Cause and predictors of neonatal mortality among neonates admitted to the Neonatal Intensive Care Units of public Hospitals in eastern Ethiopia: Facilities based prospective follow-up study

Assefa Desalew (✉ assefad100@gmail.com)

Haramaya University College of Health and Medical Sciences <https://orcid.org/0000-0001-6065-0708>

Yitagesu Sintayehu

Haramaya University College of Health and Medical Sciences

Nardos Teferi

Haramaya University College of Health and Medical Sciences

Firehiwot Amare

Haramaya University College of Health and Medical Sciences

Bifitu Geda

Haramaya University College of Health and Medical Sciences

Teshager Worku

Haramaya University College of Health and Medical Sciences

Kebebush Abera

Haramaya University College of Health and Medical Sciences

Abiyot Asefaw

Haramaya University College of Health and Medical Sciences

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Abstract

Background: The first month is the most crucial period for child survival and neonatal mortality continues to remain high with little improvement over the years in Sub-Saharan Africa including Ethiopia. This region shows the least progress to reducing this high mortality rate and it continues to be a significant public health issue. The facilities-based cause and predictors of neonatal death in the neonatal intensive care unit are not well documented in this study setting. Hence, the aim of this study was to determine the cause and predictors of neonatal mortality among infants admitted to the neonatal intensive care units in Eastern Ethiopia.

Method: Facilities-based prospective follow-up study was conducted among neonates admitted to the neonatal intensive care units of public hospitals in Eastern Ethiopia from November to December 2018. Data was collected using a pre-tested, structured questionnaire and a follow-up checklist. The main outcomes and cause of death was set by pediatricians and residents. Epi-Data 3.1 and SPSS 25 Version software were used for data entry and analysis. Binary logistic regression was used to find out the predictors of facilities-based neonatal mortality.

Result: The proportion of facilities-based neonatal mortality was 20%. The top five causes of death were a complication of prematurity (49%), birth asphyxia (37.8%), infection (32.6%), meconium aspiration syndrome (17.3%) and congenital malformation (6.1%). Low birth weight, preterm births, length of stay in NICU, low 5 minute Apgar score, hyperthermia and initiation of feeding were predictors of neonatal death among infants admitted to the neonatal intensive care units in public hospitals, Eastern Ethiopia.

Conclusion In summary, the proportion of facilities-based neonatal deaths was unacceptably high. The main causes of death were preventable and treatable. Hence, improving ANC and this would lead to early detection, anticipating high-risk newborns and timely intervention is very essential. Furthermore, early initiation of feeding and a better referral linkage to tertiary facilities could lead to a reduction of neonatal death in this setting.

Background

The first month is the most crucial period for child survival. Globally, an estimated 2.5 million newborns die in the first month of life, approximately 7,000 every day in 2017. Currently, an estimated 18 neonatal deaths per 1,000 live births occur during the neonatal period[1, 2] with neonatal deaths accounting for 46% of under-five mortality [2, 3]. 70% of these early neonatal deaths were due to conditions that could be prevented or treated with access to simple, affordable interventions[1, 2, 4–8].

Moreover, 98% of the above deaths occur in developing countries with a greater burden occurring in Sub-Saharan Africa (SSA). In this region, about one million infant deaths occur in the first month of life which represents the highest neonatal mortality rate(NMR) among those countries participating in the sustainable development goals(SDGs) and showing the least progress to reducing the NMR[1, 3, 6, 9, 10].

The majority of these deaths are caused by infectious diseases, intrapartum asphyxia, pregnancy-related complications and premature births[11].

Neonatal death continues to remain a significant public health issue in Ethiopia with only a slight reduction from 39 per 1000 live births in 2008 to 29 per 1000 live births in 2017[12, 13]. A facilities-based study in Ethiopia indicated that the proportion of neonatal death was 14.3% in Gondar and 23.3% Addis Ababa[13, 14]. Despite multiple efforts by both government and other stakeholders, neonatal death remains higher in Ethiopia than in many developing countries[10]. Although this country is committed to achieving SDGs related to both maternal and child health, which was clearly reflected in the Health Sector Development Program IV and the Health Sector Transformation program, the benefit has not been achieved to date through a reduction in deaths in this population. The Minister of Health is working collaboratively with the World Health Organization (WHO) to improve the quality of neonatal intensive care units (NICU) in the health facilities, however, more is needed[14, 15].

The continued reduction in neonatal deaths is critical to progress towards achieving the SDGs. Therefore, determining the facilities-based causes and predictors of neonatal death in the Eastern Ethiopia context are crucial and essential. Since the recent establishment of the NICU in this setting, data are limited both in the country and study setting. Hence, this facility-based prospective Follow-up study aimed to fill in these gaps and be used as inputs for policymakers and program implementers to design appropriate intervention which could contribute to the reduction of neonatal mortality and morbidity in Ethiopia.

Methods

This facility-based Prospective follow-up study was conducted among all neonates admitted to the NICU in Eastern Ethiopia from November 1 to December 30, 2018. All public health facilities which have the NICU in Harari regional state, Dire Dawa administration and eastern and western Harrarghe Zone from Oromia regional state were included. These facilities have been providing health services for an estimated catchment area of 6,565,406 population. A total of 10 public hospitals in this study area provide NICU services.

All neonates admitted to the NICU during the study period were included from randomly selected six public hospitals. A structured questionnaire and checklist which had been adapted from various literature were utilized. The tool contained information related to obstetrics, ANC visit, age at admission, sex, gestational age at birth, Apgar score, admission diagnosis, birth weight, duration of hospital stay, the need for ventilator support, neonatal outcome and cause of death. It was prepared in English and translated to the local language then re-translated back to English to ensure consistency and understandability.

Maternal and demographic data were obtained by interviewing the mother or reviewing the referral record by neonatal nurses and each neonate was monitored daily until discharge or death. A final assessment of the cause of death was determined by the pediatrician and resident after conducting the necessary laboratory investigation and thorough review of medical records.

Prematurity was defined as a live-birth newborn delivered before 37 completed weeks. For participants with unknown last normal menstrual period, residents used ultrasound and the new Ballard score to estimate the gestational age. Birth weight was classified using WHO weight classification and was measured upon admission using the digital infant weight scale (Seca)[16]. Birth asphyxia was diagnosed when the newborn present with all of the following criteria: 1) persistence of an APGAR score of 0–7 at 5 minutes, neonatal neurologic sequelae (seizures, coma, and hypotonia), and multiple organ involvement (kidney, lungs, liver, heart, and intestines[17, 22].

Two-day intensive training course was administered for the twelve neonatal nurses, pediatric residents, and pediatricians before data collection of data. Training consisted of the purpose of the study, enumeration procedures, how to interview and follow-up the neonates. The tool was pre-tested and necessary modifications were made for local context prior to data collection. After data collection, all completed questionnaires were checked for completeness and manually cleaned. Double data entry was performed to check the clarity.

Statistical Analysis

The tool was coded and entered into EPI data version 3.1, and exported into SPSS version 25 statistical software for analysis. Data was summarized and presented using descriptive statistics. The outcome variables were coded as “1” for died whereas “0” for improved. The association between the outcome variables (i.e. Neonatal death) and independent variables were analyzed using a binary logistic regression model. Covariates having a p-value < 0.2 were retained and entered into the multivariable logistic regression analysis using a forward stepwise approach. Hosmer and Lemeshow, the goodness-of-fit test was used to assess whether the necessary assumptions were fulfilled. The results were presented as adjusted odds ratio (AOR) with 95% confidence intervals (CI) using a p-value < 0.05 as statistically significant associated factors with the outcome variable.

Ethical clearance was obtained from the Institutional Health Research Ethics Review Committee in the College of Health and Medical Science, Haramaya University. Following the approval, an official letter of cooperation was given to the Region and City administration Health Bureau, Zonal and Woreda health office and hospitals. Permission was then obtained from respective officials and the purpose and importance of the study was explained to each enrolled to mothers or caregivers and head of each facility. Overall, data were collected after written informed consent was obtained from each participant and all data was kept confidential with their names and addresses not recorded on the questionnaire.

Results

Maternal Socio-demographic and ANC characteristics

A total of 489 neonates were admitted during the study period. Two hundred seventy-nine (57.1%) mothers of the neonates were ages 21-30 years with a mean age of 26.44 ± 6.04 years. And 198(40.5%) were unable to read and write, while 452(90%) of the mothers were

married and more than half of 255(52.1%) participants were urban residents. Regarding ANC follow-up, two-third of mothers 378(77.3%) had attended at least one prenatal visit however only 116(23.7%) had received the recommended follow up for their current pregnancy (which is 4 or more ANC visits). 180(36.8%) mothers started ANC follow-up before 24 weeks of gestation and 49 (started after 30 weeks. (Table 1).

Table 1: Characteristics of mothers whose neonates were admitted to the NICU of public hospitals in Eastern Ethiopia, 2018[n=489].

Characteristics	Category	Frequency	Percent
Age	less than 20 years	109	22.3
	21-30 years	279	57.1
	31-40 years	95	19.4
	≥ 41 years	6	1.2
Education level	Unable to read and write	198	40.5
	Able to read and write	59	12.1
	Primary Education	111	22.7
	Secondary Education	80	16.4
Marital status	College and above	41	8.4
	Single	28	5.7
	Married	452	92.4
	Divorced	7	1.4
Residence	Widowed	2	0.4
	Urban	255	52.1
	Rural	234	47.9
ANC follow-up	Yes	378	77.3
	No	111	22.7
Place of ANC follow up	Public	320	65.4
	Private	58	11.9
Gestational age at the start of ANC follow up	< 24wks	180	36.8
	24 -29 wks	149	30.5
	30- 35 wks	37	7.6
	greater than 35wks	12	2.5
Number of ANC follow up attended	One	37	7.6
	Two	80	16.4
	Three	145	29.7
	four and above	116	23.7

Obstetrics characteristics

Two hundred eighty-three (57.9%) of neonates were from multiparous mothers and 90% delivered as a singleton with 380 (77.7%) delivering at the index Hospital. About 299(61.1%) were delivered by midwives, and 288(58.9%) mothers had a labor duration ranging from 4-12 hours. More than two-thirds, 338(69.1%) mothers delivered through spontaneous vaginal delivery and 319(65%) of neonates were full term at birth (Table 2).

Table 2:Obstetric characteristics of mothers whose neonates were admitted to the NICU of public hospitals in Eastern Ethiopia, 2018[n=489].

Characteristics	Category	Frequency	Percent
Parity	Primipara	206	42.1
	Multipara	283	57.9
Type of pregnancy	Single	440	90.0
	Twins	49	10.0
Place of delivery	At the index Hospital	380	77.7
	Another hospital	30	6.1
	Health center	53	10.8
	Private facilities	4	0.8
	Home	22	4.5
Birth attendant	Midwife	299	61.1
	Physician	151	30.9
	Nurse	11	2.2
	Health extension workers	2	0.4
	Traditional birth attendants	23	4.7
	Others	3	0.6
Duration of labor	< 4hrs	43	8.8
	4-12hrs	288	58.9
	Greater than12 hrs.	158	32.3
Amniotic fluid status during labor	Clear	360	73.6
	Meconium stained	107	21.9
	Bloodstained	22	4.5
Mode of delivery	Spontaneous Vaginal	338	69.1
	Cesarean section	122	24.9
	Instrumental Delivery	29	5.9
Gestational age at birth	Very preterm	63	12.9
	Late preterm	97	19.8
	Term	319	65.2
	post-term	10	2.0
Length of hospital stay	<3 days	160	32.7
	4-7	229	46.8
	>7	100	20.4

Complications during pregnancy

Eighty-one (16.6%) of mothers had a complication during the current pregnancy with preeclampsia or eclampsia 43(8.8%), being the most common. In addition, 30(6.1%) mothers had medical illness during pregnancy. Two hundred twenty-six (46.2%) of the

mothers had a complication during labor with the most common complication being prolonged duration of labor in 103 (21.1%) of the women. (Table 3).

Table 3: Obstetric and Labor complications among mothers whose neonates were admitted to the NICU of public Hospitals in Eastern Ethiopia, 2018[n=489].

Characteristics	Category	Frequency	Percent
Obstetric complications during current pregnancy	Yes	81	16.6
	No	408	83.4
	Preeclampsia or eclampsia	43	8.8
	Chorioamnionitis	8	1.6
	Premature rupture of membrane	18	3.7
	Ant partum hemorrhage	17	3.5
	Other	1	0.2
Medical illness during pregnancy	Yes	30	6.1
	No	459	93.9
	Diabetes mellitus	5	1.0
	Hypertension	8	1.6
	Tuberculosis	1	0.2
	Cardiac disease	1	0.2
	Anemia	14	2.9
	Human immunodeficiency virus	3	0.6
	Others	2	0.4
Complication during labor	Yes	226	46.2
	No	263	53.8
	Prolonged labor	103	21.1
	Premature rupture of membrane	62	12.7
	Fetal distress	84	17.2
	Cord prolapsed	8	1.6

Neonatal Characteristics

The majority of newborns, 306(62.6%) were males and 378(77.3%) were admitted within the first day of life. More than half 274(56.4%) of the neonates had a normal birth weight

(2500-3999grams). Three-fourths of the neonates, 350(71.6%) were hypothermic upon admission, and 133(27.2%) of neonates suffered from birth asphyxia at 5 minutes (based on the 5 minute Apgar score). And 301(61.1%) initiated exclusive breastfeeding in the first hour (Table 4).

Table 4: Characteristics among neonates admitted to the NICU of public Hospitals in Eastern Ethiopia, 2018[n=489].

Variable	Category	Frequency	Percent
Sex of the newborn	Male	306	62.6
	Female	183	37.4
Age of neonate on admission	≤ one day	378	77.3
	>one days	111	22.7
Birth weight	< 1000grams	8	1.6
	1000-1499 grams	33	6.7
	1500-2499 grams	145	29.7
	2500-3999 grams	274	56.0
	≥ 4000 grams	29	5.9
Temperature at admission(⁰ c)	< 36.5	350	71.6
	36.5-37.5	92	18.8
	>37.5	47	9.6
Score at Apgar5 th minutes	≤3	7	1.4
	4-6	126	25.8
	7-10	251	51.3
	Unknown	105	21.5
Initiation of Feeding in 1 st hour with	NPO	152	31.1
	EBF	301	61.1
	Formula Feeding	36	7.4

Treatment modalities

Four hundred thirty-five (89%) of neonates had received antibiotics and 416(85.1%) had intravenous fluids as therapeutic treatment while only 72(14.7%) utilized the kangaroo mother care (figure 1).

The proportion of neonatal deaths

Among admitted newborns, 98(20%) died and the majority of deaths occurred within the first day of life (Figure2).

Cause of Neonatal Mortality

The most common cause of neonatal mortality was prematurity 48(49%) followed by birth asphyxia 37(37.8%) and infection 32(32.6%) among **the** neonates admitted to the NICU as shown in (Figure3).

Predictors of Neonatal death

In the multivariate logistic analysis, low 5 minute APGAR score, low birth weight, preterm birth, length of hospital stay, febrile illness and feeding status were independent predictors of neonatal mortality. Being preterm was almost three times more likely to die as compared with term neonates (AOR, 2.78 [95% CI: 1.17, 6.57]). Low birth weight babies were two times more likely to die when compared with normal birth weight (AOR, 2.39 [95% CI: 1.04, 5.41]). Furthermore, neonates with low 5 minute APGAR score was five times more likely to die as compared with 5 minutes APGAR score of greater than or equal to seven (AOR, 5.18[95% CI: 2.51, 10.66]); length of staying was another variable found to be predictors of mortality(AOR,3.63 [95% CI:1.82, 7.22]). Neonates who were hospitalized for less than 3 days were more likely to die than those who were hospitalized 4-7 days; this implied that majorities of deaths occurred in the first 72 hours of life. In addition, neonates with fever on admission were seven times more likely to die as compared with afebrile neonates on admission (AOR, 6.68 [95% CI: 1.34, 33.13]). Moreover, neonates who did not initiate breastfeeding with in the first 24 hours were twelve times more likely to die than those who initiated exclusive breastfeeding within the first 24 hours of life(AOR, 12.16 [95% CI: 5.98, 24.70])(Table 5).

Table 5: Multivariate analysis for Predictors of Neonatal Mortality among neonates admitted to NICU of public hospitals, Eastern Ethiopia, 2018[n=489]

Neonatal mortality					
Characteristics	Died	Improved	COR	AOR	P value
Maternal Age					
30 years	51	228	1		
31-39 years	29	80	1.62(0.96, 2.73)	1.50(0.67, 3.34)	-
40 years	17	78	0.97(0.53, 1.78)	1.85(0.76, 4.48)	
40+ years	1	5	0.89(0.102, 7.818)	2.40(0.23, 24.89)	
Marital status					
Married	88	364	1	1	
Single	9	19	1.96(0.86, 4.48)	1.33(0.35, 5.03)	
Widowed	1	8	0.52(0.06, 4.18)	1.62(0.15, 16.94)	-
Religion					
Muslim-Para	50	233	1	1	
Hindu-para	48	158	1.42(0.91, 2.21)	1.94(0.93, 4.05)	-
Mode of delivery					
Vaginal (in this hospital)	253	127	1	1	
Cesarean section	46	41	0.56(0.29, 1.09)	0.50(0.17, 1.51)	
Mode of labor	16	6	0.35(0.08, 1.53)	0.26(0.03, 2.40)	-
Duration of labor					
≤ 2 hrs	177	111	1	1	
> 2-4 hrs	27	16	0.80(0.35, 1.81)	0.45(0.12, 1.63)	-
> 4-12 hrs	111	47	0.69(0.41, 1.14)	0.62(0.30, 1.25)	
Mode of delivery					
Spontaneous vaginal	221	117	1	1	
Cesarean section	79	43	1.23(0.73, 2.05)	1.00(0.47, 2.10)	-
Instrumental	15	14	2.78(1.24, 6.17)	1.34(0.40, 4.44)	
Length of hospital stay					
≤ 3 days	172	57	1	1	
4-7 days	68	92	4.03(2.43, 6.67)	3.63(1.82, 7.22) *	.000
> 7 days	75	25	0.77(0.35, 1.63)	0.61(0.23, 1.58)	
Gestational age at birth					
Term	227	92	1	1	
Preterm	82	78	3.56(2.23, 5.66)	2.78(1.17, 6.56) *	.020
Very preterm	6	4	4.65(1.25, 17.19)	4.54(0.83, 24.70)	
Birth weight					
1000-3999 grams	211	86	1	1	
≤ 1000 grams	77	86	3.46(2.17, 5.49)	2.39(1.04, 5.49) *	.040
> 4000 grams	27	2	0.23(0.03, 1.73)	0.67(0.06, 6.80)	
APGAR at 5 th minutes					
≥ 7	188	63	1	1	
< 7	68	65	5.62(3.32, 9.47)	5.18(2.51, 10.66) *	.000
Temperature on admission	59	46	1.33(0.67, 2.60)	2.50(0.82, 7.54)	

5-37.5c ⁰	64	28	1	1	
3.5c ⁰	218	132	3.37(1.56, 7.23)	2.75(0.97, 7.78)	
7.5c ⁰	33	14	1.25(0.38, 4.05)	6.68(1.345, 33.13)	.020
iation eding F O	237 53	64 99	1 16.71(9.32, 29.94)	1 12.16(5.98, 24.70)	
	25	11	2.69(0.930, 7.80)	1.71(0.47, 6.15)	

*statistically significant at $p \leq 0.05$; EBF: Exclusive breastfeeding; NPO: nothing per month; FF: Formula Feeding

Discussion

The findings of this study indicate that the proportion of neonatal deaths was 20% with the main cause of death being complications of prematurity 49%, birth asphyxia 37.8%, infection 32.6%, MAS 17.3%, RDS 16.1% and congenital malformation 6.1%. In the multivariate logistic analysis, low 5 minute APGAR score, low birth weight, preterm birth, length of stay, febrile illness and feeding status were independent predictors of neonatal death among neonates admitted to the NICU of public hospitals in Eastern Ethiopia.

This finding is in agreement with studies conducted in Ethiopia and other developing countries which showed the proportion of neonatal mortality 18.69% in India, 20.2% in Eastern Nepal, 20.3% -18.8% in Nigeria and 23.3% in Central Ethiopia[7, 18–22]. However, it is greater than the studies carried out in Northern Vietnam which found neonatal mortality at 13.9%, in India 7.16%, Ghana 16%, South Africa 13.8%, and in Cameroon 15.7%[5, 23–26]. The differences in the proportion of death could be explained the discrepancy in the quality of care delivered through those studies setting. In addition, this study was done in NICU hospital in which most of the newborn referred to this hospital were with complication and might have overestimated the prevalence of the neonatal morbidities

Regarding the main causes of death, the present findings revealed that a complication of prematurity 49%, birth asphyxia 37.8%, infection 32.6%, MAS 17.3%, RDS 16.1% and congenital malformation 6.1% were found as the main cause of death. This was supported by findings from WHO, Northern Vietnam, India, Ghana, Nigeria, Cameroon, South Sudan, and Southern and Northern Ethiopia[5, 11, 18–20, 23, 24, 25, 27–30]. This causal agreement clearly indicates the neonatal survival interventions should target the intrapartum as well as immediate and early neonatal periods.

Intrapartum, neonatal conditions and immediate neonatal care practices were the most important predictors of neonatal death in the present study. Birth asphyxia, prematurity, low birth weight and failure to initiate early feeding early were all found to significantly increase the likelihood of neonatal deaths. These findings are consistent with previous studies in Ethiopia and other countries, in which the intrapartum and neonatal conditions were found to be the important predictors of neonatal mortality[21, 26, 28, 30–33]. This may be explained by the fact that premature and low birth weight babies were more likely to be prone to complications such as hypothermia, infections, and birth asphyxia (result in tissue hypoxia and multi-organ failure). Therefore, provisions of quality neonatal care including quality resuscitation, thermal care, and appropriate feeding are important to avert some of these factors[34–37].

Furthermore, a short duration of less than 3 days of life in the NICU was found to be significantly associated with neonatal death. This contrasts with a study in the Somali region where a shorter stay in the NICU was protective against mortality. However, it is consistent with the fact that most neonatal deaths occur in the first 72 hours following birth, and any intervention at this critical time has a significant contribution to saving the life of the neonate[38, 40]. In addition, febrile illness ($\geq 37.5^{\circ}\text{C}$) on admission was found to be a significant predictor of neonatal mortality. This is likely due to the high proportion of infection in the present study setting.

Generally, effective care can reduce many neonatal deaths in the first month: A significant proportion of neonatal deaths could be avoided by appropriate resuscitation care[41]. Most of the infection-related deaths could be avoided by treating maternal infections during pregnancy, ensuring a clean birth, care of the umbilical cord and immediate, exclusive breast-feeding [42, 43]. There is a range of evidence-based interventions available that can improve the survival of premature and low-Birthweight newborns. The promotion of early and exclusive breastfeeding prevention and treatment of hypothermia, including kangaroo mother care[43, 44, 45], topical skin-cleansing with chlorhexidine may reduce morbidity and mortality secondary to infection[10, 46]. The gap for the care of mothers and babies in the first few days of life is important even where women do deliver in facilities. Communities and decision-makers need to be informed that neonatal deaths are a huge portion of child deaths, and need therefore to receive adequate attention.

One strength of this study was it's the inclusion of multiple facilities and neonates was followed prospectively from admission to discharge or death. In addition, it was carried out without sampling therefore the possibility of sampling error is eliminated. However, the relatively small sample size and wide CI in the multivariate model associated with some variables may undermine the strength and validity of this study. Another limitation is the follow up was restricted from admission to discharge only hence, this study does not reflect population-based neonatal mortality rather, it reflects the institution based neonatal death.

Conclusion

In conclusion, the proportion of facilities-based neonatal mortality was unacceptably high. Five common causes of neonatal death were prematurity, birth asphyxia, infection, respiratory morbidity, and congenital malformation. Preterm births, low birth weight, low 5 minute APGAR score, a short stay in NICU, failure to initiation early breastfeeding and temperature($\geq 37.5^{\circ}\text{C}$) at admission were significant predictors of mortality in Eastern Ethiopia. Hence improving ANC and this would lead to early detection, anticipating high-risk newborns and timely interventions are essential to reducing neonatal deaths. Furthermore, early initiation of feeding and a better referral linkage to tertiary facilities could contribute to the reduction of neonatal mortality and morbidity in this setting.

Abbreviations

ANC
Antenatal Care
AOR
Adjusted Odd Ratio
APGAR
Appearance, Pulse, Grimace, Activities, and Respiration
CI
Confidence Interval
CSA
Central Statistical Agency
EBF
Exclusive Breast Feeding
MAS
Meconium Aspiration Syndrome
NICU
Neonatal Intensive Care Unit
NMR
Neonatal Mortality Rate
RDS
Respiratory Distress Syndrome
SDG
Sustainable Development Goal
SPSS
Statistical Package for Social Sciences
UNICEF
United Nations International Children's Emergency Fund
WHO
World Health Organization

Declarations

Ethics approval and consent to participate

Ethical clearance was obtained from the Institutional Health Research Ethics Review Committee College of health and medical science, Haramaya University. Following the approval, a written official letter of cooperation was given to the regional health Bureaus and facilities. Informed written consent was obtained from the participants. Furthermore, confidentiality was assured throughout the process.

Availability of data and materials

All the data of this study is available from the corresponding author upon reasonable request.

Consent to publish

Not applicable

Conflict of interest

The authors declare that they have no conflicts of interest.

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Author contributions

A.D., Y.S., and N.T. designed the study, performed the statistical analysis and drafted the manuscript. B.G. and F.A. and participated in the study design and statistical analysis. T.W., K.A, and AA involved in the inception of the study. All authors contributed, read and approved the final version of the manuscript.

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Authors' information

¹School of Nursing and Midwifery College of Health and Medical Sciences, Haramaya University, Harar, Ethiopia

²School of Medicine, College of Health and Medical Sciences, Haramaya University, Harar, Ethiopia

³School of Pharmacy, College of Health and Medical Sciences, Haramaya University, Harar, Ethiopia

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Figures

Figure 1

Treatment modalities delivered to neonates admitted to NICU of public Hospitals in Eastern Ethiopia, 2018[n=489].

Figure 2

Proportion of neonatal death among neonates admitted to the NICU of public Hospitals in Eastern Ethiopia, 2018[n=489].

Figure 3

Cause of Neonatal Mortality among neonates admitted to NICU of public hospitals in Eastern Ethiopia 2018[n=489].