Cause and Predictors of Neonatal Mortality among Neonates admitted to 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 is stagnated in sub-Saharan Africa including Ethiopia. And the trend in reduction is slower than infant and child mortality. The facilities-based cause and predictor of neonatal death in the neonatal intensive care unit were not well documented in this study setting. Hence the aim of this study was to determine the cause and predictors of neonatal mortality among neonates admitted in neonatal intensive care units in eastern Ethiopia.

Method: Facilities-based prospective follow-up study was conducted among neonates admitted in neonatal intensive care units of public hospitals in eastern Ethiopia from November to December 2018. Data were collected using pre-tested, structured questionnaire and follow-up checklist. The main outcomes, cause of death was set by senior pediatricians and residents. Epi-Data 3.1 and SPSS 25 version software were used for 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 cause of death was 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, low 5^{th}minutes Apgar score, hyperthermia and initiation of feeding were predictors of neonatal death among Neonates admitted in neonatal intensive care units in public hospitals, eastern Ethiopia.

Conclusion

In summary, the proportion of facilities-based Neonatal death was unacceptably high. The main causes of death were preventable and treatable. Hence, 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 contribute for 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 newborn were died 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 in the neonatal period[1,2]. Neonatal death accounts for 46% of under-five mortality [2, 3]. And about, 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 the greater burden of deaths occurs and stagnated in sub-Saharan Africa (SSA). In this region, one million neonatal mortality occurs in the first month of life which had the highest neonatal mortality rate(NMR) among sustainable development goals(SDGs) regions and showing the least progress to the reducing of NMR[1,3,6,9,10]. Most of these deaths are caused by infectious diseases, intrapartum asphyxia, pregnancy-related complications and premature births[11].

Neonatal death still remains a significant public health problem in Ethiopia. In the last decade, NMR has a slower reduction, for example, 39 in 2008 to 29 in 2017 per 1000 live birth [12,13]. facilities-based study in Ethiopia (and) indicated that the proportion of neonatal death was 14.3% in Gondar and 23.3% Addis Ababa[13,14]. Despite many efforts by the government and other stakeholders, neonatal death remains higher than many developing countries[10]. Even though, the country is committed to achieving SDGs related both maternal and child health, which was clearly reflected in the Health Sector Development Program IV and the Health Sector Transformation program and working collaboration with World Health Organization (WHO) to improve the quality of neonatal intensive care units (NICU) in the health facilities, the reduction is still not well accelerated [14,15].

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

Methods

This facility-based prospective follow-up study was conducted among all neonates admitted in NICU in eastern Ethiopia from November 1 to December 30, 2018. Public health facilities which have NICU setting 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 estimated 6,565,406 total populations in the catchment areas. A total of 10 public hospitals are currently providing care for a sick newborn in their NICU.

All neonates admitted in NICU during the study period were included from six public hospitals. Structured questionnaire and checklist which was adapted from different kinds of literature were used. The tool contains information related to obstetrics, ANC visit, age at admission, sex, and gestational age at birth, Apgar score, admission diagnosis, birth weight, and duration of hospital stay, the need of 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 referral record by neonatal nurses and each neonate was monitored daily until discharge or death. A final assessment of the cause of death was set by the pediatrician and residents after conducting the necessary laboratory investigation. In this study, any neonatal conditions or diagnosis identified for deceased neonates were considered as causes of death. In other words, causes of deaths were defined as the underlying neonatal conditions, which presented in the admitted of the deceased neonate.

Prematurity was described as live-birth newborn delivered before 37 completed weeks. For mothers who did not know dates of their 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[16]. Birth weight was measured during admission using a digital infant weighing scale (Seca), which was placed on a fixed and leveled couch and enumerated for each newborn. Birth asphyxia was diagnosed whenever a newborn had an Apgar score <7 in the first or fifth minutes[17].

Twelve neonatal nurses, pediatric residents, and senior pediatricians had received refreshment trained intensively for two days about the purpose of the study, enumeration procedures, how to interview and follow-up of the neonates. Then the tool was pre-tested and necessary modifications were made to suit to local context prior to data collection. The principal investigators shared ethical issues and ways of addressing contingency management. Then, all completed questionnaires were checked for completeness and cleaned manually. After that, double data entry was done to check the clarity.

Statistical Analysis

The tool was coded and entered into EPI data version 3.1, and then exported to SPSS version 22 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 forward stepwise approach. Hosmer and Lemeshow, goodness-of-fit test were used to assess whether the necessary assumptions were fulfilled. The results were presented as adjusted odds ratio (AOR) with 95% confidence intervals (CI). A p-value<0.05 was considered for declaring 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. Then, permission was obtained from respective officials. The purpose and importance of the study were explained to the study participants and facilities heads. Overall, data were collected only after fully written informed consent was sought from each participant. All findings were kept confidential. The names and address of the participants were not recorded on the questionnaire.

Results

Maternal Sociodmographic and ANC characteristics

A total of 489 neonates were admitted in the study period. About 279 (57.1%) mothers of the neonates were in the age group of 21-30 years with a mean age of 26.44 $\pm$6.04 years. And 198 (40.5%) were unable to read and write, while 452(90%) of the mothers were

married moreover, more than half of 255(52.1%) participants were an urban resident. Regarding ANC follow-up, two-third of mothers 378(77.3%) had attended ANC at least once but only 116(23.7%) were received the recommended follow up for the current pregnancy. Around 180(36.8%) of mothers, started ANC follow up before 24 weeks of gestation (Table 1).

Table 1: Characteristics of mothers of neonates who were admitted to 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
	College and above	41	8.4
Marital status	Single	28	5.7
	Married	452	92.4
	Divorced	7	1.4
	Widowed	2	0.4
Residence	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

The majority, 283(57.9%) of neonates were from multi-Para mothers. Ninety percent of the neonates were delivered as a singleton and 380 (77.7%) were delivered at the index Hospitals. Regarding birth attendants, 299(61.1%) were midwives, about 288(58.9%) of mothers had a labor duration ranging 4-12 hours. In addition, more than two-thirds 338(69.1%) of the deliveries were through spontaneous vaginal delivery and 319(65%) of neonate were birth at term gestation (Table 2).

Table 2: Obstetrics characteristics of mothers with their neonates who were admitted to 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
	HEWS	2	0.4
	TBA	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	Pre-term	160	32.7
	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

Only 81(16.6%) of mothers had a complication during the current pregnancy. From those complications, preeclampsia or eclampsia 43(8.8%) was the commonest one. In addition, about 30(6.1%) mothers were suffered from Medical illness during pregnancy. Nearly half 226(46.2%) of the mothers had a complication during labor and the most common complication 103 (21.1%) were prolonged duration of labor (Table 3).

Table 3: distribution on complications during current pregnancy and labor among mothers of neonates admitted to 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, 306(62.6%) were male and more than three- fourth 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). More than two-thirds 350(71.6%) of the neonates were hypothermic upon admission, around 35(27.2%) of neonates have suffered from birth asphyxia at 5th minute and 301(61.1%) were initiated exclusive breastfeeding (Table 4).

Table 4: Neonatal characteristics among neonates admitted to 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 Apgar 5th minutes	≤3	7	1.4
	4-6	126	25.8
	7-10	251	51.3
	Unknown	105	21.5
Initiation of Feeding	NPO	152	31.1
	EBF	301	61.1
	Formula Feeding	36	7.4

Treatment modalities

Nearly, 435 (89%) of neonates have received antibiotics and Intravenous fluids 416(85.1%) as main treatment while only 72 (14.7%) were utilizing the kangaroo mother care (figure 1).

The proportion of Neonatal death

Among admitted newborn, 98(20%) died and the majority of death occurs in the first day of life. the remaining were survived and discharged (Figure2).

Cause of Neonatal Mortality

Regarding the cause of death, the most common causes were prematurity 48(49%) followed by birth asphyxia 37(37.8%) and infection 32(32.6%) among neonates admitted in NICU as shown in (Figure3).

Predictors of Neonatal death

In the multivariate logistic analysis, low 5th minutes Apgar score, low birth weight, preterm birth, length of hospital stay, being febrile 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 about 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 5th minutes Apgar score was five times more likely die as compared with 5th 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 stayed for less than 3 days were more likely die than those who stayed 4-7 days , this implied that majorities of deaths occurred in the first 72 hours of life. In addition, neonates with fever at admission were seven times more likely to die as compared with the normal temperature at admission (AOR, 6.68 [95% CI: 1.34, 33.13]). Moreover, neonates who have not initiated feeding in the first 24 hours were about twelve times more likely to die than those were initiated with exclusively breastfeeding (AOR, 12.16 [95% CI: 5.98, 24.70]) and found to be significant predictors of neonatal mortality (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					
21-30 years	51	228	1		
<20 years	29	80	1.62(0.96, 2.73)	1.50(0.67, 3.34)	-
31-40 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)	
Others	1	8	0.52(0.06, 4.18)	1.62(0.15, 16.94)	-
Parity					
Multi-Para	50	233	1	1	
Primi-para	48	158	1.42(0.91, 2.21)	1.94(0.93, 4.05)	-
Place of delivery					
Inborn (in this hospital)	253	127	1	1	
Other facility	46	41	0.56(0.29, 1.09)	0.50(0.17, 1.51)	
Home	16	6	0.35(0.08, 1.53)	0.26(0.03, 2.40)	-
Duration of labor					
4 -12 hrs	177	111	1	1	
less than 4 hrs	27	16	0.80(0.35, 1.81)	0.45(0.12, 1.63)	-
More than 12hrs	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					
4-7 days	172	57	1	1	
<3 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
Post term	6	4	4.65(1.25, 17.19)	4.54(0.83, 24.70)	
Birth weight					
2500-3999 grams	211	86	1	1	
Less than 2499 grams	77	86	3.46(2.17, 5.49)	2.39(1.04, 5.49) *	.040
$\geq$ 4000 grams	27	2	0.23(0.03, 1.73)	0.67(0.06, 6.80)	
APGAR at 5th minutes					
7-10	188	63	1	1	
$\leq$ 6	68	65	5.62(3.32, 9.47)	5.18(2.51, 10.66) *	.000
Unrecorded	59	46	1.33(0.67, 2.60)	2.50(0.82, 7.54)	
Temperature on admission					
36.5 –37.5c^0	64	28	1	1	
<36.5 c^0	218	132	3.37(1.56, 7.23)	2.75(0.97, 7.78)	
>37.5 c^0	33	14	1.25(0.38, 4.05)	6.68(1.345, 33.13) *	.020
Initiation of Feeding					
EBF	237	64	1	1	
NPO	53	99	16.71(9.32, 29.94)	12.16(5.98, 24.70) *	.000
FF	25	11	2.69(0.930, 7.80)	1.71(0.47, 6.15)	

*statistically significant at p ≤ 0.05

Discussion

The finding of the present study indicated that the proportion of neonatal death was 20%. The main cause of death was a complication 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 5th minutes Apgar score, low birth weight, preterm births, length of stay, being febrile and feeding status were independent predictors of neonatal death among Neonates admitted in NICU of public hospitals in eastern Ethiopia.

This finding is in agreement with studies conducted in Ethiopia and developing countries like 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 13.9%, in India 7.16%, in Ghana 16%, in South Africa 13.8%, and in Cameroon 15.7%[5,23-26]. This difference in the proportion of death could be explained by the related factors for each study and discrepancy in the quality of care delivered through those studies setting.

With regard to the main causes of death, the present finding 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 indicated that 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 not initiating feeding early were found to increase the likelihood of neonatal death by five times, nearly three times, two times and about twelve times respectively. These findings are consistent with other previous studies in Ethiopia and different 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 baby was more likely to be prone for complications like hypothermia, infections, and birth asphyxia (result in tissue hypoxia and multi-organ failure). So that, provision of quality neonatal care including, quality resuscitation, thermal care, and appropriate feeding important to avert some of these factors significantly [34-37].

Furthermore, short duration, less than 3 days of life at NICU was found significantly associated with neonatal death. This is in contrast, to study in the Somali region; a short stay in the NICU was protective against mortality. However, it consistent with the established fact that most of the 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 neonates[38,40]. In addition, neonates with fever (≥37.5 °c) at admission are significantly found to be predictors of neonatal mortality. This might be due to a high proportion of infection in the present study setting.

Strength of this study was its multi facilities inclusion and neonates were prospectively followed from admission to discharge or death. In addition, it was carried out without sampling; hence it is used for eliminating any possible sampling error. However, its relatively small number study subject and some variables mentioned in the multivariate model had wide CIs which may undermine the strength of this study. Another limitation is that the follow up was restricted from admission to discharge; hence, this article 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 5th minutes APGAR score, short duration in NICU, Not early initiation of feeding and temperature(≥37.5°c) at demission were significant predictors of mortality in eastern Ethiopia. Hence early detection, anticipating high-risk newborns and timely interventions are very essential. Furthermore, early initiation of feeding and a better referral linkage to tertiary facilities could contribute for 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 sought from the participants. Furthermore, confidentiality was assured throughout the process.

Availability of data and materials

All the data of this study are available from the corresponding author upon 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 A. involved in the inception of the study. All authors contributed, read and

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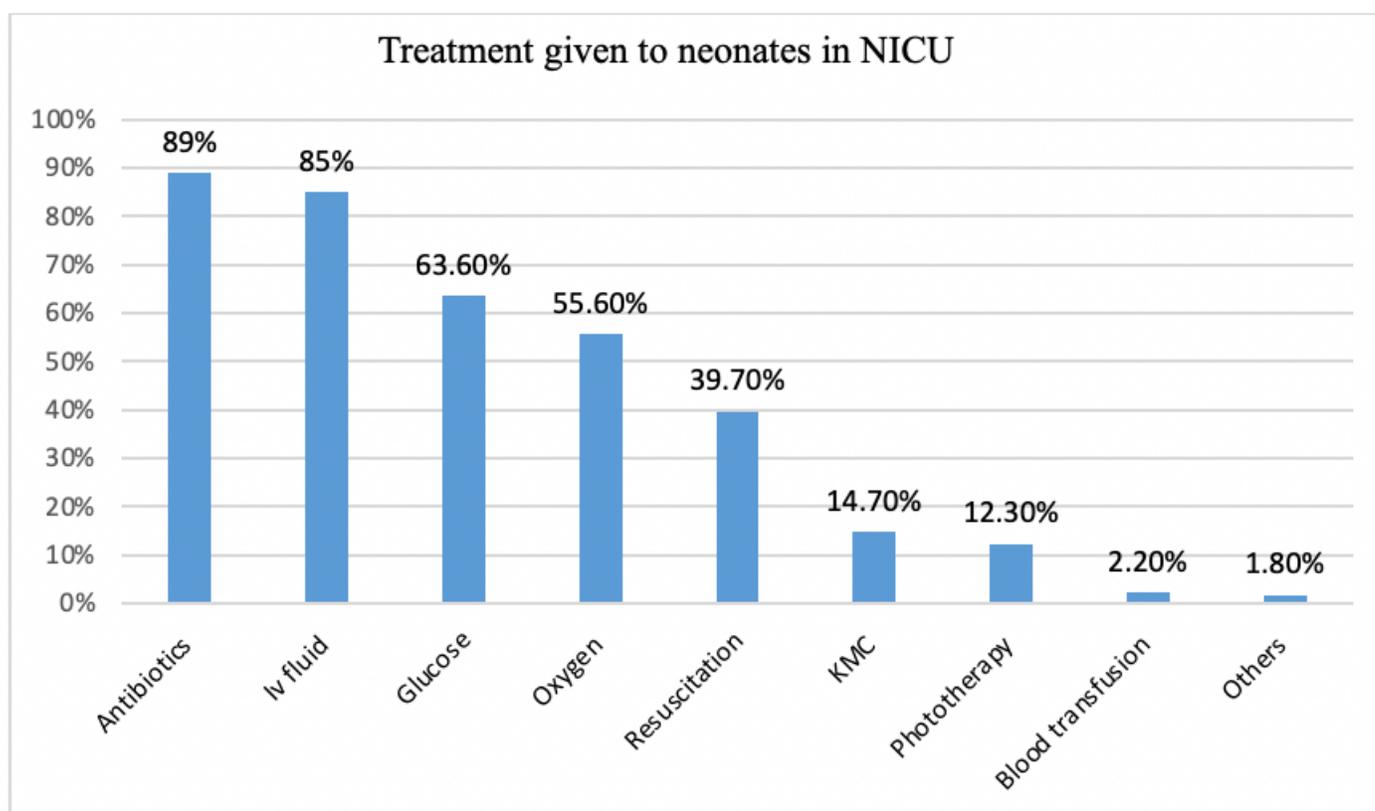
Figures

Figure 1

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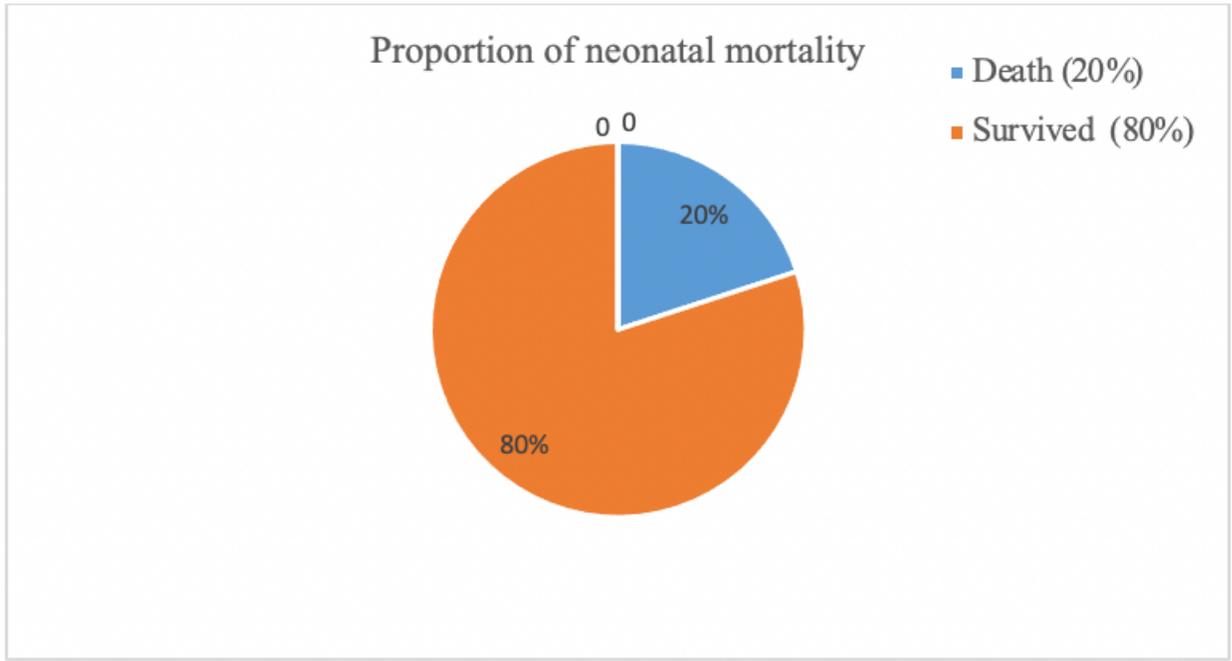
Proportion of neonatal mortality

Figure 2

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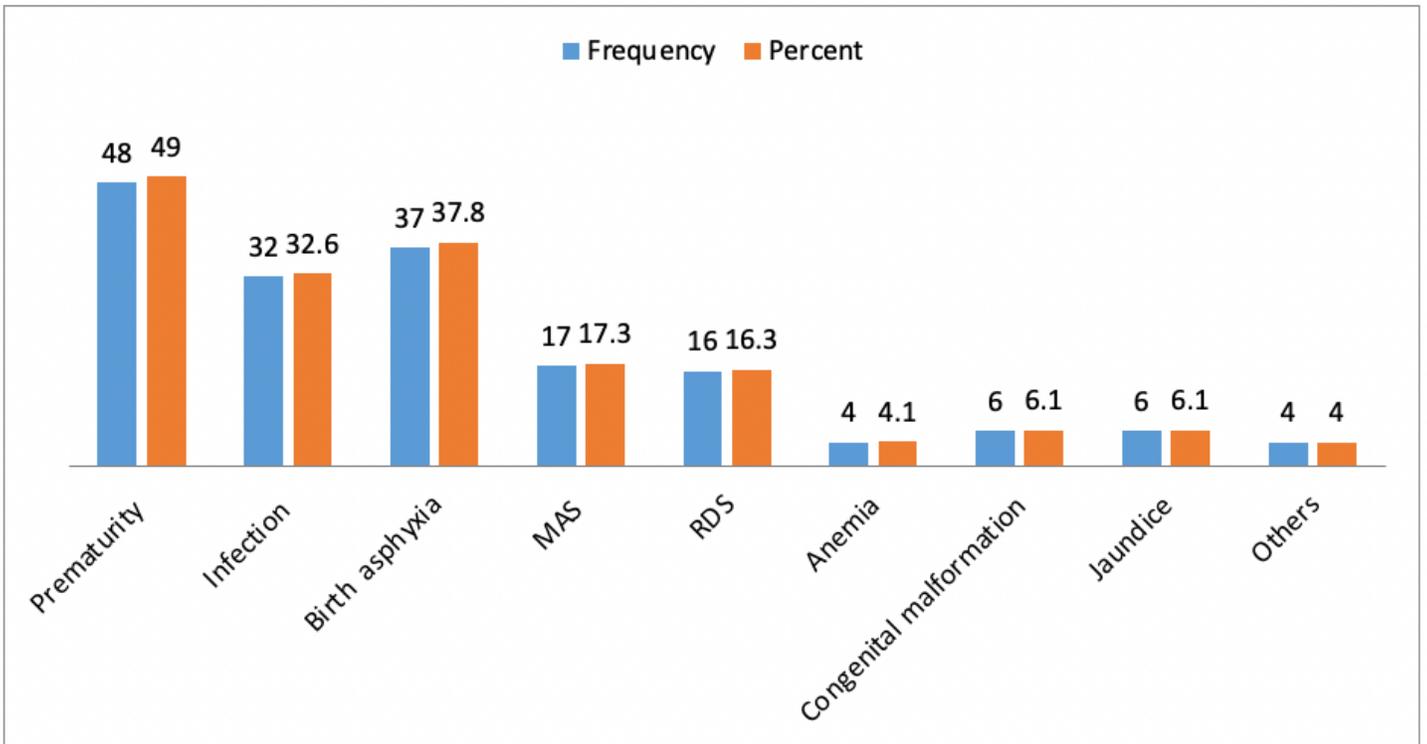

Figure 3

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