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Research article

Determinants of neonatal mortality in the neonatal intensive care unit of Dilla University Referral Hospital, Southern Ethiopia; 2019–2020; A matched, case–control study

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ABSTRACT

Background: Neonatal mortality rate (NMR) refers to the number of deaths occurring from birth to 28 days of life per-1000 Live Births (LB). The global NMR declined from 37 deaths per- 1,000 LB in 1990 to 18 in 2017, whereas it was 27 deaths per 1000 LB in the Sub-Saharan region. Ethiopia plans to reduce the NMR from 28 deaths to 11 deaths per 1,000 LB by 2020 and to end all preventable child deaths by 2035. The aim of this study was to identify the determinants of neonatal mortality in the neonatal intensive care unit (NICU) of Dilla University Referral Hospital (DURH).

Methods: An age-matched case control study was conducted at DURH's NICU. Two controls having age 2 days before or after the case were used for matching. One hundred eighteen cases (died) and 236 controls (survived) neonates admitted to the NICU from January 11, 2018, to February 25, 2020, were studied. Missed data were filled by multiple imputations. Multicollinearity was checked by the variance inflation factor. For variables with a P-value <0.2 on bivariable conditional logistic regression, multivariable conditional logistic regression analysis was performed to control for confounders using clogit command in a survival package to identify the risk factors for neonatal mortality using R version 3.6.3.

Result: Gestational age <37 weeks (Adjusted matched odds ratio (AmOR): 14.02; 95% confidence interval (CI): 3.68–53.46), first-minute APGAR score <7 (AmOR: 5.68; 95% CI: 1.76–18.31), perinatal asphyxia (PNA) (AmOR: 4.62; 95% CI: 1.15–18.53) and being twins (AmOR: 6.84; 95% CI: 1.34–34.96) were significantly associated with neonatal deaths in our study. Furthermore, antenatal care and follow-up during pregnancy (AmOR: 0.15; 95% CI: 0.04–0.53) and having a normal random blood sugar level at admission (AmOR: 0.1; 95% CI: (0.02–0.66) were found to be determinant of neonatal mortalities in our study.

Conclusion: Gestational age less than 37 weeks, first-minute APGAR scores <7, being twins, diagnosis of PNA, antenatal care and follow-up of mothers during pregnancy and normoglycemia in neonates at admission were significant determinant of neonatal death in the NICU of DURH.

1. Introduction

The neonatal period is the age of a neonate during the first 28 days of life and can be further subdivided into the early neonatal age (within the first 7 days) and the late neonatal age (8–28 days). The neonatal mortality rate (NMR) refers to the number of baby deaths occurring from birth to 28 days of life per 1000 Live Births (LB) [1]. According to data from the United Nations Inter-agency Group for Child Mortality Estimation (UNIGME), the global NMR declined from 37 deaths per 1,000 LB in 1990 to 18 deaths in 2017. The UNIGME further stated that 2.5 million newborns died in the first month of life and about 36% died on the same day they were born. In addition, in 2017, three-quarters of all newborn deaths worldwide occurred in the first week of life [2].

Data from the United Nations Children's Fund (UNICEF) in 2015 showed that about 240 babies died every day in Ethiopia. The NMR in Ethiopia was 28 deaths per 1,000 LB. The NMR in rural areas was 43 deaths per 1,000 LB and it was 41 deaths per 1,000 LB in urban areas; 50 deaths per 1000 LB were reported among the poorest households

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compared with 37 deaths per 1000 LB among the richest households in Ethiopia [3]. The Global Health Observatory (GHO) by WHO in 2016 showed 2.6 million neonatal deaths annually. Of these deaths, 1 million neonates died on the first day they were born, and nearly 1 million died within the next 6 days [4]. Atlas of African Health Statistics in 2019 by WHO predicted that NMR will not met SDG targets stating NMR of 12/1000LB by 2030 if each country counties with the MDG 4 trends [5]. By 2030, the World Health Organization (WHO) Sustainable Development Goal (SDG3.2) plans to end preventable deaths of newborns and recommends that all countries should reduce the NMR to at least as low as 12 deaths per 1000 LB [6].

In 2005, the Ethiopian Federal Ministry of Health (EFMoH) developed a national strategy for child survival in Ethiopia, and the total budget required for the strategy over the 5-year period was estimated to be approximately 1.2 billion USD [7]. The EFMoH maternal and child health directorate developed a National Newborn and Child Survival Strategy in 2015. One of the goals of this strategy (2015–2020) was to reduce the NMR from 28 deaths to 11 deaths per 1,000 LB by 2020. In addition, the EFMoH also plans to end all preventable child deaths by 2035 [8].

The 2016 Ethiopian Demographic Health Survey (EDHS) reported that the NMR of Ethiopia was reduced from 49 deaths per 1,000 LB in 2000 to 29 deaths per 1,000 LB in 2016. The EDHS further stated that, in Ethiopia, 1 out of 35 neonates died within the first month, and 1 out of 21 newborns died before celebrating their first birthday [9]. The risk factors of NM greatly varied from institution to institution in different studies, both in Ethiopia and abroad. Many literature studies on the predictors of NM in Ethiopia also reported inconsistent results. Therefore, we conducted an age-matched case–control study to identify the determinants of NM in the neonatal intensive care unit (NICU) of Dilla University Referral Hospital (DURH).

2. Methods

A matched case–control study was conducted at DURH's NICU, in Dilla town, which is the capital city of Gedeo Zone. The hospital is providing teaching services for undergraduate and postgraduate programs in medical and many health science departments. The hospital has one NICU with sixteen beds. Currently, there are eight senior paediatricians and sixteen neonatal nurses working in the NICU. The NICU has two incubators and three heaters. The sources of oxygen in the NICU are cylinders and oxygen concentrators.

Ethical clearance was obtained from the institutional review board of Dilla University College of Medicine and Health Sciences. The objective of the study was explained to the hospital administrators, medical director, and NICU staff. Confidentiality of the information of the mothers and their neonates was ensured at all levels.

The methodology in this study is based on the international guidelines for observational studies according to Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) 2010 statement (Supplementary-STROBE checklist) (Table S1).

Cases were defined as neonates who were admitted to the NICU between January 11, 2018, and February 25, 2020, and died within the first 28 days of life. whereas controls are neonates admitted to the NICU during the preceding year, survived the first 28 days of life, and are age-matched to the case.

All case neonates registered in the NICU logbook and age matched with two control neonates were included and analyzed. Case neonates for whom two control neonates matching in age were not found, neonates with an unknown outcome at discharge, neonates with an unknown birthdate, and neonates referred to another institution were excluded from both the case and the control groups. The sample size was calculated from a previous case–control study in Ethiopia using a matched case–control study formula. Home delivery gave us the largest sample size [10].

P1 = exposure rate of the control group = 43.86%, P2 = exposure rate of the cases = 66.67%, r = odds ratios = 2.3, m = discordant pairs required to detect odds ratios (since it is matched case control),

n = sample size.

Here, P2 can be calculated. An almost similar number is obtained from the calculation (0.64) and the previous study (0.67). The number of discordant pairs is given by:

$$P = \frac{r}{1+r} = \frac{2.3}{1+2.3} = 0.7$$

$$m = \frac{\left[\left(Z1-\frac{\alpha}{2}\right)+Z1-\beta\sqrt{P(1-P)}\right]^2}{(P-0.5)^2} = \frac{\left[\left(\frac{1.96}{2}\right)+1.28\sqrt{0.7(1-0.7)}\right]^2}{(0.67-0.5)^2} = 61.5$$

$$M = \frac{m}{P1(1-P2)+P2(1-P1)} = \frac{61.5}{0.44(1-0.67)+0.67(1-0.44)} = 118$$

n = 3M (1 case vs 2 controls ratios) or control = 2*cases = 2*118 = 236.

Total sample size (n) = 354. Therefore, 118 cases and 236 controls were studied.

Cases were selected randomly from neonates who died in NICU within the first 28 days between January 11, 2018, and February 25, 2020, until the desired sample size was achieved, and two control neonates matched in age for every case were collected. The NICU registration logbook was used to conveniently combine the card numbers of the case and control neonates who had matched in age and had been admitted to the NICU. One case and 2 controls who matched in age (control's age must be 2 days before or 2 days after the case) were sampled together. Finally, 118 strata containing 1 case and 2 controls matching in age were sampled together and analysed.

Data were collected from all eligible mothers' and neonates' charts using a structured questionnaire (Table S2). The questionnaire was prepared from the articles in the literature review, 2016EDHS, and 2019 WHO African statistics [11, 12, 13, 14, 15, 16, 17]. All maternal and neonatal risk factors were collected from the NICU registration log book, delivery registration log book, maternal and neonatal chart (card), Health Management Information System (HMIS), referral papers, and death reports. **The** maternal chart was reviewed for residence area of mother, maternal age, GA, gravida, parity, ANC follow-up, pregnancy-related complications (PIH, APH, PROM), labor initiations and duration, mode of delivery, place of delivery, and for other necessary data. Neonates' charts and referral papers were reviewed for neonates' APGAR score, sex, birth type, weight, vital signs, place of delivery, the reason for admission, treatment provided in the NICU, length of NICU stay, outcome, and for other necessary data using a structured questionnaire tool.

Data were checked manually for completeness, and then they were coded and entered into STATA (SE) version 14. Missing data were <10% for all variables. Missed values were coded by -99 in stata and were filled by multiple imputations. The logit command in stata does not support constant outcomes for multiple imputations [18]. Therefore, data were finally imported from stata to R and multiple imputations was done in R version 3.6.3 (R Development Core Team) after a MICE (Multivariate Imputation via Chained Equations) package was installed and loaded to the R library.

For continuous data predictive mean matching (PMM), for binary categorical independent variable logistic regression (logreg) and 3 and above categorical predictor variable polynomial regression (polyreg) commands were used for multiple imputations in R. In bivariable analysis, the imputed variables and the original data with the missed value had almost comparable results.

The Hosmer–Lemeshow test was used to check the model fitness. Multicollinearity was checked by the variance inflation factor (VIF) and tolerance. Gravida was excluded due to collinearity with parity. Interaction among the independent variables was tested by stratified analysis.

Finally, the clogit command in survival package in the R library was used for conditional logistic regression analysis. Both bivariable matched conditional logistic regression analysis (CmOR) and multivariable matched conditional logistic regression (AmOR) was performed to assess

the association between outcome and independent variables. In bivariable conditional logistic regression analysis, a p value less than 0.2 was considered as a candidate for multivariable matched conditional logistic regression analysis. Multivariable matched conditional logistic regression analysis was performed on 19 variables to identify the risk factors for neonatal death and variables having a p value < 0.05 were considered to be statistically significant. The confidence intervals (CIs) were used for the odds ratios. Finally, the results were presented using tables and texts.

2.1. Operational definitions of variables

Perinatal Asphyxia: is failure to initiate and sustain breathing at birth and is diagnosed if the neonate has at least one of the following characteristics: need for more than 10 min of resuscitation, metabolic acidosis, and an Apgar score of less than 5 in the fifth minute [19].

Hypoglycaemia: plasma glucose concentration is less than 40 mg/dL(20).

Anemia: a hemoglobin (Hgb) or hematocrit (HCT) more than 2 standard deviation below for the age or less than normal range for postnatal age and birth weight [19].

Jaundice: a yellowish discoloration of the skin or sclera due to bilirubin deposition [19].

Respiratory distress syndrome: is defined as lung immaturity caused by insufficient surfactant substance, manifests as the following signs and symptoms: tachypnoea >60 Bpm, sternal retraction, intercostal/subcostal recession, flaring of alae nasi, tracheal tug, grunting, cyanosis and hypoxia [20].

Low birth Wight: A birth weight less than 2500 g [19].

Small for gestational age – Birth weight blow ten percentile [19].

3. Results

During January 11, 2018, to February 25, 2020, a total of 4026 neonates were delivered in DURH, of which 1702 neonates were admitted to the NICU. From the total admission to the NICU, 9.46% was recorded as death. Data were complete with a response rate of 96%. In our study, 24 (20.3%) of the mothers of cases and 22 (9.3%) of the mothers of controls gave birth at age <20 years, and 23 (19.5%) of the mothers of cases and 30 (12.7%) of the mothers of controls gave birth when they were over 35 years old (Table 1). The mean maternal ages were 22 ± 7 years for the cases and 25 ± 2 years for the cases and controls. Our results revealed that, 62 (52.5%) of the cases and 66 (28%) of the controls were LBW, respectively. The mean neonatal weights for the cases and controls were 2377 ± 817 g and 2735.76 ± 691.58 g, respectively (Table 2).

In a multivariable conditional logistic regression analysis, 6 risk factors were identified to be significantly associated with neonatal mortality. These risk factors were GA<37 weeks, lack of ANC follow-up during pregnancy, first-minute APGAR score <7, twin birth, hypoglycemia at admission, and diagnosis of PNA (Table 3).

Table 1. Socio-demographic data of neonates in the NICU of DURH.

Variable	Case (n = 118) (%)	Control (n = 236) (%)	Total (n = 354) (%)
Address of mother			
Dilla city	23 (19.5%)	77 (32.6%)	100 (28.3%)
Out of Dilla city	95 (79.7%)	159 (66.1%)	254 (70.6%)
Mother's age (at birth)			
<20 years	24 (20.3%)	22 (9.3%)	46 (12.9%)
20–35 years	71 (60.2%)	184 (77.9%)	255 (72.1%)
>35 years	23 (19.5%)	30(12.7%)	53 (14.9%)
Sex of neonate			
Male	60 (50.9%)	126 (53.4%)	186 (52.5%)
Female	58 (49.2%)	110 (46.6%)	168 (47.5%)

Table 2. Data on variables associated with NM.

Variable	Cases (n = 118) (%)	Controls (n = 236)	Total (n = 354) (%)
Gestational age			
<37 weeks	88(74.6%)	43(18.2%)	131(37%)
≥37 Weeks	30(25.4%)	193(81.8%)	223(62.99%)
APGAR score 1st minute			
<7	101(85.6%)	114(48.3%)	215(60.73%)
=>7	17(14.4%)	122(51.7%)	139(39.27%)
RBS			
<40	14(11.9%)	14(5.9%)	28(7.91%)
40–125	70(59.3%)	170(72%)	240(67.8%)
>125	34(14.4%)	52(22%)	86(24.29%)
Birth type			
Single	90(76.3%)	209(88.6%)	299(84.46%)
Twin	28(23.7%)	27(11.4%)	55(15.54%)
ANC follow up			
Yes	83(70.3%)	214(90.7%)	297(83.9%)
No	35(29.7%)	22(9.3%)	57(16.1%)
PNA			
Yes	36(30.5%)	25(10.6%)	61(17.23%)
No	82(69.5%)	211(89.4%)	293(82.77%)
Neonate size at birth for GA			
Small	16(13.6%)	13(5.5%)	29(8.19%)
Appropriate	102(86.4%)	223(94.5%)	325(91.81%)
Congenital Anomalies			
Yes	24(20.4%)	31(13.5%)	55(15.54%)
No	94(79.7%)	205(86.9%)	299(84.46%)
Anemia			
yes	18(15.3%)	15(6.4%)	33(9.32%)
No	100(84.8%)	221(93.6%)	321(90.68%)
Neonatal Jaundice			
Yes	29(24.6%)	22(9.3%)	51(14.41%)
No	89(75.4%)	214(90.9%)	303(85.5%)
RDS			
Yes	34(28.8%)	12(5.1%)	46(12.99%)
No	84(71.2%)	224(94.9%)	308(87.00%)
LBW			
Yes	62(52.5%)	66(28%)	128(36.16%)
No	56(47.5%)	170(72%)	226(63.84%)
Supplemental Oxygen			
Yes	110(93.2%)	171(72.5%)	281(79.38%)
No	8(6.8%)	65(27.5%)	63(17.8%)

Our study found that neonates born before 37 weeks of pregnancy were 14 (AmOR: 14.02; 95% CI: 3.68–53.46) times more likely to die compared with neonates who were born at or above 37 weeks of GA. Neonates born to mothers who attended ANC follow-up (AmOR: 0.15; 95% CI: 0.04–0.53) during the pregnancy period were 85% less likely to die compared with neonates whose mothers had no ANC follow-up during their pregnancy. Twin born neonates were 7 times more likely to die within the first 28 days of life compared with neonates who were born single (AmOR: 6.84; 95% CI: 1.34–34.96) (Table 3).

Neonates having a first-minute APGAR score of <7 (AmOR: 5.68; 95% CI: 1.76–18.31) at birth were 5.68 times more likely to die in comparison with neonates whose first-minute APGAR scores were 7 or more. Neonates having a normal random blood sugar (RBS) level at admission (AmOR: 0.1; 95% CI: 0.02–0.66) were 90% less likely to die compared with neonates who were diagnosed with hypoglycemia at admission. The odds of neonatal death was 4.6 times more likely among neonates diagnosed with PNA (AmOR: 4.62; 95% CI: 1.15–18.53) as compared with neonates who had no PNA diagnosis at admission (Table 3).

Table 3. Multivariable analysis of selected risk factors associated with neonatal mortality in the NICU of DURH.

Variable	Category	CmOR (95% CI)	AmOR (with 95% CI)
Address of mother	Dilla city	1	1
	Out of Dilla city	2.1 (1.2–3.66)	1.29 (0.37–4.49)
Mother's age (at birth)	<20 years	2.66 (1.42–4.99)	1.25 (0.3–5.15)
	20–35 years	1	1
	>35 years	2.03 (1.66–3.86)	0.98(0.27–3.43)
ANC	Yes	0.23 (0.12–0.44)	0.15 (0.04–0.53)
	No	1	1
GA	<37 weeks	14.78 (7.38–29.57)	14.02 (3.68–53.46)
	=>37 weeks	1	1
Birth type	Single	1	1
	Twin	2.51 (1.37–4.62)	6.84 (1.34–34.96)
APGAR1	=>7	1	1
	<7	6.5 (3.45–12.14)	5.68 (1.76–18.31)
APGAR5	=>7	1	1
	<7	3.32 (2.07–5.32)	1.13 (0.35–3.62)
Size	Small	1	1
	Appropriate	0.37 (0.17–0.81)	0.51 (0.09–3.42)
Respiratory rate	<30	5(1.82–13.78)	1
	30–60	1	0.21 (0.04–1.1)
	>60	1.67 (1.03–2.71)	0.48 (0.09–2.29)
RBS	<40	3.66 (1.34–10.05)	1
	40–125	1	0.1 (0.02–0.66)
	>125	1.55 (0.94–2.55)	0.16 (0.02–1.12)
PNA	Yes	3.49 (1.97–6.2)	4.62 (1.15–18.53)
	No	1	1
Congenital Anomalies	Yes	1.71 (0.94–3.10)	0.63 (0.19–2.1)
	No	1	1
Anemia	Yes	2.4 (1.21–4.76)	0.82 (0.12–5.67)
	No	1	1
Jaundice	Yes	3.3(1.75–6.23)	4.18 (0.5–34.94)
	No	1	1
RDS	Yes	9.91 (4.13–23.74)	3.18 (0.6–16.9)
	No	1	1
LBW	Yes	2.87 (1.78–4.62)	0.45 (0.15–1.33)
	No	1	1
Supplemental Oxygen	Yes	6.85 (2.85–16.42)	1.26 (0.24–6.52)
	No	1	1
Phototherapy	Yes	2.76 (1.46–5.23)	0.37 (0.04–3.63)
	No	1	1
Blood transfusion	Yes	3.11 (1.35–7.19)	1.44 (0.2–10.34)
	No	1	1
Anticonvulsant	Yes	4 (2.35–6.81)	2.02 (0.74–5.52)
	No	1	1

1: Reference category, CmOR: Crude matched odds ratio, CS: Cesarean delivery, GA: Gestational age, Other sources of admission: directly from home, born in the ambulance, DURH: Dilla University Referral Hospital, 1: reference category, SpO2: Arterial oxygen saturation, RBS: Random blood sugar.

4. Discussion

Our study showed that GA less than 37 weeks at delivery was 14-fold more strongly associated with neonatal death compared with GA at or above 37 weeks at the time of delivery. Similar to our results, neonates born before 37 weeks of GA in Brazil were six times more likely to die compared with term neonates [21]. Our finding is also in agreement with other earlier studies [22, 23], both of which showed 3-fold higher NM rate among preterm neonates compared with term neonates in 2020.

In contrast to our finding, cohort studies in Ethiopia by Animut et al. at Debre Markos Referral Hospital (AHR: 1.1; 95% CI: 0.7–1.7) in 2020 [24] and Paul et al. in Cameroon (AOR: 0.73; 95% CI: 0.32–1.68) [25] did not show premature birth to be associated with neonatal mortality compared with term birth. Such differences might be due to the severity of prematurity, skills of the health professional, and study design.

In our study, mothers who did undergo ANC during their pregnancy were 85% less likely to lose their neonates compared with mothers who did not undergo ANC. This result is consistent with other studies conducted in Ethiopia and Kenya, which found that mothers who had no ANC follow-up during pregnancy were 6 times and 4 times more likely to have neonatal death, respectively [26, 27].

In contrast to our finding, a prospective cohort study by Tekleab et al. on 216 neonates in Addis Ababa, Ethiopia, in 2016 did not show lack of ANC follow-up to be associated with NM [14]. This difference might be seen due to large sample size in our study. In addition, this difference might be also due to factors such as residence area, early access to health facilities, education level, and awareness of mothers on danger signs of pregnancy.

In our study, neonates having a first-minute APGAR score of <7 was 5.68 times more likely to die compared with neonates having a first-minute APGAR score greater than or equal to 7. This result is in parallel with those of other previous studies in Cameroon and Ethiopia, which showed that first-minute APGAR scores <7 were 16, 3, and 2 times, respectively, more likely to cause NM in the NICU compared with their counterparts [25, 28, 29].

Our study demonstrated that the odds of neonatal death were seven times higher among twin neonates than among single neonates. In similar to our results, Bellizzi et al. found 7.6 times higher neonatal death among twin births compared with that observed among single born neonates using data from 60 middle income countries in 2018 [30]. A study by Muhammed et al. in Afghanistan in 2018 showed that the NMR in twin births was 9 times higher than that in single births [31].

In addition to the above, other studies in Ethiopia in 2019 by Orsido TT, Asseffa, and NA et al. [26] and Mengistu et al. in 2020 [32] also showed that twin born neonates were 2 and 4 times more likely to die compared with single born neonates, respectively. This higher neonatal death among the twin births might be due to being small size for GA, LBW, high risk of being preterm and developing anemia in the twins than single born neonates.

In contrast to our findings, a study by Gotbi et al. (AOR: 0.2; 95% CI: 0.02–2.5) in Iran did not show higher neonatal mortalities among twins than among single neonates [33]. Such differences might be attributed to the country's infrastructure, quality of NICU services, and sample size.

In our study, neonates diagnosed with PNA (AmOR: 4.62; 95% CI: 1.15–18.53) at admission were 4.6 times more likely to die compared with neonates not diagnosed with PNA. This finding is consistent with those of studies from Gondar, Jimma, and Wolaita Sodo in Ethiopia, which showed 6 times, 5 times, and 2 times higher NMR among neonates diagnosed with PNA compared with their counterparts, respectively [13, 34, 35]. Such neonates may develop hypoxia and hypercarbia, which may result in multiple organ failure and death [36].

According to our study, neonatal death is 90% less likely to occur in neonate with normal random blood sugar (RBS) levels at admission. This finding is in line with that of a previous study conducted by Ayenew et al. in 2019 at Gondar in Ethiopia, which showed a 4-fold higher NMR among preterm neonates diagnosed with hypoglycemia at admission compared with preterm neonates having normoglycemia [37].

Neonates may experience prolonged repetitive hypoglycemia due to the inability to suck immediately after birth or later on [20]. Therefore, close follow-up by health personnel and management of hypoglycemia with glucose-containing fluid may lead to an increase in neonatal survival.

Maternal pre-pregnancy risk factors were not identified as predictors of neonatal mortality in our study. However, a cohort study by Hayelom et al. in 2016 conducted on a sample size of 1024 individuals from the Tigray region of Ethiopia identified maternal place of residence and history of abortion as major determinants of NM [38]. Such an

inconsistency may occur due to the level of NICU and its health professional level of education [19].

Other risk factors during pregnancy such as labor initiation and duration were not identified as determinants of neonatal mortality in our study. Unlike our findings, findings of another study by Samuel D. et al. in Ethiopia 2019 showed that induced labor, duration of labor >18 h and time of rupture of membrane >12 h were 3, 3 and 4 times more likely to cause NM, respectively, compared with their counterparts [39]. These differences may be due to factors related to the place of delivery and the skills of the health professional [40].

Even though pregnancy-related complications such as pregnancy-induced hypertension (PIH) and APH were not shown to have statistical associations with NM in our study, it was found by Afrasiabi et al. in Iran [41] and by Yeshambel et al. by 2020 [42] in Ethiopia to have strong associations with neonatal deaths in the NICU. Such differences might be attributed to the study design and large sample size in their studies.

Based on the finding of this study, ANC follow-up and neonatal normoglycemia will have significant impact to reduce neonatal mortality in NICU. Generally, in order to reduce NM rate encouraging mothers to visit health facility for ANC follow-up during the pregnancy period, monitoring labor with a partograph, and engaging in regular breastfeeding should be put into practice in order to lower the NM rate.

The finding of this study in the country with a higher neonatal mortality will be useful for policymaker, program intervention to reduce neonatal mortality and as input for future researcher in neonatal mortality. Furthermore, understanding the causes of neonatal death may allow for the development of targeted interventions to improve outcomes.

The limitations of this study are originated from the data source. Data were collected from secondary data sources and missing values were seen and were filled by multiple imputations. Even though maternal history is written in neonatal cards in details, maternal card (chart) was not obtained for neonates who came to DURH's NICU by referrals from other health institutions and this is the second limitations of this study.

In conclusion, gestational age less than 37 weeks, first-minute APGAR score <7, being twins, and diagnosis of PNA were significantly associated with neonatal deaths in the NICU of DURH, whereas having ANC follow-up during pregnancy and neonatal normoglycemia at admission were associated with a lower likelihood of neonatal mortality. Finally, we recommend that future studies should be conducted to identify the risk factors predisposing preterm neonates to PNA in the DURH's NICU.

Declarations

Author contribution statement

Bedru Jemal,Teshome Abebe and Abebayehu Zemedkun: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data.

Bivash Basu, Simeneh Mola, Derartu Neme and Seyoum Hailu: Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Data availability statement

Data will be made available on request.

Declaration of interest's statement

The authors declare no conflict of interest.

Additional information

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