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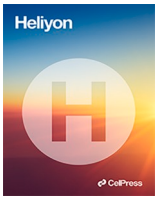

Research article

Predictors of neonatal mortality among neonates admitted to NICU at Dubti General hospital, Northeast Ethiopia

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ABSTRACT

Background: In Ethiopia, despite various strategies and interventions being implemented, the rate of neonatal mortality remains high. Despite numerous published articles in Ethiopia, there is a lack of sufficient data regarding the time to death and its predictors in neonatal mortality, especially in pastoral communities like the Afar region. Therefore, this study aims to evaluate neonatal mortality and its predictors among neonates admitted to the neonatal intensive care unit at Dubti General Hospital, Northeast Ethiopia.

Method: We conducted a facility-based retrospective follow-up study, involving a sample of 479 neonates admitted to the neonatal intensive care unit at Dubti General Hospital. Data entry was performed using Epi-Data version 4.6, and subsequent analysis was carried out using STATA version 14.1. To identify predictors of neonatal mortality, we applied the Cox-proportional hazard model.

Results: Out of the total, 87 neonates (18.16 %) passed away. The overall incidence of neonatal mortality was 27.2 deaths per 1000 neonate-days spent in the neonatal intensive care unit, with a 95 % confidence interval of [21.8, 34.2]. Appearance, pulse, grimace, activity, and respiration score less than or equal to 5 [AHR = 0.33, 95%CI: 0.07, 0.62], respiratory distress syndrome [AHR = 3.22, 95%CI: 1.71, 6.07], Neonatal hypothermia [AHR = 3.12, 95%CI: 1.31, 7.42]. No initiation of breastfeeding [AHR = 3.68, 95%CI: 1.44, 9.36], no antenatal care visits [AHR = 0.25, 95%CI: 0.13, 0.48] and maternal birth related complication [AHR = 2.71, 95%CI: 2.43, 11.14] are predictors.

Conclusion: The mortality rate was notably high, with several factors identified as independent predictors of newborn death, including Appearance, pulse, grimace, activity, and respiration, respiratory distress syndrome, hypothermia, initiation of breastfeeding, antenatal care visits, and maternal birth-related complications. There is a pressing need for intensified programming efforts aimed at improving child survival within healthcare facilities, particularly addressing neonatal complications. Enhancing prenatal care during pregnancy and early detection and treatment of intrapartum disorders are recommended strategies for enhancing newborn health outcomes.

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1. Introduction

Neonatal mortality poses a significant public health challenge, accounting for 44 % of under-five mortalities worldwide. Over 99 % of neonatal deaths occur in middle and low-income countries, with Sub-Saharan African nations being particularly affected [1]. It strongly indicates one country's socioeconomic and health system status [2]. Despite a global decrease in neonatal mortality rates, substantial disparities persist among regions and nations. Annually, the African region experiences 1.12 million newborn deaths [3].

In Ethiopia, the neonatal mortality rate between 2014 and 2018 stood at 33 deaths per 1000 live births, indicating that approximately 1 in every 30 children dies within the first month of life. This rate showed a decline from 39 deaths per 1000 live births in 2005 to 29 deaths per 1000 live births in 2016, before rising again to 33 deaths per 1000 live births in 2019 [4].

Regionally, the under-5 mortality rate is at its highest in Afar, with 125 deaths per 1000 live births, and lowest in Addis Ababa, with 39 deaths per 1000 live births. Concerningly, there has been no progress in reducing early childhood deaths over the past decade. While national rates of early childhood mortality are decreasing, the rates are on the rise in the Afar region. However, the neonatal mortality rate in Afar slightly falls below the national average, standing at 38 deaths per 1000 births [5]. Common factors contributing to neonatal death in Ethiopia include sepsis, birth asphyxia, birth injury, prenatal respiratory disorders, preterm birth, and congenital anomalies [6].

The Ethiopian government has implemented significant interventions as part of a national strategy for newborn and child survival, spanning from 2015/16 to 2019/20. The most effective measures included institutional delivery, oral rehydration solutions (ORS), pneumonia case management, breastfeeding, and severe newborn infection case management. The implementation of this revised package of high-impact interventions aimed to reduce under-five mortality to 29 deaths per 1000 live births by 2020 [7]. Efforts are ongoing to further reduce neonatal mortality through the expansion of facilities and healthcare provider coverage, aiming to increase the presence of skilled birth attendants, utilization of family planning services, antenatal care attendance, and postnatal care utilization. However, Ethiopia continues to face high rates of neonatal and under-five mortality, particularly in the Afar region [8].

Despite the implementation of various strategies and interventions to mitigate neonatal mortality, the current rate remains far from target levels [9]. At 33 deaths per 1000 live births, neonatal mortality contributes significantly to under-five mortality rates, accounting for 44 % [10]. While there has been a gradual decline in Sub-Saharan Africa and more notably in Ethiopia, the reduction remains stagnant in the Afar region. Here, seasonal mobility and geographical displacement play a significant role as communities search for water and pasture for their livestock. This lifestyle impacts the uptake of reproductive healthcare services, particularly neonatal healthcare services [11].

Most studies have been conducted in non-pastoral communities within the country, and their findings are not sufficiently representative of the Afar community. Additionally, there has been no study to explore neonatal mortality and its predictors in the neonatal intensive care unit (NICU) of the study area using survival analysis. Therefore, this study aims to assess the time to death and its predictors among neonates admitted to the NICU at Dubti General Hospital in the Afar region of Northeast Ethiopia.

2. Methods and material

2.1. Study design, period, and area

A facility-based retrospective follow-up study was conducted in the Afar regional state, situated in the northeastern part of Ethiopia, from March 30 to June 2022. The population of this region consists primarily of pastoralists or agro-pastoralists, who heavily rely on their livestock for sustenance. Over the years, there has been a notable decline in financial poverty in Afar, with a decrease of 32 % observed between 2000 and 2016. The poverty rate has seen a significant reduction in recent times. In 2015–2016, the headcount poverty rate stood at 24 %, aligning closely with the national average. However, food poverty, though not experiencing as substantial a decrease, remains at 28 %, marking it as the third-highest rate among all regions [11].

Administratively the region is divided into five zones, thirty-six woredas, and five city administrations [12]. This study was conducted at Dubti woreda, which is part of Administrative Zone 1. According to the 2007 national census conducted by the Central Statistical Agency of Ethiopia (CSA), the total population of the area is 65,342, comprising 34,893 men and 30,449 women. Of this population, 32,940 individuals, or 50.41 %, reside in urban areas. The study area is situated at Dubti General Hospital, which is located 12 km away from Samara. The hospital caters to approximately 994,449 people and is equipped with various departments to enhance service delivery. These departments include the medical ward, pediatric ward, surgical ward, and gynecology ward. The hospital offers a range of maternal and child health-related services, such as delivery services and antenatal care (ANC), as well as postnatal care services, family planning, and other related services. Additionally, the hospital provides inpatient pediatric care and treatment, including a neonatal intensive care unit (NICU) capable of admitting and providing care for an average of 26 neonates per month. The NICU has a capacity to admit 8 neonates at a time and is equipped with 8 beds.

2.2. Population

All neonates admitted to the NICU of Dubti General Hospital between January 1, 2019, and December 31, 2021, were eligible for inclusion in the study. Neonates with incomplete records on their patient cards and the NICU logbook were excluded from the analysis.

2.3. Sample size determination and sampling procedure

The sample size for the first objective was calculated using Epi Info version 7. The following assumptions were considered to calculate the sample size for survival (mortality) estimation: an expected neonatal death rate of 2.7 % at the NICU (23), a margin of error of 1.5 %, power of 80 %, and confidence level of 95 %, then, a sample size of 448 was obtained for the first objective.

For the second objective, the Cox proportional hazard model technique was used, considering the existence of censoring, and adjusting for additional factors. Mortality was regarded as a failure (outcome), and the causes are characteristics derived from various literature that have a substantial correlation with neonatal mortality in the NICU. ANC, APGAR 1st minute, and; preterm and duration of stay (28), birth weight (29), number of gestation, and neonatal resuscitation (23).

After computing several factors, the sample size was calculated considering Gestation (multiple) as exposed which gives 479 which is the highest number of samples from all sample sizes calculated using several factors.

So, the minimum largest sample size was 479 for the second objective. Finally, from the sample sizes estimated for both specific objectives, the minimum largest sample size was 479, which is the final sample size of this study.

The total number of patients admitted to NICU from January 1, 2019, to December 31, 2021, was 1005. The first medical record numbers (MRN) of the neonates were obtained from the NICU logbook. Then, based on the medical record number, the medical cards of the neonates were retrieved from the card room by card room workers. The study units were selected using a systematic sampling method.

2.4. Study variables

Dependent variable: Time to death of neonates (measured in age in days less than 28 days)

Independent variables: Socio-demographic factors (age of neonates at admission, sex of neonates, maternal age, place of delivery, place of residency)**,** Neonatal factors (APGAR score, prematurity, delayed initiation of EBF, had resuscitation, RDS, hypothermia, neonatal sepsis), Maternal factors (ANC follow up, parity, mode of delivery, duration of labor, twin pregnancy, birth-related complication)

2.5. Operational definition

Death: any death during the neonatal period that occurred at NICU since the admission date.

Censoring: Neonates who were alive at the end of follow-up (December 31, 2021) or lost-to-follow-up (transferred out, self-withdraw from the care)

Incomplete card: when 10 % of the variables or outcome status is not registered in the abstraction form will be considered incomplete.

Transferred out: Neonates who are transferred to another facility and the date of transfer is recorded.

Alive: neonates who were still alive during discharge will be assessed as alive.

Survival time: Follow-up time in the day, from the date of admission at NICU to the date of death or censoring.

Preterm birth (PTB): Babies born alive before 37 weeks of pregnancy or fewer than 259 days since the first day of a woman's last menstrual period [13].

Kangaroo mother care (KMC): as early, continuous, and prolonged skin–to–skin contact (SSC) between the mother and preterm babies; exclusive breastfeeding or breast milk feeding; early discharge after hospital–initiated KMC with continuation at home; and adequate support and follow–up for mothers at home [14].

Low birth weight (LBW): birth weight $<$2500 gm.

2.6. Data collection procedure and quality assurance

Secondary sources were used to gather data, and data was collected using an abstraction checklist prepared in English and Afar language after examining the national NICU logbook format and other publications [15–18]. The data collection checklist has three parts, the first part contains socio-demographic characteristics of the mothers, the second section includes maternal and obstetric characteristics that incorporate all the important variables important to the study, and the third part consists of neonatal status and other characteristics of neonates admitted to the NICU.

The data collectors received one day of training on the study's objectives and ethical considerations. Prior to the actual research, a pre-test was conducted to validate the checklist's reliability beyond the study area. Throughout the data collection period, the primary investigator provided daily supervision. At the end of each day, the completeness of information across all variables in the data collection form was verified to ensure accuracy. Incomplete data from chart records were excluded from the sample, and incomplete checklists were removed from the dataset after being cleaned, coded, and entered a computer.

2.7. Data management and statistical analysis

Data entry was performed using Epi-Data version 4.6, with consistency checks conducted during the process. Entry errors, missing values, and outliers were manually verified by cross-referencing with the checklist. Subsequent analysis was carried out using STATA version 14.1. Descriptive statistics, including median, interquartile range (IQR), mean, and standard deviation (SD), were employed to

summarize the characteristics of the cohort. Survival probability following admission to the NICU was determined using the Kaplan-Meier (KM) method, and log-rank tests were used to compare survival curves among variables with categories. The incidence of death relative to person-days at risk was calculated. The Cox-proportional hazard model was applied after confirming the assumption of proportionality of hazards to assess the relationship between predictors and mortality. The hazard ratio was used to quantify the strength of this relationship. Both bivariable and multivariable Cox regression analyses were conducted to estimate the unadjusted hazard ratio and adjusted hazard ratio (AHRs), respectively.

3. Result

3.1. Socio-demographic characteristics of study participants

The study involved 479 newborns observed over a three-year period at Dubti General Hospital. The median length of stay in the NICU was five days (interquartile range [IQR] = 3–7). Males accounted for over half of the neonates (56.4 %). More than half (52.6 %) of the parents resided in urban areas. Most of the neonates (69.6 %) were admitted to the hospital within 24 h of delivery. Additionally, the majority (77.6 %) of the neonatal mothers were aged between 20 and 34, with a median age of 27 years (IQR = 24–31) (Table 1).

3.2. Neonatal factors

Among the total participants, 166 neonates (39.6 %) were born with low birth weight, and more than half (54.1 %) were preterm, with nearly one-third (30.1 %) being premature babies. Half of the neonates (51.8 %) had sepsis, 25.3 % experienced birth asphyxia, 45.4 % suffered from hypothermia, 23.5 % were diagnosed with RDS, 32.8 % experienced hypoglycemia, 10.6 % had congenital malformations, 16.9 % had pathologic jaundice, 35.6 % had a 1st minute APGAR score less than 5, and 16.0 % had a 5th minute APGAR score less than 5 (Table 2).

3.3. Care and treatment-related factors

Approximately one-fourth (23.75 %) of the neonates underwent resuscitation, while 32.3 % received kangaroo mother care. The vast majority (90.1 %) were treated with antibiotics, and 10.9 % were administered anticonvulsants. One-fourth (26.1 %) were placed inside an incubator, and 26.2 % never initiated breastfeeding (Table 3).

3.4. Maternal obstetric characteristics

Most of the neonates' mothers (68.2 %) had undergone at least one ANC follow-up, and the majority (58.2 %) were multiparous. Concerning the number of gestations, 14.3 % were twin pregnancies. Additionally, 63.5 % of the mothers experienced spontaneous vaginal births, while 87.5 % delivered their neonates in healthcare institutions. In terms of intrapartum complications, 45.8 % of the neonates were affected, and one-fifth (21.6 %) experienced prolonged labor duration (Table 4).

3.5. Neonatal mortality and survival estimates

The 479 observed neonates contributed to a total of 2973 neonate days of observations. Among them, eighty-seven (18.16 %) died, with a 95 % CI of [14.81, 21.91]. The overall incidence of neonatal mortality was 27.2 deaths per 1000 neonate-days of NICU stay, with a 95 % confidence interval of [21.8, 34.2]. The median survival time in the NICU was 27 days, with cumulative proportions of survival at the end of the 1st, 7th, and 28th days of NICU stay being 98.7 %, 80.5 %, and 32.5 % respectively.

Table 1
Socio-demographic characteristics of neonates and mothers of neonates admitted to NICU of Dubti General Hospital, Afar region, Northeast Ethiopia.

Variables	Number	Percentage (%)
Sex of the neonates		
Female	209	43.6
Male	270	56.4
Residency		
Urban	252	52.6
Rural	227	47.4
Age of neonates at admission		
≤ 1 days	332	69.6
2–4 days	73	15.3
≥5 days	72	15.1
Maternal age (years)		
under 20	45	9.4
20-34	371	77.6
35 and above	62	13.0

Table 2
Perinatal characteristics of neonates admitted to NICU of Dubti General Hospital, Afar region, Northeast Ethiopia.

Variables	Number	Percentage (%)
Low birth weight (LBW)		
No	253	60.4
Yes	166	39.6
Gestational age (GA)		
Under 37	259	54.1
37 and above	220	45.9
Prematurity		
No	335	69.9
Yes	144	30.1
Sepsis		
No	231	48.2
Yes	248	51.8
Birth asphyxia		
No	313	74.7
Yes	106	25.3
Birth trauma		
No	441	92.6
Yes	35	7.4
Hypothermia		
No	261	54.6
Yes	217	45.4
RDS		
No	365	76.5
Yes	112	23.5
Hypoglycemia		
No	321	67.2
Yes	157	32.8
Congenital malformation		
No	428	89.4
Yes	51	10.6
Macrocephaly		
No	464	97.1
Yes	14	2.9
Pathologic jaundice		
No	397	83.1
Yes	81	16.9
APGAR score 1st		
≤5	149	35.6
>5	270	64.4
APGAR score 5th minute		
≤5	67	16.0
>5	352	84.0

3.6. Multivariable Cox regression model for predictors of neonatal mortality

According to the final multivariable Cox regression model, newborns with a 5th minute APGAR score greater than 5 exhibited a 57 % lower hazard of death compared to those with APGAR scores less than or equal to 5 (AHR = 0.33, 95 % CI: 0.07, 0.62]. Additionally, the presence of RDS emerged as a significant predictor of neonatal death in the NICU. Neonates diagnosed with RDS faced a 3.2 times higher risk of death compared to those without RDS [AHR = 3.22, 95 % CI: 1.71, 6.07]. Furthermore, neonatal hypothermia emerged as another significant predictor of newborn death, with neonates affected by hypothermia facing triple the risk of death compared to their counterparts [AHR = 3.12, 95 % CI: 1.31, 7.42].

The absence of breastfeeding initiation was associated with a 3.67 times greater hazard of death compared to early initiation within 1 h after birth [AHR = 3.67, 95 % CI: 1.44, 9.36]. Additionally, pregnant women who had at least one ANC follow-up experienced a reduced risk of neonatal mortality. Thus, newborns born to mothers who had at least one ANC follow-up had a 75 % lower risk of death compared to those whose mothers had no ANC follow-up [AHR = 0.25, 95 % CI: 0.13, 0.48]. Furthermore, maternal birth-related complications were associated with a 2.71 times higher hazard of neonatal mortality compared to their absence [AHR = 2.71, 95 % CI: 2.43, 11.14] (Table 5).

4. Discussion

This study aimed to investigate neonatal mortality and its predictors among neonates admitted to the NICU of Dubti General Hospital, Northeast Ethiopia. The incidence of neonatal mortality in this study was 27 deaths per 1000 neonate-days of NICU hospitalization, with a proportion of death at 18.16 %.

Table 3
Care and treatment are given to the neonates, at Dubti General Hospital, Afar region, Northeast Ethiopia.

Variables	Frequency	Percentage (%)
Resuscitations		
No	360	76.3
Yes	112	23.7
KMC		
No	320	67.7
Yes	153	32.3
Treated by Antibiotics		
No	45	9.4
Yes	434	90.6
Treated by Anticonvulsant		
No	427	89.1
Yes	52	10.9
Incubator		
No	354	73.9
Yes	125	26.1
Breastfeeding initiation		
Within 1 h	160	33.5
After 1 h	193	40.4
Not initiated	125	26.2

Table 4
Maternal obstetric characteristics of neonates admitted to Dubti General Hospital, Afar region, Northeast Ethiopia.

Variables	Number	Percentage
ANC		
No	152	31.8
Yes	326	68.2
Parity		
Primiparous	200	41.8
Multiparous	278	58.2
Twin pregnancy		
No	408	85.7
Yes	68	14.3
Mode of delivery (n = 1104)		
Caesarian section	122	25.5
Spontaneous vaginal	304	63.5
Instrumental assisted	53	11.1
Place of delivery (n = 1104)		
Home	60	12.5
Health institution	419	87.5
Intrapartum maternal complication (n = 1104)		
No	259	54.2
Yes	219	45.8
Duration of Labour (n = 1094)		
No (≤14hr for prim/≤20hr multipara)	373	78.4
Yes (>14hr for prim/>20hr for multipara)	103	21.6

A study conducted in northwest Ethiopia unveiled an overall newborn mortality rate of 25.8 fatalities per 1000 neonate days, aligning with the findings of the current study [19]. Similarly, research conducted at Wolaita Sodo Referral Hospital in southern Ethiopia reported a newborn death incidence of 27 per 1000 neonate-days observed [20]. However, several previous studies did not report the neonate-days mortality rate [18,21–23].

In our study, the mortality rate among hospitalized neonates over a period of 3 years was 18.16 % [95 % CI: 14.81 %, 21.91 %], which closely resembled recent research conducted at Arbaminch Hospital in southern Ethiopia, where 20.8 % of the population experienced mortality [21]. This rate was lower than the mortality rate documented in research conducted in Addis Ababa, Ethiopia, where 23.3 % of deaths were reported (34). However, the findings of the present study were notably higher than those of several prior studies conducted in Ethiopia and other countries. For instance, Sabzevar Hospital in Iran recorded a 10.6 % death rate (35), while research conducted in Kenya reported a rate of 9.2 % (36), Additionally, Nekemte Hospital in East Wollega reported rates of 5.7 %, 13.3 %, and 14.3 % (32), respectively, and Felege Hiwot Referral Hospital [24] and Gondar Hospital in northern Ethiopia [23] reported similar findings. This variation may be attributed to contextual factors; hospitals with an adequate number of skilled medical staff may exhibit higher neonatal survival rates. High neonatal mortality rates are often associated with limited access to competent pregnancy and newborn health services [25].

After adjusting for other covariates, the present study revealed that 5th-minute APGAR scores were independently associated with

Table 5
Bivariable and Multivariable Cox-proportional hazard regression for predictors of neonatal mortality among neonates admitted to NICU of Dubti General Hospital, Afar region, Northeast Ethiopia.

Variable	Survival status		CHR [95 % CI]	AHR [95 % CI]
	Censored	Died		
Age at admission				
≤1	259	73	1	1
4	64	9	0.59[0.29 1.20]	0.96[0.26 3.63]
≥5	68	4	0.25[0.09 0.69]	0.38[0.07 2.01]
APGAR score				
≤5	36	31	1	1
>5	306	46	0.27[0.16 0.43]	0.33[0.07 0.62] *
LBW				
No	221	32	1	1
Yes	121	45	2.068[1.28 3.35]	0.77[0.22 2.73]
RDS				
No	338	27	1	1
Yes	52	60	7.67[4.80 12.25]	3.22 [1.71 6.07] *
Prematurity				
No	294	41	1	1
Yes	98	46	2.58[1.66 4.02]	1.171[0.31 4.47]
Birth Asphyxia				
No	268	45	1	1
Yes	74	32	2.34[1.49 3.69]	0.73[0.27 1.95]
Hypoglycemia				
No	256	65	1	11
Yes	135	22	0.70[0.42 1.17]	1.57[0.73 3.39]
Hypothermia				
No	248	13	1	
Yes	143	74	6.24[3.45 11.29]	3.12[1.31 7.42] *
Pathologic jaundice				
No	337	60	1	1
Yes	54	27	2.58[1.62 4.11]	1.18[0.62 2.21]
Resuscitation				
No	310	50	1	1
Yes	77	35	2.27[1.44 3.58]	0.65[0.27 1.57]
Anticonvulsant				
No	365	62	1	1
Yes	27	25	3.21[1.95 5.27]	1.64[0.73 3.66]
KMC				
No	254	66	1	1
Yes	133	20	0.49[0.29 0.82]	0.65[0.32 1.31]
Incubator				
No	310	44	1	1
Yes	82	43	2.55[1.64 3.96]	0.79[0.30 2.08]
Breastfeeding				
Within 1 h	151	9	1	1
After 1 h	173	20	1.60[0.73 3.55]	1.71[0.62 4.71]
Not initiated	67	58	7.86[3.87 15.97	3.67[1.44 9.36] *
ANC				
No	81	71	1	1
1 and above	310	16	0.09[0.05 0.17]	0.25[0.13 0.48] *
Twin pregnancy				
No	339	69	1	1
Yes	50	18	1.49[0.88 2.56]	1.41[0.74 2.69]
Mode of delivery				
Caesarean Section(C/S)	108	14	1	1
Spontaneous Vertex Delivery (SVD)	241	63	2.18[1.14 4.15]	1.73[0.72 4.16]
Instrumental	43	10	1.94[0.80 4.69]	1.69[0.57 5.09]
Birth related complication				
No	249	10	1	1
Yes	142	77	9.83[4.91 19.66]	2.71[2.43 11.14] *

Note: *p < 0.05, AHR-Adjusted hazard ratio, ANC-Antenatal Care, CI-confidence interval, CI- Confidence interval, C/S-Caesarean Section, SVD-Spontaneous Vertex Delivery, KMC- Kangaroo mother care, RDS-respiratory distress syndrome, LBW-Low birth weight, APGAR-Appearance, Pulse, Grimace, Activity, and Respiration.

newborn death. Consistent findings were reported in similar research conducted in Ethiopia [26] and Ghana [22], where a 5th-minute APGAR score of 0–3 was identified as a significant predictor of newborn mortality. This association may be attributed to the APGAR score's evaluation of the neonate's overall respiratory effort and adaptation to the environment shortly after birth. Consequently, a newborn with a low APGAR score exhibits poor responses to the transition from fetal to extra-uterine life and faces an increased risk of

mortality [27].

Moreover, the present study identified that neonates diagnosed with respiratory distress syndrome (RDS) face a threefold increased risk of mortality. Similar findings have been reported in other studies, albeit with varying degrees of association. For instance, research conducted in northern Ethiopia highlighted a greater risk of mortality among newborns with RDS [23], while another study in western Ethiopia reported a similar trend [15]. Additionally, studies conducted in other African countries [22,28], and Mexico [29] have also documented elevated mortality risks among neonates with RDS. However, the risk of mortality observed in the current study exceeds that reported in Mexico. Issues related to the respiratory system necessitate prompt attention, and a lack of timely intervention and expertise may contribute to neonatal mortality. This could be attributed to deficiencies in infrastructure, accessibility, and the availability of quality care within close proximity to communities, as well as insufficient human resources [30–32].

This study revealed that neonates born to mothers without any history of ANC follow-up during the index neonate's pregnancy faced a higher risk of mortality compared to neonates born to mothers with ANC history. Similarly, a retrospective cohort study conducted in Southern Ethiopia found that neonates delivered to mothers who did not attend ANC visits during pregnancy were six times more likely to die than those born to mothers who did attend ANC visits [20]. Consistent findings have been reported in several studies conducted in Ethiopia and other Sub-Saharan African nations [16,24,33], highlighting the crucial role of ANC as a predictor of neonatal death. This may be attributed to the fact that during ANC follow-up, potential pregnancy risks are identified, and appropriate precautions are recommended. Therefore, these findings underscore the importance of ANC screening and follow-up care, emphasizing the need for special attention in maternal healthcare programs.

The present study identified birth-related complications as a significant predictor of neonatal mortality. Specifically, the risk of mortality was found to be nearly three times higher in neonates delivered to mothers with intrapartum problems compared to those born to mothers without any intrapartum issues. This finding aligns with previous research conducted in Ethiopia, which also indicated a link between prolonged rupture of membranes and an elevated risk of mortality, as observed in a study conducted in southern Ethiopia [21]. Based on Cameron's study report, the risk for a neonate delivered to a woman who experienced an intrapartum problem was 1.8 times higher [34]. This could be attributed to the interconnectedness of a woman's health with that of her pregnancy, with birth-related issues exerting a significant impact on the health and survival of the neonate [27].

5. Conclusion

The current study has revealed a significant newborn mortality rate within the NICU, highlighting the urgent need for enhanced efforts to improve newborn survival, reduce neonatal mortality, and prevent unnecessary child deaths. Independent predictors of newborn death identified in the study include APGAR scores, RDS, hypothermia, initiation of breastfeeding, ANC follow-up, and maternal birth-related complications.

Specifically, neonatal patients with low APGAR scores, hypothermia, and RDS require targeted care to improve outcomes. Strengthening health extension programs alongside concurrent health promotion initiatives such as media campaigns and community mobilization should be prioritized to enhance mothers' health-seeking behaviors. Additionally, interventions aimed at preventing early neonatal death in the research area should focus on improving maternal health conditions both before birth, through increased ANC visits, and post-delivery, by promoting early breastfeeding initiation.

As a limitation of the study, utilization of secondary sources may have resulted in the exclusion of important predictors that were not considered in the study, such as the mother's income, birth interval, family-related problems, educational attainment, and nutritional status. Furthermore, the exclusion of incomplete charts from the study may introduce selection bias.

Ethical consideration

An ethical clearance letter (CMHS/0312/2022) was obtained from Samara University College of Medical and Health Sciences, Research and Ethical Review Committee (RERC). As the study was conducted through a review of records, no consent was required from the mothers or caregivers of the study subjects. To keep confidentiality all collected data were coded and locked in a separate room before inserting into the computer and names were not included in the data collection format. After inserting to the computer, the data was locked by password, and the data was not disclosed to any person other than the principal investigator.

Data availability statement

Data will be made available on reasonable request to the corresponding author.

CRediT authorship contribution statement

Wongel Zekarias: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization. **Mubarek Shemsu:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis. **Ahmed Abduletif Abdulkadr:** Writing – review & editing, Software, Methodology, Formal analysis. **Setognal Birara Aychiluhm:** Writing – review & editing, Writing – original draft, Software, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Acronyms and abbreviations

AHR	Adjusted hazard ratio
AHR	Adjusted hazard ratio
APGAR	Appearance, Pulse, Grimace, Activity, and Respiration
ANC	Antenatal Care
CI	Confidence interval,
CPAP	Continuous positive airway pressure
CSA	Central statistical agency
ECG	Electrocardiography
EMDHS	Ethiopia Mini Demographic and Health Survey
HEW	health extension workers
IQR	Interquartile range
KMC	Kangaroo mother care
LBW	Low birth weight
MDGs	Millennium developmental goals
NICU	Neonatal intensive care unit
NMR	Neonatal mortality rate
ORS	Oral rehydration solution
RDS	Respiratory distress syndrome
SDGs	Sustainable developmental goals
SSA	Sub-Saharan Africa

SVDSpontaneous Vertex Delivery.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e32924.

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