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

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Abstract

Background The first month is the most crucial period for child survival. 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 neonatal mortality and it continues to be a significant public health issue. The facilities-based causes 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 causes and predictors of neonatal mortality among infants admitted to the neonatal intensive care units in Eastern Ethiopia. **Methods** 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 were collected using a pre-tested, structured questionnaire and a follow-up checklist. The main outcomes and causes of death were set by pediatricians and medical residents. Epi-Data 3.1 and Statistical Package for Social Sciences Version 25 software were used for data entry and analysis respectively. Multivariable logistic regression was used to find out the predictors of facilities-based neonatal mortality. **Results** The proportion of facilities-based neonatal mortality was 20%(95% CI: 16.7-23.8%) The causes of death were complications of preterm birth 28.58%, birth asphyxia 22.45%, infection 18.36%, meconium aspiration syndrome 9.18%, respiratory distress syndrome 7.14% and congenital malformation 4.08%. 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** The proportion of facilities-based neonatal deaths was unacceptably high. The main causes of death were preventable and treatable. Hence, improving timing and quality of ANC is essential for early detection, anticipating high-risk newborns and timely interventions. 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]. More than 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 neonatal deaths. 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 Ethiopian 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 interventions which could contribute to the reduction of neonatal mortality and morbidity in Ethiopia.

Methods

Study area, design, and population

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 Hararghe Zone from Oromia regional state were included. These facilities have been providing health services for an estimated catchment area of 6,565,406 populations. 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. However, neonates who were admitted for observation, neonates whose mothers or guardians were not present at all during the study period were excluded.

Sample size and sampling technique

Even though we included all neonates consecutively admitted to the NICU, we checked the adequacy of the sample size using the formula for double population proportion to determine the sample size. Statcalc of Epi Info statistical software Version 7 was used to calculate sample size for the study at 95% confidence level, power of 80% and an assumption of ratio of unexposed to exposed equivalent to 1. Based on this, the sample size was calculated to be 468. An addition of 5% was made for the non-response rate, and then the final sample size was calculated to be 491.

Ten public hospitals in eastern Ethiopia provide NICU service. Among these, five were selected by simple random sampling technique: Garamuleta Hospital, Deder Hospital, Chiro Hospital, Dilchora Referral

Hospital, and Hiwot Fana Specialized University Hospital. Proportional allocation to size was used to distribute the calculated sample size based on the estimated case follow per month in each selected public hospital.

Data collection method

A structured questionnaire and checklist which had been adapted from various literature were utilized[4,6,22]. 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 causes of death. It was prepared in English and translated to the local languages then re-translated back to English to ensure consistency and understandability.

Maternal and demographic data were obtained by interviewing the mothers or reviewing the referral records 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 medical 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 has at least one of the following signs, not breathing or gasping, < 30 breaths per minute or < 7 APGAR score, had neonatal neurologic sequelae (seizures, coma, and hypotonia), or multiple organ involvement (kidney, lungs, liver, heart, and intestines[17,22].

Data quality management

A two-day intensive training course was administered for the twelve neonatal nurses, pediatric residents, and pediatricians before data collection. 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 to Statistical Package for Social Sciences Version 25 statistical software for analysis. Data were 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.

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 aged 21-30 years with a mean age ($\pm$ SD) of 26.44 $\pm$ 6.04 years. One hundred ninety-eight (40.5%), 452(90%) and 255(52.1%) mothers were unable to read and write, married and urban residents respectively. 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 was 4 or more ANC visits). One hundred eighty (36.8%) mothers started ANC follow-up before 24 weeks of gestation and 149(30.5%) started after 24 -30 weeks of gestation (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	< 24weeks	180	36.8
	24 -29 weeks	149	30.5
	30- 35 weeks	37	7.6
	greater than 35weeks	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%) neonates were delivered from multiparous mothers. Four hundred forty (90%) were a singleton type and 380 (77.7%) delivered at the index hospital. About 299(61.1%) mothers were delivered by midwives, and 288(58.9%) mothers had a labor duration ranging from 4-12 hours. More than two-thirds (69.1%) of mothers were delivered through spontaneous vaginal delivery and 319(65%) 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(< 34 weeks)	63	12.9
	Late preterm(34-36weeks)	97	19.8
	Term(37-42weeks)	319	65.2
	post-term(>42weeks)	10	2.0
Length of hospital stay	<3 days	160	32.7
	4-7days	229	46.8
	>7days	100	20.4

Complications during pregnancy

Eighty-one (16.6%) mothers had a complication during the current pregnancy. Preeclampsia or eclampsia account for 43(8.8%). In addition, 30(6.1%) mothers had a medical illness during pregnancy. Two hundred twenty-six (46.2%) mothers had a complication during labor with the most common complication being prolonged duration of labor in 103 (21.1%) participants (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 the 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

Three hundred six (62.6%) and 378(77.3%) of newborns were male and admitted within the first day of life respectively. More than half (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%) suffered from birth asphyxia at 5 minutes (based on the 5 minute Apgar score). Three hundred one (61.1%) newborn 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
Apgar score at 5 minute	≤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	Nothing per mouth	152	31.1
	Exclusive Breast Feeding	301	61.1
	Formula Feeding	36	7.4

Treatment modalities

Four hundred thirty-five (89%) 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 and causes of Neonatal Mortality

Among admitted newborns, 98(20%) died and the remaining were survived from admission to discharge in NICU (Figure2). The most common causes of neonatal mortality were complications of preterm 28(28.58%) followed by birth asphyxia 22(22.45%) and neonatal infection 18 (18.36%) (Figure3).

Predictors of Neonatal Mortality in NICU

In the multivariable 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 (AOR: 2.78, 95% CI: 1.17, 6.57) more likely to die compared with term neonates. Low birth weight babies were two times (AOR: 2.39, 95% CI: 1.04, 5.41) more likely to die when compared with normal birth weight. Furthermore, newborn with low 5 minute APGAR score was about five times (AOR: 5.18, 95% CI: 2.51, 10.66) more likely to die compared with 5 minutes APGAR score of greater than or equal to seven; length of stay was another variable found to be predictors of neonatal mortality. Newborn who were hospitalized for less than 3 days were nearly four times (AOR: 3.63, 95% CI: 1.82, 7.22) more likely to die than those who were hospitalized 4-7 days; this implies that majority of deaths occurred in the first 72 hours of life. In addition, neonates with fever on admission were nearly seven times (AOR: 6.68, 95% CI: 1.34, 33.13) more likely to die compared with afebrile neonates. Moreover, neonates who did not initiate breastfeeding within the first 24 hours were twelve times (AOR: 12.16, 95% CI: 5.98, 24.70) more likely to die than those who initiated exclusive breastfeeding within the first 24 hours of life (Table 5).

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

Characteristics	Neonatal mortality				P value
	Died	Improved	COR	AOR	
Maternal Age					
< 20 years	51	228	1		
20-29 years	29	80	1.62(0.96, 2.73)	1.50(0.67, 3.34)	.335
30-39 years	17	78	0.97(0.53, 1.78)	1.85(0.76, 4.48)	.212
≥ 40 years	1	5	0.89(0.10, 7.82)	2.40(0.23, 24.89)	.532
Marital status					
Married	88	364	1	1	
Single	9	19	1.96(0.86, 4.48)	1.33(0.35, 5.03)	.766
Others	1	8	0.52(0.06, 4.18)	1.62(0.15, 16.94)	.543
Parity					
Nullipara	50	233	1	1	
Paripara	48	158	1.42(0.91, 2.21)	1.94(0.93, 4.05)	.680
					.068
					.068
Mode of delivery					
Normal (in this study)	253	127	1	1	
Cesarean section	46	41	0.56(0.29, 1.09)	0.50(0.17, 1.51)	.275
Emergency	16	6	0.35(0.08, 1.53)	0.26(0.03, 2.40)	.205
Duration of labor					
≤ 4 hrs	177	111	1	1	
> 4 hrs	27	16	0.80(0.35, 1.81)	0.45(0.12, 1.63)	.225
					.225
					.184
Duration of delivery					
≤ 12hrs	111	47	0.69(0.41, 1.14)	0.62(0.30, 1.25)	.184
Spontaneous vaginal	221	117	1	1	
Caesarean section	79	43	1.23(0.73, 2.05)	1.00(0.47, 2.10)	.460
					.460
					.944

umental	15	14	2.78(1.24, 6.17)	1.34(0.40, 4.44)	.944
th of hospital stay					
ays	172	57	1	1	
ays	68	92	4.03(2.43, 6.67)	3.63(1.82, 7.22) *	.000
ays	75	25	0.77(0.35, 1.63)	0.61(0.23, 1.58)	.310
					.310
stational age at					
(37-42weeks)	227	92	1	1	
rm (<37weeks)	82	78	3.56(2.23,5.66)	2.78(1.17, 6.56) *	.020
term (>42weeks)	6	4	4.65(1.25,17.19)	4.54(0.83, 24.70)	.051
weight					
0-3999 grams	211	86	1	1	
s than 2499 grams	77	86	3.46(2.17, 5.49)	2.39(1.04, 5.49) *	.040
00 grams	27	2	0.23(0.03, 1.73)	0.67(0.06, 6.80)	.858
					.86
AR at 5 th minutes	188	63	1	1	
	68	65	5.62(3.32, 9.47)	5.18(2.51, 10.66) *	.000
corded	59	46	1.33(0.67, 2.60)	2.50(0.82, 7.54)	.092
perature on admission					
-37.5c ⁰	64	28	1	1	
5c ⁰	218	132	3.37(1.56, 7.23)	2.75(0.97, 7.78)	.057
5c ⁰	33	14	1.25(0.38, 4.05)	6.68(1.35, 33.13) *	.020
tion of Feeding					
	237	64	1	1	
	53	99	16.71(9.32, 29.94)	12.16(5.98, 24.70) *	.000
	25	11	2.69(0.93, 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

Despite advancement in technologies and interventions made to improve the life of newborns, Neonatal death remains as unfinished agenda as a serious public health concern in developing countries including Ethiopia. Therefore we conducted this prospective study to determine the causes and predictors of neonatal mortality in the neonatal intensive care units in Eastern Ethiopia. Accordingly the proportion of neonatal deaths was 20 % (95% CI: 16.7-23.8%). This resulted mainly from preventable causes, which is unconscionable in the 21st century. The present finding was in agreement in the proportion of neonatal mortality with studies conducted in Ethiopia and other developing countries like in India (18.69%), Eastern Nepal (20.2%), Nigeria (18.8%) and Central Ethiopia (23.3%) [19-22]. However, it was greater than the studies carried out in Northern Vietnam (13.9%), India (7.16%), Ghana (16%), South Africa (13.8%) and Cameroon (15.7%) [5,23-26]. These variations between studies might be explained, in part, by the discrepancy in the follow-up time, sample size and quality of prenatal care delivered in these facilities. In addition, the present study was conducted in the hospital which had recently established NICU; this might result in a difference in the distribution of essential equipments, skilled manpower, and socioeconomic condition of the population, as well as geographical locations.

In the current study the main causes of death were complications of preterm birth (28.58%), birth asphyxia (22.45%), and neonatal infection (18.36%). This was supported with reports and 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]. In current finding, more than 70% of the neonatal deaths are attributed to prematurity, neonatal sepsis and birth asphyxia. From this finding we can conclude that more neonatal survival interventions should be targeted towards the intra-partum period as well as in immediate and early neonatal periods.

Birth asphyxia, preterm, 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]. In fact, preterm 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 neonatal infection in the present study setting.

This finding emphasizes the need to improve the quality of care in health facilities. In particular, we strongly believe that achieving high-quality intrapartum and postnatal care is required to improve neonatal health. 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, immediate and, 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.

The strengths of this study were, 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 multivariable model associated with some variables may undermine the strength of this study. The study was conducted at hospitals; therefore neonates delivered at home and died at home could be missed. Hence, this study does not reflect population-based neonatal mortality rather; it reflects the institution based neonatal death in the given time period. Another limitation is the follow up was restricted from admission to discharge only for two months.

Conclusion

The proportion of facilities-based neonatal mortality was unacceptably high. Five common causes of neonatal death were preterm, 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 initiate early breastfeeding, and temperature ($\geq 37.5^{\circ}\text{C}$) at admission were significant predictors of mortality in Eastern Ethiopia. Efforts to address birth asphyxia and neonatal infections and preterm birth, are critical to achieving survival goals newborn. Improving timing, quality of ANC is essential for early detection, anticipating high-risk newborns and timely interventions. 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

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.

Consent for publication

Not applicable

Availability of data and materials

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

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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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

Causes of Neonatal Mortality among neonates admitted to NICU of public hospitals in Eastern Ethiopia 2018[n=98].