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Magnitude of neonatal near miss in public hospitals in Eastern Ethiopia: A cross-sectional study

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Abstract

Objectives: Although neonatal near miss is an emerging concept and a tool for improving neonatal care, its magnitude and associated factors are less researched in Ethiopia. Thus, this study was aimed to uncover the magnitude of neonatal near miss and its associated factors in public hospitals in Eastern Ethiopia.

Methods: A facility-based cross-sectional study was employed on a randomly selected 405 mother–neonate pairs. An interview using a structured questionnaire accompanied by review of medical records was used to collect data from the mothers and records of the neonates. Neonatal near miss was defined as having any of the pragmatic (gestational age $<$ 33 weeks, birth weight $<$ 1750 g, and fifth minutes Apgar score $<$ 7) or management criteria. Crude and adjusted logistic regression analysis was done to identify associated factors and presented with adjusted odds ratio with 95% confidence interval.

Results: Of 401 mother–neonate pairs included in the study, 126 (31.4%, 95% confidence interval = [26.9, 36.2]) neonates had at least one neonatal near miss event at discharge. Neonatal near miss was more likely among neonates from referred women (adjusted odds ratio = 2.24, 95% confidence interval = [1.25, 4.03]), no antenatal care (adjusted odds ratio = 2.08, 95% confidence interval = [1.10, 3.93]), antepartum hemorrhage (adjusted odds ratio = 4.29, 95% confidence interval = [2.16, 8.53]), premature rupture of membrane (adjusted odds ratio = 4.07, 95% confidence interval = [2.05, 8.07]), obstructed labor (adjusted odds ratio = 2.61, 95% confidence interval = [1.23, 5.52]), non-vertex presentation (adjusted odds ratio = 3.03, 95% confidence interval = [1.54, 5.95]), and primiparous (adjusted odd ratio = 2.67, 95% confidence interval = [1.49, 4.77]).

Conclusions: In this study, we found that neonatal near miss is higher than previous findings in Ethiopia. Improving neonatal near miss requires promoting antenatal care, maternal referral system, and early identification and management of obstetric complications.

Keywords

Eastern Ethiopia, public hospitals, neonatal near miss

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Introduction

Despite all the efforts, the decline in neonatal mortality rate (NMR) is slow worldwide. In 2018, 2.5 of 5.3 million under-five deaths were among the neonates, with sub-Saharan Africa accounting for the highest magnitude (28 per 1000 live births).[1] As such, neonatal mortality remained a major challenge in several low- and middle-income countries.[2,3] Although neonatal mortality is an indicator of neonatal health, it shows only the iceberg tip of neonatal ill-health, with majority of neonates surviving the complications going unnoticed.[2] Therefore, understanding the true magnitude of neonatal ill-health requires studying neonates who survived

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from severe complications (neonatal near miss (NNM)) in addition to neonatal deaths.[4]

NNM refers to a neonate that almost died but survived from severe complications that occurred within the first 28 days of life.[5,6] Analogous to maternal near miss, NNM is an emerging approach and is becoming a key indicator for assessing quality of neonatal care to reduce preventable neonatal morbidity and mortality.[5,7] Study of NNM has an invaluable contribution to reduce neonatal mortality.[2,5,6] Although there is no commonly agreed identification criteria for NNM, the Latin American Center for Perinatology (CLAP) proposed a standard definition and identification criteria for NNM based on the World Health Organization multi-country study.[6,7] As such, NNM identification criteria consist of two set of criteria: pragmatic (gestational age $<$ 33 weeks, birth weight $<$ 1750 g, and fifth minutes Apgar score $<$ 7) and management based (use of continuous positive air pressure (CPAP), use of vasoactive drugs, bag and mask ventilation, use of phototherapy, use of anticonvulsant drugs, respiratory distress, any intubation, etc. (listed in the subsection "measurement and variables")).[2,6,7]

Despite the wider acceptance of NNM as a concept, there is a paucity of information and the need for more studies in different settings was previously indicated.[2,5,6] Studying NNM in Ethiopia, where reduction in neonatal mortality is still slow,[3] would generate data on important factors for neonatal survival.[8] However, the magnitude of NNM remained uncovered.[9–13] In addition, methodological limitations, such as non-random sampling[14,15] or use of secondary data,[16] may underestimate or overestimate NNM cases and made it difficult to generalize findings. In this study, we assessed the magnitude of NNM and its associated factors among neonates born in major public hospitals in Harari Region, Eastern Ethiopia.

Methods

Study settings

This study was conducted in public hospitals in Harar, Eastern Ethiopia. Harar is the capital city of Harari Region, located 526 km away from the capital city, Addis Ababa. According to population projection from the 2007 census, the region has an estimated population of 263,656 in 2020/2021.[17] There are two public hospitals, one private hospital, one police hospital, eight health centers, 54 private clinics, and 24 health posts in the region—majority of which are located in Harar. The study was conducted in Hiwot Fana Comprehensive Specialized University Hospital (HFSUH) and Jugel hospital (JH). HFSUH is the tertiary hospital affiliated with Haramaya University while JH is a regional hospital located in the same town. Both hospitals provide maternal neonatal and child health services. HFSUH provides comprehensive specialized care including the only well-established neonatal intensive care unit (NICU) in the region. It is serving as a major referral center serving more than 5 million people in Eastern Ethiopia. The study was conducted from 20 June to 20 August 2021.

Study design and population

A facility-based cross-sectional study design was conducted. All neonates born in public hospitals in Harari Region were the source population, while all live births in both hospitals during the study period were the study population. All randomly selected live births with their mothers during the study period were the study units.

Inclusion criteria

All live births with their mothers were included in the study.

Exclusion criteria

Self-discharges or discharges against medical advice and neonates referred out were excluded from the study.

Sample size and sampling techniques

Sample size was calculated using single population proportion formula and factors associated with NNM using Epi-Info Version 7.2.4.0 Stat Calc. computer software using the assumptions like power 80%, confidence interval 95%, percent of cases among exposed and unexposed, and finally, the largest sample size was considered ($n = 405$). After sample was allocated to each hospital proportionally based on the expected births over the study period, a systematic random sampling technique was employed to select eligible neonate–mother pairs and interviewed at discharge. Every third live birth from the delivery registration book were identified and interviewed at discharge.

Data collection

Data were collected through interview of the mother using a structured questionnaire supplemented with review of maternal and neonatal medical records.[6] The questionnaire consists of data on maternal and fetal sociodemographic, obstetric conditions, and identification of the presence of any of the pragmatic or management-based NNM criteria.[6,7] Data were collected by four well-trained BSc midwives and supervised by two MSc midwives in maternity and neonatal nursing, who are fluent in the local languages (Afan Oromo and Amharic). A pre-tested structured interviewer-administered questionnaire was used to collect sociodemographic data complemented with review of maternal and neonatal records at discharge. Onsite daily supervision was carried out throughout the data collection period.

Measurement and variables

The outcome of the study, NNM, was categorized as "Yes" (code as 1), if they fulfill any of the pragmatic or/and

management criteria at discharge[2,6,7] or No (coded as 0) otherwise. The independent variables included socio-demographic characteristics (age, education, occupation, residence, referral status, smoking status), medical, and obstetrics conditions (diabetes mellitus, syphilis, anemia in pregnancy, parity, history of abortion, history of neonatal loss, antenatal care (ANC), birth interval, onset of labor, pregnancy induced hypertension, premature rupture of membrane, antepartum hemorrhage, obstetric complications, and neonatal conditions).

Operational definition

NNM: any neonate identified with at least one of the following pragmatic or/and management criteria but survived either by chance or treatment (Box 1).[6]

Box 1. Neonatal near miss identification criteria.[2,6,7]

Pragmatic criteria	Management criteria
• Birth weight < 1750 g • Gestational age < 33 weeks • 5th minutes Apgar score < 7; validated by world health organization multi-country studies (WHOMCS)[6]	• Parenteral therapeutic antibiotics • Positive pressure ventilation • Parenteral nutrition • Nasal continuous positive airway pressure • Any intubations • Phototherapy use • Use of anticonvulsant drugs • Use of vasoactive drugs • Cardiopulmonary resuscitation (CPR) • Use of steroid for the treatment of refractory hypoglycemia • Use of any blood products and any surgery done

Statistical analysis

All collected data were cross-checked for completeness and consistency, coded, and double-entered to Epi-Data 3.1 and exported to SPSS 26 for analysis. Descriptive summary measures such as frequency, percentages, means, and standard deviation were used to describe the characteristics of the participants. Bivariable logistic analysis was used to identify variables associated with NNM, and variables with p value of <.25 in the bivariable analysis were candidates for multivariable analysis after checking for multicollinearity. Multicollinearity was checked using variance inflation factor (VIF) or tolerance test and standard error. No variables with VIF > 10 or standard error of >2 or tolerance test <0.1 were identified with the test. Model fitness was also checked using Hosmer-Lemeshow tests, and the model was fitted. Association was described using adjusted odds ratio (AOR) along with 95% confidence interval (CI). Finally, $p < .05$ in the multivariable analysis was considered as a cut-off point for statistically significant association.

Results

Characteristics of study participants

Of 405 women–neonate pairs approached, 401 (99%) were included in the study. The mean age of the mothers was 26.7 years (± 5.5 years), ranging from 16 to 40 years. The majority of the mothers were 20–34 years old (81%), married (93.3%), and housewives (78.8%; Table 1). A fifth of the mothers had pregnancy induced hypertension (20.2%), history of abortion (22%), and prolonged labor (19.2%). One in four (38.7%) births was by cesarean section (Table 2). Majority of the neonates had vertex presentation (83.8%) and delivered at term (78.6%). However, a third of the neonates had non-reassurance fetal heart rate (34.9%) and were admitted to NICU (29.7%; Table 3).

Magnitude of NNM. At discharge, 126 (31.4%; 95% CI = [26.9, 36.2]) neonates had at least one NNM event. Accordingly, 3 out of 10 neonates delivered in public hospitals developed NNM at discharge. The most frequent pragmatic criteria of NNM were low fifth minutes Apgar score (54.8%) while use of parenteral antibiotics (61.9%) and cardiopulmonary resuscitation (61.9%) were the major NNM events as per the management-based criteria (Table 4).

Factors associated with NNM

After controlling for confounding factors, antenatal care, parity, antepartum hemorrhage, premature rupture of membrane, obstructed labor, non-vertex presentation, and maternal referral status were significantly associated with NNM. The odds of NNM among neonates born to mothers who were referred from other facilities were 2 times (AOR = 2.24, 95% CI = [1.25, 4.03]) compared with those from mothers who were not referred. Neonates of primiparous women were almost 3 times (AOR = 2.65, 95% CI = [1.49, 4.77]) more likely to have NNM compared with their counterparts. Moreover, NNM was 2 times (AOR = 2.08, 95% CI = [1.10, 3.93]) and 4 times (AOR = 4.29, 95% CI = [2.16, 8.53]) higher among mothers with no antenatal care and who had antepartum hemorrhage (APH), respectively, compared

Table 1. Sociodemographic characteristics of mothers of neonates born in public hospitals in Harari Region, Eastern Ethiopia, 2021 ($n=401$).

Characteristics	Frequency (n)	Percent (%)
Age of mothers in years		
<20	40	10.0
20–34	325	81.0
35–49	36	9.0
Marital status		
Married	374	93.3
Others	27	6.7
Maternal education		
No formal education	269	67.1
1–8	58	14.4
9–12	36	9.0
Diploma and above	38	9.5
Paternal education level ($n=396$)		
No formal education	210	53.0
1–8	60	15.2
9–12	57	14.4
Diploma and above	69	17.4
Maternal occupation		
Housewife	316	78.8
Merchant	50	12.5
Non-government employee	29	7.2
Daily laborer	6	1.5
Paternal occupation ($n=396$)		
Farmer	184	46.5
Merchant	91	23.0
Non-government employee	76	19.2
Daily laborer	45	11.3
Residence		
Urban	174	43.4
Rural	227	56.6
Mother's smoking status in pregnancy		
Yes	14	3.5
No	387	96.5
Maternal referred from other facilities		
Yes	222	55.4
No	179	46.6

with their counterparts. Neonates born from mothers with premature rupture of membrane and obstructed labor were 4 (AOR=4.07, 95% CI = [2.05, 8.07]) and 2 (AOR=2.61, 95% CI = [1.23, 5.52]) times more likely to develop NNM, respectively, compared with their counterparts. In addition, neonates with non-vertex presentation were 3 times (AOR=3.03, 95% CI = [1.54, 5.95]) more likely to become near miss than their counterparts (Table 5).

Discussion

In this study, we assessed the magnitude of NNM and its associated factors among neonates born in major public

Table 2. Maternal medical and obstetrics conditions among neonates born in public hospitals in Harari Region, Eastern Ethiopia, 2021 ($n=401$).

Variables	Frequency (n)	Percent (%)
Diabetes mellitus		
Yes	14	3.5
No	387	96.5
Anemia in pregnancy		
Yes	27	6.7
No	374	93.3
Syphilis in pregnancy		
Yes	12	3.0
No	389	97.0
Parity		
1	149	37.2
2–4	183	45.6
⩾5	69	17.2
History of abortion		
Yes	88	22.0
No	313	78.0
History of stillbirth		
Yes	42	10.5
No	359	89.5
History of neonatal loss		
Yes	24	6.0
No	377	94.0
Had ANC visit		
Yes	321	80.0
No	80	20.0
Number of ANC visits ($n=321$)		
1–3 times	189	58.9
⩾4 times	132	41.1
Gestational age at first ANC visit (321)		
⩽12 weeks	71	22.1
>12 weeks	250	78.9
Onset of labor		
Spontaneous	294	73.3
Induced	76	19.0
CS before labor	31	7.7
Obstetrics complications		
Pregnancy-induced hypertension	81	20.2
Antepartum hemorrhage	65	16.2
Premature rupture of membrane	58	14.5
Prolonged labor	77	19.2
Obstructed labor	49	12.2
Oligohydramnios	17	4.2
Mode of delivery		
SVD	200	49.9
Instrumental assisted vaginal delivery	46	11.5
CS	155	38.6

ANC: antenatal care; CS: cesarean section; SVD: spontaneous vertex delivery.

Table 3. Neonatal characteristics among neonates born in public hospitals in Harari Region ($n = 401$).

Characteristics	Frequency (n)	Percent (%)
Fetal presentation at birth		
Non-vertex	65	16.2
Vertex	336	83.8
Non-reassurance fetal heart rate pattern		
Yes	140	34.9
No	261	65.1
Sex of neonate		
Male	205	51.0
Female	196	49.0
Gestational age at birth		
<37 weeks	75	18.7
37–42 weeks	315	78.6
>42 weeks	11	2.7
5th minutes Apgar score		
<7	69	17.20
⩾7	332	82.80
Birth weight (grams)		
<2500	41	10.2
2500–3999	341	85.0
⩾4000	19	4.8
Neonatal complication		
Yes	147	36.7
No	254	63.3
Type of complication identified ($n = 147$)		
Birth asphyxia	86	58.5
Respiratory distress syndrome	89	60.5
Meconium aspiration syndrome	105	71.4
Birth trauma	18	12.2
Hypothermia	43	29.3
Hypoglycemia	12	8.2
Congenital malformation	7	4.8
Admitted to NICU		
Yes	119	29.7
No	282	70.3

NICU: neonatal intensive care unit.

Table 4. Description of pragmatic and management events among NNM cases ($n = 126$).

Neonatal near miss events	Frequency (n)	Percent (%)
Pragmatic criteria		
Birth weight < 1750 g	9	7.1
5th minutes Apgar score < 7	69	54.8
Gestational age < 33 weeks at birth	15	11.9
Management criteria		
Use of therapeutic parenteral antibiotics	78	61.9
Use of nasal continuous positive air pressure	49	38.9
Positive pressure ventilation	68	54.0
Use of any intubation	29	23.0
Use of parenteral nutrition	25	19.8
Use of phototherapy	19	15.1
Cardiopulmonary resuscitation	78	61.9
Use of any vasoactive drugs	33	26.2
Use anticonvulsants	26	20.6
Use of steroids for the treatment of refractory hypoglycemia	6	4.8
Any surgery done	6	4.8
Use of any blood products	5	4.0
Any pragmatic or management markers of severity	126	100[a]

NNM: neonatal near miss.
[a]Percentage >100% since some neonates have more than one neonatal near miss event.

hospitals in Harari Region, Eastern Ethiopia. We found that the overall magnitude of NNM was 31.4% (95% CI = [26.9, 36.2]), which is relatively higher than other countries report and much higher than world health organization multi-country studies (WHOMCS) (7.25%).[6] NNM was found to be more likely among women who were referred from other facilities, primiparous, had no prenatal care, had antepartum hemorrhage, obstructed labor, premature rupture of membrane, and neonates with non-vertex fetal presentations at birth.

Our finding is in line with findings in Ethiopia [Hawassa (33.4%)[15] and Debre Tabor (32.9%)[16]] and Brazilian university hospitals (30.3%).[18] However, it is higher than some other studies in Ethiopia [Jimma (26.7%)[14] and Injibara (23.3%)[19]], Nepal (7.9%),[20] Brazil [(8.7%),[21] (22.2%),[22] (3.3%)[23]], and the WHOMCS (7.3%).[6] This might be related with differences in sociodemographic conditions and mothers' ability of early recognition of complications and health-seeking behavior, study settings, and NNM identification criteria. However, our study is lower than a finding from Uganda (36.7%)[24] and Ghana (70%).[25] This might be related with differences in inclusion criteria and settings.

Consistent with previous studies, NNM was more likely among neonates born to women who were referred from other facilities, primiparous, did not have prenatal care, had obstetric complications, and non-vertex fetal presentations. The high burden of NNM among neonates born to mothers who were referred from other facilities was also reported in Ethiopia[11,19] and India.[26] This might be related to the delays in reaching facilities on time and the obstetric complications leading to referral.[27] Given problems with our referral system—delays, poor communication, and safety of roads and distances—it is more likely that the women will reach the appropriate facilities after it is too late for preventing maternal or neonatal complications.[28] In addition, effect of obstetric complications on adverse neonatal outcomes was previously reported.[29]

In line with several studies,[16,19,22,30] we found that NNM was higher among primiparous mothers. This might be

Table 5. Factors associated with NNM in public hospitals in Harari Region, Eastern Ethiopia, 2021.

Variables category	Neonatal near miss (NNM)		COR (95% CI)	AOR (95% CI)
	Yes (%)	No (%)		
Maternal age in years				
<20	18 (45.0)	22 (55.0)	2.20 [1.13, 4.30]	1.13 [0.48, 2.69]
⩾35	20 (55.6)	16 (44.4)	3.37 [1.70, 6.80]	2.70 [0.99, 6.70]
20–34	88 (27.1)	237 (72.9)	1	1
Maternal referral status				
No	27 (15.1)	152 (84.9)	1	1
Yes	99 (44.6)	123 (55.4)	4.53 [2.80, 7.40]	**2.24 [1.25, 4.03]***
Anemia in pregnancy				
No	112 (29.9)	262 (70.1)	1	1
Yes	14 (51.9)	13 (48.1)	2.52 [1.15, 5.53]	1.68 [0.61, 4.59]
Parity				
1	59 (39.6)	90 (60.4)	1.81 [1.18, 2.79]	**2.67 [1.49, 4.77]***
⩾2	67 (26.6)	185 (74.4)	1	1
Antenatal care visit				
No	43 (53.8)	37 (46.2)	3.33 [2.01, 5.53]	**2.08 [1.10, 3.93]***
Yes	83 (25.9)	238 (74.1)	1	**1**
History of abortion				
No	86 (27.5)	227 (72.5)	1	1
Yes	40 (45.5)	48 (54.5)	2.20 [1.35, 3.58]	1.48 [0.79, 2.76]
Antepartum hemorrhage				
No	84 (25.0)	252 (75.0)	1	1
Yes	42 (64.6)	23 (35.4)	5.48 [3.11, 9.64]	**4.29 [2.16, 8.53]***
Obstructed labor				
No	100 (28.4)	252 (71.6)	1	1
Yes	26 (53.1)	23 (46.9)	2.85 [1.55, 5.23]	**2.61 [1.23, 5.52]***
PROM				
No	91 (26.5)	252 (73.5)	1	1
Yes	35 (60.3)	23 (39.7)	4.21 [2.36, 7.51]	**4.07 [2.05, 8.07]***
Fetal presentation				
Vertex	83 (24.7)	253 (75.3)	1	1
Non-vertex	43 (66.2)	22 (33.8)	5.96 [3.37, 10.54]	**3.03 [1.54, 5.95]***

NNM: neonatal near miss; COR: crude odds ratio; AOR: adjusted odds ratio; CI: confidence interval; PROM: premature rupture of membrane.
*Indicates that significant at $p < .05$, 1, reference.

related with limited experience of pregnancy, danger signs, labor, and delivery, delay in health-seeking, and high risk for prolonged labor, induction of labor, and birth asphyxia among primaprous.[31,32] Moreover, our finding shows those neonates born to mothers with no antenatal care were more likely to develop NNM in agreement with other studies.[9,10,16,28] Having prenatal care will enable women to get information about their pregnancy, knowledge regarding danger signs, and where to seek care when needed,[33,34] thus reducing risk of NNM. We also found that complications in pregnancy or labor and delivery are significant contributors of NNM. Consistent with other studies, NNM is more likely among neonates born to a woman who had APH.[16,30] Given APH increases the risk of compromised fetal blood perfusion, which leads to uteroplacental insufficiency, this might result in preterm birth and birth asphyxia and thereby NNM.[31,35–37] Similarly, neonates born to a mother with premature rupture of membrane (PROM) were more likely to have NNM, a finding supported by previous studies.[10,16,19] Since association of PROM with preterm birth, respiratory distress syndrome, intravascular hemorrhage, cord prolapse, reduced amniotic fluid volume, chorioamnionitis, neonatal sepsis, and birth asphyxia was reported,[38–40] this finding was expected. Similarly, obstructed labor[14,16,19] and non-vertex presentation were associated with NNM.[10,14]

Strengths and limitations of the study

The strength of this study is the use of combined data collection technique (face-to-face interview and review of medical records) which enabled us to identify basic sociodemographic and obstetric factors. However, our study has also some limitations. *First*, our follow-up was limited to hospital discharges or 28 days, whichever comes first. As a result, NNM after discharge or among neonates referred out might be missed. *Second*, since we limited our observation to only

hospital births, NNM might be overestimated since majority of births—especially low risk births are occurring at home or health centers—since mainly women with high risk pregnancies are giving birth in facilities.

Conclusion

We found that NNM among neonates delivered in public hospitals in Eastern Ethiopia is higher than findings from similar settings in Ethiopia. NNM was more likely among neonates born to a woman who is referred, primiparous, and had no prenatal care, had non-vertex presentation, and obstetrics complications (antepartum hemorrhage, premature rupture of membrane, and obstructed labor). Improving NNM and attaining sustainable development goals require addressing major obstetric complications resulting in NNM. Further study on the quality of care provided to neonates and delays in the referral system is warranted to identify missed opportunities in the care.

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Author contributions

M.A.T., A.K.T., and A.S. conceived study. M.A.T. analyzed and interpreted the data under the close mentorship and supervision of A.K.T., A.S., and G.T. M.A.T. wrote the original draft of the manuscript with continuous input from A.K.T., A.S., and G.T. All authors contributed to the writing and reviewed the article and approved the final manuscript to be published.

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