes	212(60.23)	140(39.77)	0.77 (0.55 - 1.08)
	No	195(75)	65(25)	1

Note: AHR= Adjusted Hazard Ratio, CI= Confidence Interval, 1 = Reference
p-value <0.05(*), p-value <0.01 (**), and p-value <0.001 (***)

5. DISCUSSION

This study found that the overall incidence of preterm neonatal mortality at the end of the follow-up period was 33.50% (95% CI: (29.76 - 37.39)), with an incidence rate of 52.76 deaths per 1000 preterm neonate-days. The median survival time of the preterm neonates was 18 days. The result indicates a high level of preterm neonatal mortality, and it is evidence of the urgent necessity of intervention. Prevention of preterm death requires improved antenatal care and improved neonatal care, combined with well-trained health professionals. The policy actions need to focus on preterm care through adequate financing and the development of explicit guidelines. The strategy also must include targets for reducing, monitoring progress, and fostering cooperation and innovation to decrease preventable preterm death. Unified intervention is needed to reduce avoidable deaths and improve survival rates among preterm neonates.

The preterm neonatal mortality rate in this study was consistent with studies from various hospitals across the entire country of Ethiopia and globally. Preterm neonatal mortality rates have been reported as 34.9% in Addis Ababa (Birhanu et al., 2022), 32.57% in Mizan-Tepi University Teaching Hospital (Mihretu et al., 2024), and 35% in another study (Bereka et al., 2021). Also, 32.1% was reported in Tigray hospital (Girma et al., 2023), 31% at Felege Hiwot hospital in Bahir Dar city (Belay et al., 2022), and 31.6% in Fort Portal Regional Referral Hospital in Uganda (Egesa et al., 2020).

However, this study found a higher preterm neonatal mortality rate compared to those reported in upper-middle- and high-income countries, including in China (1.9%) (Xu et al., 2019) and a different study mentioned a rate of 5.01% (Yan et al., 2018), Iran (27.4%) (Basiri et al., 2015) and Saudi Arabia (7.19%) (Alghadier et al., 2024). The distinction could be due to economic and sociodemographic differences between Ethiopia and those nations. Infants born preterm in those countries have received improved care during the pre-pregnancy, antenatal, intrapartum, and postnatal periods (Kikuchi et al., 2016). These economic and sociodemographic differences may lead to differences in the quality of service provision in preterm neonatal care, and developed countries might be better equipped with skilled professionals, a support labor force, and advanced equipment necessary for preterm neonatal care (Huka et al., 2023, Aynalem et al., 2021).

The findings of the study were higher preterm neonatal mortality compared to the findings of some studies conducted within and outside Ethiopia. For instance, the rates of mortality were lower as reported in Uganda (7.8%) (Opio et al., 2019), Western Sierra Leone (20.7%) (Luke et al., 2024), Nigeria (18.7%) (Michael et al., 2021), and Jordan (12.3%) (Razeq et al., 2017). Similarly, in India and Pakistan, a multicenter study revealed a mortality rate of 23% (Dhaded et al., 2022). In Ethiopia, the preterm mortality rates reported in various hospitals were also less than the current finding, including 22.2% at Aksum referral and general specialty hospital (Gebremeskel et al., 2020), 22.7% as a multicenter prospective observational study conducted in 5 Ethiopian hospitals (Muhe et al., 2019), 25.1% in Jimma University Medical Center (Toma et al., 2021), 25.5% in public west Guji and Borena zones' hospitals (Huka et al., 2023), 28.8% in University of Gondar comprehensive specialized hospital(Yismaw et al., 2019), and 29.7% in Tikur Anbesa Specialized Hospital (Aynalem et al., 2021). Variations in outcomes across studies conducted in Jordan and a multicenter study from India and Pakistan may be explained by differences in economic status, healthcare facilities, study settings, and service quality (Toma et al., 2021). Differences within studies from Ethiopia, Nigeria, Sierra Leone, and Uganda may further be indicative of differences in service quality between hospitals, with some offering more specialized services (Mihretu et al., 2024, Bereka et al., 2021). Additionally, the high sample size utilized in this study might have contributed to the observed higher mortality rate.

In this study, the overall incidence rate of preterm neonatal death was found to be 52.76 (95% CI: 46.01 to 60.50) per 1000 preterm neonate-days, with a median survival time of 18 days. This finding in line with previous research conducted in public hospitals within West Guji and Borena zones, which reported a preterm neonatal mortality of 47.7 (95% CI: 40.2–56.7) per 1000 neonatal days, and a median survival time of 18 days (Huka et al., 2023). This may be due to similarities in study populations, study designs, and the healthcare facilities across the regions.

The incidence rate of mortality found in this study was significantly higher than that reported in several comparable settings. It was greater than the incidence rate of 3.9 per 1,000 person-days reported in the Busoga region of Uganda (Opio et al., 2019). Additionally, it was greater than the incidence rate of 36.6 per 1,000 neonate-days mentioned in two specialized hospitals in the Tigray region, where the mean survival time was 18.7 days (Girma et al., 2023). Similarly, the findings of this study indicate a higher incidence of mortality compared to previous studies conducted in various parts of Ethiopia. For instance, the incidence of mortality was 39.1 per

1,000 person-days with a median survival time of 21 days at Tikur Anbesa Specialized Hospital (Aynalem et al., 2021), 26.08 per 1,000 person-days at Nigist Eleni Mohammed Memorial Hospital (Tirore et al., 2024), and 28.9 per 1,000 neonate-days at Jimma University Medical Center (Toma et al., 2021). This difference may be due to the differences in the health care quality, patient demographics, referral patterns, or availability of neonatal intensive care services at the various study sites.

Conversely, the incidence rate observed in this study was lower than that reported in studies conducted in Bench Sheko, Sheka and Keffa Zones, which recorded an incidence rate of 61.69 deaths per 1000 neonate-days with a mean survival time of 17.46 days (Mihretu et al., 2024) and in a study at Mizan Tepi University Teaching Hospital, which reported an incidence rate of 62.15 deaths per 1000 person-day observations with a median survival time of 15 days (Bereka et al., 2021). The lower discrepancy may be explained by variations in study setting, design, quality of care, and healthcare access among those hospitals and the current study hospitals.

This study also identified predictors of mortality among preterm neonates. Accordingly, preterm neonates born to mothers who had four or more ANC contacts had a 44% lower risk of death compared to those whose mothers had fewer than four ANC contacts (AHR: 0.56 (95% CI: 0.36 –0.89)). This finding is supported by studies conducted at the University Teaching Hospital of Butare in Rwanda, where a 78% reduction in mortality was observed (Habimana et al., 2023) and at Mbarara Regional Referral Hospital in South Western Uganda, which reported a 65% reduction risk of mortality in preterm neonates born to mothers with ≥ ANC contact (Tibaijuka et al., 2021). This might be because of the protective effect of adequate antenatal care, likely due to improved maternal health monitoring, early detection of complications, and timely interventions (WHO, 2016). Additionally, regular ANC visits enhance maternal awareness of danger signs and promote maternal and fetal health in reducing antenatal pregnancy complications, which were associated with preterm neonatal death (Kuhnt and Vollmer, 2017).

In this study, preterm neonates who had a fifth-minute APGAR score of <7 were 1.80 times more likely at hazard of die than those who had an APGAR score of ≥7 (AHR: 1.80 (95% CI: 1.22 - 2.66)). This finding is supported by other studies conducted in tertiary hospitals in Ghana (Agbeno et al., 2021) and Sierra Leone (Luke et al., 2024), multiple hospitals in China (Xu et al., 2019) and Iran (Basiri et al., 2015, Ghorbani et al., 2017). Similarly, studies in Ethiopian facilities, such as in Mizan Tepi University Teaching Hospital (Bereka et al., 2021) and Tikur

Anbessa Specialized Hospital in Addis Ababa, were aligned with current findings (Aynalem et al., 2021). This may be attributed to the fact that the 5-minute APGAR score assesses how well the newborn is adapting to the extrauterine environment. A low score at this stage suggests poor physiological adaptation, which increases the risk of neonatal mortality (FMHE, 2021). Moreover, neonates with a fifth-minute APGAR score below 7 often require intensive and specialized care. In settings where timely and advanced medical support from skilled professionals equipped with appropriate resources are lacking, these newborns are at a substantially increased risk of mortality compared to those with higher APGAR scores (Bereka et al., 2021).

From the current study, preterm neonates who had perinatal asphyxia (PNA) were 1.55 times more at risk of mortality compared to their counterparts (AHR: 1.55 (95% CI: 1.08 - 2.22)). This finding aligns with previous studies conducted in China (Xu et al., 2019, Yu et al., 2021), at Mbarara Regional Referral Hospital in Southwestern Uganda (AHR = 14.80, 95% CI: 5.21–42.02) (Tibaijuka et al., 2021) and in several hospitals across Ethiopia, including the University of Gondar Comprehensive Specialized Hospital (AHR = 1.55, 95% CI: 1.09–2.20) (Yismaw et al., 2019), and comprehensive specialized hospitals in the Tigray region (AHR: 2.13 (95% CI: 1.32 to 3.47)) (Girma et al., 2023). The possible explanation was that perinatal asphyxia remains a major cause of neonatal death in the country due to poor-quality and limited emergency obstetric and newborn care services. Perinatal asphyxia can also damage vital organs, disrupt gas exchange, and worsen organ immaturity in preterm neonates, increasing the risk of death. Additionally, it often leads to severe complications like hypoxic-ischemic encephalopathy and intraventricular hemorrhage, especially in preterm infants (FMHE, 2021).

In the current study, preterm neonates who were resuscitated with bag and mask at birth had 59% increased hazards of death as compared to those who were not resuscitated with bag and mask at birth (AHR: 1.59 (95% CI: 1.10 - 2.29)). This finding is supported by evidence from various studies conducted in public hospitals in southern Ethiopia reported that preterm neonates who required resuscitation at birth had a twofold increased risk of mortality (Huka et al., 2023). Similarly, a study from Kenya revealed that preterm neonates with a history of resuscitation were significantly more likely to die compared to their counterparts (Mwangi et al., 2022), and a study from a tertiary hospital in western Uganda found that resuscitated preterm infants had a 3.4 times higher risk of death (Egesa et al., 2020). The possible reason is that the need for resuscitation often indicates serious underlying conditions linked to poor neonatal outcomes, and in low-resource settings, inadequate resuscitation quality and limited post-care contribute to higher mortality in resuscitated preterm neonates. Moreover, resuscitation may act as a pathway for microbial entry, leading to infection, as preterm neonates generally have weak immune defenses and lead to neonatal sepsis, which is significantly associated with preterm neonatal mortality (Egesa et al., 2020, Weldearegay et al., 2020, Jabiri et al., 2016).

In this study, preterm neonates diagnosed with respiratory distress syndrome (RDS) had 1.75 times higher hazards of mortality when compared to those without RDS (AHR: 1.75 (95% CI: 1.22 - 2.51)). This is supported by studies conducted in southwestern and western Uganda, which reported preterm neonates diagnosed with RDS were 2.5 times and 2.6 times more likely to die, respectively (Tibaijuka et al., 2021, Egesa et al., 2020). Similarly, it is in line with studies done in other parts of Ethiopia, at Tikur Anbessa Specialized Hospital in Addis Ababa (Aynalem et al., 2021), at Felege Hiwot Comprehensive Specialized Hospital in Bahir Dar (Belay et al., 2022), at the University of Gondar Comprehensive Specialized Hospital, northwest Ethiopia (Yismaw et al., 2019), and at Mizan Tepi University Teaching Hospital, South West Ethiopia (Bereka et al., 2021). The reason is that the increased risk of mortality among preterm neonates with RDS can be due to the immaturity of the lungs, particularly due to insufficient production of pulmonary surfactant, a crucial substance that reduces surface tension and prevents alveolar collapse at the end of expiration (FMoHE, 2021, Wang et al., 2017).

Hazard of death among preterm neonates who were born in non-cephalic presentation had 1.7 times higher risk of mortality than their counterparts (AHR: 1.68 (95% CI: 1.12 - 2.53)). This is supported by previous studies conducted in different countries and settings. Similar results were reported in Uganda (Tibaijuka et al., 2021), in Iran, done at Shahid Akbar-Abadi University Hospital (Haghighi et al., 2013), in Ethiopia at Mizan Tepi University Teaching Hospital (Bereka et al., 2021), and in a multicenter study in five Ethiopian public hospitals (Hailemeskel et al., 2023). This could be due to the increased risk of trauma during delivery, asphyxia, and meconium aspiration syndrome among preterm neonates delivered in a non-cephalic presentation at an early gestational age, which may subsequently result in complications and death in preterm neonates (Bereka et al., 2021).

Furthermore, in this study, the preterm neonate who had neonatal sepsis had a 58% increased risk of mortality compared to those without neonatal sepsis (AHR: 1.58 (95% CI: 1.09 - 2.28)).

This is supported by findings from Tikur Anbessa Specialized Hospital, Addis Ababa, which reported that preterm neonates who developed neonatal sepsis had 1.62 times higher hazard of mortality as compared to their counterparts (Aynalem et al., 2021). And also, a study conducted in Jimma University Medical Center revealed that neonates who had neonatal sepsis were 1.71 times at risk of death, which is consistent with this study (Toma et al., 2021). This may be attributed to the increased susceptibility of preterm neonates to infections, as their immature immune systems, coupled with inadequate calorie intake, make them more vulnerable and potentially raise the risk of death (Collins et al., 2018).

Moreover, in the current study, preterm neonates who received kangaroo mother care had an 84% lower hazard of mortality compared to those who didn't receive kangaroo mother care (AHR: 0.16 (95% CI: 0.09 - 0.27)). This is similar to studies done in the south-western and Busoga regions of Uganda (Tibaijuka et al., 2021, Opio et al., 2019), in Jimma (Toma et al., 2021), in the Bench Sheko Zone, Sheka Zone, and Keffa Zone of Ethiopia (Mihretu et al., 2024), in Addis Ababa (Birhanu et al., 2022), in Gondar (Yismaw et al., 2019), and in the Tigray region (Girma et al., 2023). This might be because most preterm neonates in those studies did not receive Kangaroo Mother Care (KMC). KMC plays a vital role in protecting neonates from infections, effectively managing hypothermia, enhancing gastrointestinal function and cardiorespiratory stability, and promoting the initiation and continuation of breastfeeding (WHO, 2015).

6. STRENGTHS AND LIMITATIONS

Strength

This study showed survival status and indicated important predictors of mortality among preterm neonates, contributing to the evidence for early identification and management of preterm neonates with identified complications. Since this study involved time-to-event analysis, it allowed for the inclusion of censored study subjects in assessing their contributions. It was conducted in two major cities in eastern Ethiopia with a relatively large sample size.

Limitation

The limitation of this study is follow-up is only limited until discharge. Some events may occur after discharge. Due to the incomplete records, certain major predictors of preterm mortality, such as all maternal demographics, nutritional conditions, and institutional factors, were not addressed.

7. CONCLUSION AND RECOMMENDATION

7.1. Conclusion

The cumulative incidence of preterm neonatal mortality was found to be high in this study. The majority of preterm neonatal mortality occurred during the early neonatal period. Hypothermia, neonatal sepsis, and RDS were identified as the predominant morbidities contributing to these deaths. Being born to less than four ANC follow-up mothers, not receiving KMC, non-cephalic presentation, neonatal sepsis, respiratory distress syndrome, perinatal asphyxia, low APGAR score, and resuscitation with bag and mask at birth were identified as predictors of preterm neonatal mortality. Most of the identified maternal and neonatal predictors are both modifiable and preventable with the resources available in the health facility.

7.2. Recommendation

For Health Professionals:

- ✓ Encourage mothers to attend regular ANC visits and promote the implementation of KMC for preterm neonates as an effective, low-cost intervention to improve neonatal survival.
- ✓ Integrated maternal and neonatal care should be provided, with special attention given to preterm neonates with non-cephalic presentations, due to their increased risk of mortality.
- ✓ Provide timely resuscitation according to established protocols, and timely assess and support preterm neonates' adaptation to the extra-uterine environment using 5-minute APGAR scores.
- ✓ Prioritize improved thermal regulation, enhanced respiratory support, and strict infection control in neonatal care settings as significantly reduce preterm neonatal mortality.
- ✓ Health-care providers should emphasize the prevention, early detection, and management of identified predictors such as PNA, RDS, and neonatal sepsis.

For Public Hospital heads and the Regional Health Bureau

Public hospital leaders, along with the Harari Regional and Dire Dawa Health Bureaus, should ensure the availability of standardized neonatal resuscitation equipment and supplies for infection prevention and RDS management. Strengthen facility-based care through improved quality of ANC services and kangaroo mother care to enhance preterm newborn survival.

For researchers: A prospective study that includes maternal socio-demographics and economic, nutritional status, and institution-related factors is recommended.

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9. ANNEXS

9.1 Information Sheet and Informed Voluntary Consent Form for Heads of Public Hospitals

1. Introduction:

My name is **Boru Abera Ebsa**. I am the Principal Investigator of the study to be conducted in public hospitals of Harari Region and the Dire Dawa City Administration. I am studying for my Master's degree at Haramaya University, College of Health and Medical Sciences. I kindly request you to lend me your attention to explain to you about the study and your institution being selected as the study setting.

2. The study/project title:

Time to death and its predictors among preterm neonates admitted to the neonatal intensive care unit at public hospitals in the Harari region and Dire Dawa city administration, Eastern Ethiopia.

3. Purpose/aim of the study:

The findings of this study were of paramount importance for the hospital in planning targeted intervention programs aimed at reducing preterm neonatal mortality based on the identified predictors among preterm neonates admitted to the NICU, thereby improving overall neonatal health and enhancing fetal and neonatal outcomes. Furthermore, this study was conducted as part of the principal investigator's thesis, fulfilling a partial requirement for the completion of a Master's program in Maternity and Neonatal Nursing.

4. Procedure and duration:

Data were reviewed and extracted from selected medical cards and registration books of preterm neonates by trained data collectors using a structured checklist to gather pertinent information for the study. The checklist contained 52 variables used to extract data from the neonates' medical records and logbooks. The review of preterm neonates' medical cards covered the period from November 1, 2021, to October 30, 2024, and the medical chart review was conducted from January 1 to 31, 2025.

5. Risks and benefits:

The risk of participating in this study was very minimal. It was not possible to obtain informed consent from the neonates' families, as the authors had no direct contact with either the neonates or their families, given that data were collected from medical charts after the neonates had been discharged. Instead, informed consent was obtained from the hospital management. There was no direct payment made to the neonates' families for participating in the study; however, payment for each selected preterm neonate's medical card was made according to hospital regulations. The findings from this research were expected to provide important information for public hospital administration, the Harari Region Health Bureau, and the Dire Dawa City Administration Health Bureau.

6. Confidentiality:

The extracted information was kept confidential. No information that could identify a particular preterm neonate's medical card was recorded. The findings of the study were general to the study community and did not reflect anything specific about individual neonates. The checklist was coded to exclude names. No references were made in oral or written reports that could link participants to the research.

7. Rights:

Since it was impossible to obtain informed consent from the neonates' families, as the authors had no contact with either the neonates or their families because the data were collected from the neonates' medical charts after discharge, informed consent was instead obtained from the hospital management. The hospital administration also retained the right to stop the study if any misconduct or unethical procedures were observed during the data collection process on the hospital's premises.

8. Contact address:

If there are any questions or inquiries at any time about the study or the procedures, please contact:

Principal investigator (PI): BORU ABERA EBSA

E-mail: boru.abera20@gmail.com

Mobile phone number: +251926665875/+251915834364

Institutional Health Research Ethics Review Committee (IHRERC):

Office phone: 0254662011; P.O. Box 235, Harar, Ethiopia

9. Declaration of informed voluntary consent:

I have read the participant information sheet. I have clearly understood the purpose of the research, the procedures, the risks and benefits, issues of confidentiality, the rights to participate, and the contact address for any queries. I have been allowed to ask questions about things that may have been unclear. I was also informed that the hospital administration has the right to stop this study from being conducted if any misdeeds or unethical procedures are observed during the data collection process on the hospital's premises.

Therefore, I declare my voluntary consent on behalf of hospital management to allow this study to be conducted in the hospital with my initials (signature).

Name and Signature of Head of public hospital: ______________________Date ________

Name and Signature of the PI: ________________________________ Date ___________

N.B This is signed face to face in the presence of the principal investigator.

A copy of this signed consent is given to the responsible head.

9.2 Data Extraction Sheet

Checklist Code: ______________

Name of Data Collector _________________________Signature _______Date: ____/___/_____

Instruction: Incircle the response provided or write the appropriate answer in the space provided, and skip to the next question if not necessary to fill out the checklist.

Part I: Socio-demographic Related Factors

S.№	Characteristics	Coding and categories	Remark
101	Hospital	1. HFCSUH 2. JGH 3. DRH 4. SGH	
102	Maternal Age in Years	____________________	
103	Maternal residence	1. Urban 2. Rural	
104	Sex of neonates	1. Male 3. Female	

Part II: Obstetrics and Gynecological Related Factors

S.№	Characteristics	Coding and categories	Remark
201	Maternal had Antenatal care follow-up	1. Yes 2. No	
202	ANC follow up in numbers	___________________	If 'No' to number 201, skip to the next
203	Gravidity (no of pregnancy)	__________________	
204	Parity	1. Primipara 2. Multipara (2-4) 3. Grand multipara (≥ 5 births)	

205	Previous bad obstetrics history	1. Yes 2. No	
206	Type of pregnancy	1. Singleton 2. Twin 3. Triple	
207	Onset of labor	1. Elective caesarean section 2. Spontaneous 3. Induced	
208	Place of birth	1. Home delivery 2. Health center 3. Hospital	
209	Mode of delivery	1. Spontaneous vaginal delivery 2. Caesarean section 3. Instrument assisted delivery	
210	Duration of labor in hours	____________________	
211	Preeclampsia	1. Yes 2. No	
212	Eclampsia	1. Yes 2. No	
213	Had antepartum hemorrhage	1. Yes 2. No	
214	Had PROM	1. Yes 2. No	
215	Had polyhydramnios	1. Yes 2. No	
216	Had Chorioamnionitis	1. Yes	

		2. No	
217	Antenatal steroid use	1. Yes 2. No	

Part III: Maternal Medical Conditions

S.№	Characteristics	Coding and categories	Remark
301	Diabetic Mellitus	1. Yes 2. No	
302	Mothers had anemia	1. Yes 2. No	
303	Mother's HIV status	1. Negative 2. Positive	
304	Maternal hypertension	1. Yes 2. No	

Part IV: Neonatal Related Factors

S.№	Characteristics	Coding and categories	Remark
501	Gestational age in weeks	1. Very preterm (28 to < 32 weeks of GA) 2. Moderate preterm (32 to <34 completed weeks of GA) 3. Late preterm (34 to <37 completed weeks of GA)	
502	Weight of neonate (gm)	____________________	
503	Weight for gestational age at birth	1. Appropriate 2. Small 3. Large	
504	APGAR score at 1st minute	____________________	
505	Fifth minute APGAR score	____________________	

506	Bag and mask resuscitation at birth	1. Yes 2. No	
507	Newborns temperature within 1 h of admission (with one decimal place)	______________________	
508	Peri-natal asphyxia diagnosed at birth (PNA)	1. Yes 2. No	
509	Newborn diagnosed with respiratory distress syndrome (RDS)	1. Yes 2. No	
510	Hypothermia diagnosed at admission	1. Yes 2. No	
511	Hypoglycemia diagnosed at admission	1. Yes 2. No	
512	Jaundice	1. Yes 2. No	
513	Newborn diagnosed with sepsis	1. Yes 2. No	
514	Congenital anomalies	1. Yes 2. No	
515	Had anemia	1. Yes 2. No	
516	Type of presentation	1. Cephalic 2. Non-cephalic	
517	If the question 516 is cephalic what type of cephalic presentation	1. Vertex 2. Non-vertex	Skip, If the answer of Q516 is non-cephalic
518	Neonates diagnosed with Necrotizing enterocolitis	1. Yes 2. No	

519	Newborn received kangaroo mother care	1. Yes 2. No	
520	Neonate received continuous positive airway pressure (nCPAP)	1. Yes 2. No	
521	Neonate received photo therapy	1. Yes 2. No	
522	Newborn heated with a radiant warmer	1. Yes 2. No	

Part V: Preterm Neonatal Status

S.№	Characteristics	Coding and categories	Remark
401	Delivery date	____/_____/_______(DD/MM/YY)	
402	Admission date and time	____/_____/_______(DD/MM/YY)	
403	Discharge date and time	____/_____/______(DD/MM/YY)	
404	Neonatal status at discharge	1. Died 2. Loss to follow up (discharged against medical advice) 3. Transferred out 4. Recovered/discharged	
405	Length of stay (LOS) in days	____________________	

Thank You!!

9.3 Curriculum Vitae (CV)

I. Personal Information

Name Boru Abera Ebsa
Sex Male
Date of birth June 5, 1988 E.C
Place of birth Meki Town, Dugda Woreda, East Showa Zone, Oromia
Nationality Ethiopian
Email: borua.abera20@gmail.com Mobile: 0926665875/0915834364

II. Educational background

Level	Name of School	Place	Year in E.C	Certificate
Post graduate program (candidate)	Haramaya University, CHMS	Harar City	2015- present	MSc degree (Candidate)
Undergraduate	Haramaya University	Harar City	2009-2013	BSc Degree
Preparatory school	Oda Bokota Preparatory School	Meki town, East Showa	2007-2008	Certificate
High school	Oda Bokota Secondary School	Meki town, East Showa	2004-2005	Certificate
Elementary school	Gemo Delagela Elementary School	Tuchi Sumeyan, East Showa	1996-2003	Certificate

III. Higher Education Details/Qualifications

Undergraduate attended institution: Haramaya University, College of Health and Medical Science in Midwifery (BSc Degree).

Year of Graduation: March 4, 2013 E.C / March 13, 2021 G.C.

IV. Postgraduate details

Following MSc in **Maternity and Neonatal Nursing** at Haramaya University College of Health and Medical Science.

V. Work Experience

I served as an **Assistant lecturer** at Haramaya University College of Health and Medical Science since April 2, 2014 E.C.

VI. Language skill

Excellent in speaking, writing, listening and reading of Afan Oromo (mother tongue), Amharic and English language.

VII. Computer skill

Basic computer application skill (Microsoft office in detail)

Database management softwares like EpiData, Epi-info, SPSS, Stata software and Endnote

VIII: Voluntary Work and Training

- ✓ 10/11/2011-30/12/2011 E.C Summer voluntary work in education
- ✓ 5/11/2012-25/12/2012 E.C Summer voluntary work in education
- ✓ Training on employability skills and entrepreneurship as career option 2013 E.C
- ✓ Train on basic level public health emergency management 2013 E.C.
- ✓ Train on oral skill presentation in 2012 E.C.

IX. Behavior: I am ethical, sociable, respectful, hardworking, and have the ability to work with others.

X. Interest: I will be interested in working and acquiring knowledge in my career, especially by engaging in teaching, problem-solving scientific research, and serving the community.

XI. Hobbies: Reading books, browsing internet**,** public service and volunteer work, and discussing social issue

Reference

1. Mr. Dawit Tamiru (BSc, MSc, Assistant professor): Head of School of Midwifery, Haramaya University, College of Health and Medical Science

   Phone no: +251913666045.

   E-Mail: dawittamru5@gmail.com
2. Adera Debela (BSc, MSc, Assistant professor) a lecturer at Haramaya University in the midwifery department

   Phone: +251913745011

   Email: aksanadera62@gmail.com
3. Mr. Mohammed Abdurke (BSc, MSc, Assistant Professor) a lecturer at Haramaya University, College of Health and Medical Science

   Phone: +251919231736

   Email: mameelemo@gmail.com

Declaration:

I hereby declare that all the information mentioned above is true to my knowledge, and I bear the responsibility for the above-mentioned particulars.