Survival and predictors of early neonatal death in neonatal intensive care unit of Mekelle general and Ayder comprehensive specialized hospitals, Northern Ethiopia, 2018: prospective cohort study

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Abstract
Background: Early neonatal mortality refers to deaths of neonates between 0 and 6 days of life. This contributes three-quarters of neonatal deaths globally. Its predictors vary by country with the availability and quality of health care, which was chosen as the measure of mortality and remains a global public health concern especially in sub-Saharan African countries, including Ethiopia. So the aim of this study is to determine incidence, median survival time and to identify the predictors of early neonatal mortality.

Methods: A prospective cohort study was conducted in Mekelle general and Ayder comprehensive specialized hospitals, Tigray, Ethiopia from January to March, 2018. Data were collected from 253 newborns admitted to the neonatal intensive care unit by interviewing mothers using structured questionnaires and followed for seven completed days of life (day 0 to 6). Kaplan Meier curves were used to estimate survival time, Log-rank test was used to look statistical differences among/between the categories of variables and Cox regression model was used to identify potential predictors of early neonatal deaths. The analysis was conducted using a computer program Stata version 12.

Results: Overall, in this study 32 (12.65%) neonates died which makes the early neonatal mortality rate 126.5 per 1000 live births. The median survival time of early neonates was 2 days. Predictors of early neonatal mortality were very low birth weight (AHR = 3.02; 95 % CI: 1.11, 8.25) and preterm birth (AHR=3.7; 95 % CI: 1.22, 11.188).

Conclusion: This study shows high incidences of early neonatal mortality. Very low birth weight and preterm birth were major predictors for early neonatal mortality. Managing complications of preterm and very low birth weight, preventing preterm delivery and improving quality of services and ensuring a continuum of care are recommended to increase survival of early neonate

Background
The early neonatal period begins at birth and includes the 1st seven days of life(1–3). This is very vulnerable and critical time for neonate survival because high rates of mortality and morbidity in human life present during this period(4–6). Early Neonatal Mortality (ENM) refers to deaths of neonates between 0 and 6 days of life, which uses as the measure of mortality and remains a global public
health concern especially in sub-Saharan African countries (7-9).

In 2017 globally under-five mortality rate was 39 deaths per 1000 live births and 47 percent of these occur during the neonatal period worldwide. Neonatal mortality (NM), accounting for an estimated 2.5 million or 7,000 newborns died every day with the rate of 18 deaths per 1000 live births (10-12). Three-quarters or 75% of neonatal deaths occur in the first week, and more than one-quarter occur in the first 24 hours (13-15).

According to World Health Organization (WHO) report in Uganda neonatal mortality rate (NMR), was underestimated, which was very high at 29 deaths per 1,000 live births and has not declined over a period of 15 years. The common causes of neonatal deaths in Uganda are similar to the rest of African countries like Ethiopia, include birth asphyxia, infections and complications of preterm birth (16). The gaps between rich and poor countries were widening: neonatal mortality is now 6.5 times lower in the high-income countries than in low income countries (17). According to Ethiopian demographic health survey (EDHS) 2016 Ethiopia accounted 29 deaths per 1000 live births of neonatal mortality rate and most of the neonates died in the first week of life (18).

A delay in the identification and treatment of neonatal sepsis leads to the high mortality (20). In developing countries deaths are often not registered and causes of death are not assigned to 99% of deaths (21-23). According to Ethiopian Demographic Health Survey (EDHS) 2000 to 2016 neonatal morbidity and mortality continue to be a large component of the burden of disease in Sub-Saharan Africa and its rates reflect a nation’s socio-economic status, the efficiency and effectiveness of health care services (24).

Majority of the causes of neonatal morbidity and mortality are preventable. There is a variation in neonatal mortality rate at Neonatal Intensive Care Units (NICU), which importantly reflect variations in quality of care (25). So the purpose of this study was to determine incidence, median survival time and to identify the predictors of early neonatal mortality.

The current global burden of neonatal and child death is largely concentrated in the two regions which account almost 80% of the newborn deaths. Southern Asia accounted 39% of all such deaths and sub-Saharan Africa accounted 38% among newborns. In sub-Saharan Africa, about 1 child in 36
dies in the first month, while in the world’s high-income countries the ratio is 1 in 333\((11,22)\).

Regardless of Ethiopia’s remarkable success in infant and under-5 mortality, the reduction in neonatal mortality is relatively low. EDHS 2011 reported the Neonatal Mortality Rate (NMR) as 37/1000 live births, which has not shown significant declines from the 2005 EDHS report of 39/1000 live births and in 2016 EDHS report of 29/1000 live births have great reduction but it is still under estimation\((11,26)\).

The causes of neonatal mortality are not well documented in Ethiopia; however, reports from previous studies like a study conducted in Gonder, Northwest Ethiopia identified sepsis, asphyxia, birth injury, tetanus, preterm birth, congenital malformations, and “unknown causes” as major reasons for neonatal mortality but the median survival time of the neonate was not determined \((14)\).

Even though there is a reduction on neonatal mortality that Ethiopia accounted 29 deaths per 1000 live births of neonatal mortality rate and the proportion of NM 43 % and 60.4% in U5M(Under Five Mortality) and in infant respectively, and three quarter (75 %) of these mortality happened in the first week of life, which was also the same in Tigray\((24)\) and the EDHS–2016 showed that there is still a high mortality rate comparing to the target stated in Health Sector Transformation Program (HSTP)10% which is three fold of the target\((27)\).

Different studies have done in Tigray which shows there are still different causes of neonatal mortality in all facility but those studies limited by: these were done before NICU was advanced with technology as well as care, were focused on the neonates both admitted in NICU and in pediatric wards, it was focused on neonate those who delivered by skilled health professionals and were limited to identify early neonatal mortality separately.

Globally half of all neonatal deaths are concentrated in five countries including Ethiopia which accounts 3% \((11)\). Since causes of early neonatal deaths vary by country and with the availability and quality of health care, understanding early neonatal deaths in relation to these factors is crucial. Understanding of these influences could help to deliver or optimize quality of care for neonates and it will be an input for health workers, hospital management, policy makers and program managers to develop interventions that may reduce neonatal mortality rate. This is also important in order to set health care services more focusing in maternal and child health in addition to strengthen NICU service
and may be used to put different interventions.

Methods
Study area and period
This study was conducted in Mekelle general and Ayder comprehensive specialized hospitals, Tigray regional state; which is located at 783km from Addis Ababa (the capital city of Ethiopia) from January to March, 2018. According to Central Statistics Agency 2015, Tigray region has an estimated total population of 5,056,000 with an area of 84,722 km²\(^2\)\(^{(10,54,55)}\).

The Ethiopia health care has a three-tier health-service delivery system. The primary level consists of primary healthcare units (health posts and health centers) and primary hospitals, secondary level services are provided by general hospitals and tertiary services by specialized hospitals. Tertiary level specialized hospital serving for 3.5 - 5 million people, Secondary level general hospital to serve 1-1.5 million catchment populations and Primary level: rural primary hospital60 000 -100 000 people, health Centre15 000 - 25 000 people and health post3 000 - 5 000 people and urban health center serve for 40 000 people\(^{(10)}\).

Study design
A prospective cohort study was conducted among a cohort of early neonates who were admitted to neonatal intensive care unit (NICU) from January to March, 2018 in Mekelle general and Ayder comprehensive specialized hospitals. The minimum follow up time for this study was 7 days until the event of interest occurs (neonatal death).

Source population
All early neonates admitted to neonatal intensive care unit in Mekelle general and Ayder comprehensive specialized hospitals, Tigray, Ethiopia

Study population
All early neonates admitted to neonatal intensive care unit in Mekelle general and Ayder comprehensive specialized hospitals, Tigray, Ethiopia from January to March 2018.

Study subject
Study participants selected by systematic sampling method from early age neonates in neonatal intensive care units of Mekelle general and Ayder comprehensive specialized hospitals, Tigray,
Ethiopia from January to March 2018.

Inclusion and exclusion criteria

Inclusion criteria
All early neonates in neonatal intensive care units of Mekelle general and Ayder comprehensive specialized hospitals, Tigray, Ethiopia from January to March 2018.

Exclusion criteria
All neonates’ greater ≥7 days of life admitted to neonatal intensive care units

Sample size determination
The general formula for the required number of subjects in a survival study expressed as (56).

\[ N = \frac{E}{\frac{P(E)}{p(E)}} \text{ Where } E = \frac{(Z_{a/2} + Z\beta)^2}{p(1-p)\delta^2} \]

Where E () is the number of events required to be observed in a study, and pE () is the probability of observing an event in a study. \( \delta \) is log (HR)

Sampling technique and procedure
The study hospitals selected purposely due to the service provision is given with well skilled health providers and better technology that use as referral for the entire region. Two hundred fifty three (253) study participants also selected proportional from Ayder comprehensive specialized hospital (202) and Mekelle general hospitals (51).

Study variables
The conceptual framework proposed by Mosley and Chen (57), was used in this study to identify and classify the factors that potentially influence ENM.

Dependent variable
Early neonatal mortality was categorized into ‘Yes’ if the neonate died ‘No’ if the neonate censored. Censored births were the neonates, who were alive at the end of follow up.

Independent variables
The independent variables in this study were demographic and socio-economic, maternal, delivery factors, neonatal factors, and NICU factors.

Data Collection Procedure
Data collection in NICU was carried out prospectively by interviewing mothers using structured questionnaires and from the medical record charts using the data extraction checklist of the neonates by trained nurses. During the process, the principal investigator was supervised these trained data collectors and assisted by intensive care unit head nurse. The questionnaire was derived from WHO standard verbal autopsy questionnaires (8). The questionnaire was initially developed in English and translated into local language, Tigrigna. One nurse that can speak the local language from each hospital was assign for data collection. The data collectors were collected information by interviewing all mothers whose neonate admitted to NICU of Mekelle general and Ayder comprehensive specialized hospitals from 0–6 days of life and the clinical information was extracted from medical record charts and by assessment of neonates. The mother and neonate follow for seven days and whenever the neonate discharged to home data collection was completed using phone call. Data collection included demographic and socio-economic characteristics, maternal, delivery, new born and NICU factors. The outcome variable was death in the first 0–6 days after birth.

**Data Quality control and management**

Various efforts were made to assure the data quality. Personal supervision especially in the data collection process, training was given to data collectors about the research protocols and also oriented on how to appropriately collect the data. Data quality process starts from the check list to the computer entry. The principal investigator inspects all the performances of the data collectors and measure data. Before the data were entering, it was checked for completeness and consistency by the PI. The process of data generation and entry was under close supervision of the investigator. Data were cleaned, sorting and analysis using STAT software version 12.

**Data analysis**

Death of neonate was the event of interest and the coding were “1” for death and “0” for censored. The survival time was calculated in days using the time interval between the date of birth and the date of death. Information about the number of deaths before seven complete days after birth and right-censoring (survival beyond seven days). Data was entered; cleaned, recoded and analyzed using STATA Version 12 statistical software. The statistical analysis of survival was based on Cox
proportional hazards regression model. Cox-proportional hazard model was used to identify the predictors of early neonatal death. The Cox proportional hazards model is such a model: 

\[ H(t) = h_0(t) \exp(\beta_1 x_1 + \cdots + \beta_k x_k) \tag{58,59} \]

Descriptive statistics used to describe the frequencies, percentages, rates and to calculate the mean and standard deviation after checking the distribution of the data. Kaplan Meier curves were used to show the pattern of death, estimate probability of survival and to compare the survival curves. Log-rank test was used to look statistical differences among or between the categories of variables to be included in the Cox-proportional hazard model. Cox regression model was used to identify potential predictors of early neonatal deaths.

In the Univariate or Bivariate Cox analysis the covariates; residence, mother educational status, number of newborn, distance from health facility, Birth weight, Gestational age, Apgar score in one minute, sex, admission diagnosis and medication were identified as statistically significant at \( p \_ \text{value} \leq 0.25 \) level of significance. These significant explanatory variables were included in the Cox-proportional hazard model to identify potential predictors of ENM.

After confounding variables were identified, the variables with \( p \)-values of 0.05 or less were retained in the final model analysis. Confounding and effect modification was checked by looking at regression coefficient change if greater than or equal to 15 % and multi-co linearity was checked using variance inflation factor and value of <10 was used as a cutoff point, indicating no co linearity.

Proportional hazard assumption was tested by using covariate specific proportional hazard assumption test. Residuals were checked using graphs and goodness-of-fit test by Cox Snell residuals.

Upon the finding HR and 95% CI interpretation for statistically significant predictors were perform.

**Operational definitions**

Birth asphyxia/shortness of breathing: Any respiratory problem, fast breathing, and or difficulty of breathing.

Early Neonatal Mortality: Defined as the probability of dying between (0–6) days or before seven completed days of life.

Premature: Any viable neonate before term (<37 weeks of gestation)
Results
Response rate and Socio-demographic characteristic
Response was obtained from all participants (n = 253), out of these 233(92.09) were married, 53 (20.95%) of the live births were from teenager mothers (below the age of 18 years) and those neonates born from these mothers 21 (39.62%) of them exposed to preterm. 88 (34.78 %) of the mothers had completed secondary school and 19 (7.51 %) of the mothers had run their own business and employee in governmental organizations (Table 1). The current age of the mother was normally distributed with mean and standard deviation of 24.96 (SD = ±4.3).

Maternal and pregnancy characteristics
Among the total mothers recruited into the study, 30 (11.86 %) of the mothers had previous history of abortion and 6 (2.37 %) of the mothers had a history of still birth. From the total 25 multiple births 19 (76.00%) of them were exposed to preterm births. Regarding medically diagnosed diseases, 28 (11.1 %) had medically known disease. Of these, diabetes mellitus had highest prevalence 8 (28.57 %) (Table 2).

Neonatal and Neonatal Intensive Care Unit characteristics
Regarding the neonatal characteristics, the male to female ratio was 1.3:1. One hundred two (40.32%) were preterm and 151 (59.68%) term babies. Around half, 139 (54.2 %) of neonates received antibiotic Treatment and 74 (29.2 %) were EONS case neonates. Among all 31(12.3 %) of the neonates have birth defect (Table 3).

Survival analysis and outcome of the follow up
Neonates were followed up for 1425.32 total analysis time at risk, at risk from t = 0 neonate-days. The median survival time of early neonates admitted to NICU was 2 days. In the study, 5 (15.62%) of neonatal deaths occurred in the first 24 hours, 7 (21.88 %) in the next date of birth and 18 (56.25%) death occurred within the first 72 hours. The cumulative survival rate of neonates at the end of the follow up were 86.96 % (95% CI: 0.8197, 0.9065) (Table 4 and Fig.1). Overall, in this study 32 (12.65%) neonates died which makes the ENMR 126.5 per 1000 live births. At the end of follow up,
221(87.4 %) were alive. The leading cause of death were 13 (40.6 %) Respiratory distress, 11(34.3 %) premature complication, 3 (9.3) low birth weight, 3 (9.3%) asphyxia and 2 (6.25 %) aspiration pneumonia. One hundred eighty (71.1%) were completed their follow up time in the hospital where as 73 were completed their follow up outside.

Bivariate and Multivariable analysis
Log-rank test showed that there is a significant difference of survival experience among groups of residenceX$^2$ for Log rank test = 2.25, $p = 0.1335$, mother educational statusX$^2$ for Log rank test = 4.47, $p = 0.2149$, number of newbornX$^2$ for Log rank test = 6.12, $p = 0.0134$, distance from health facilityX$^2$ for Log rank test = 3.42, $p = 0.0643$, Birth weightX$^2$ for Log rank test = 3.42, $p = 0.0643$, Gestational ageX$^2$ for Log rank test = 22.25, $p = 0.0000$, Apgar score in one minuteX$^2$ for Log rank test = 11.20, $p = 0.0037$, sex, admission diagnosis and type of medication(Table 5).

Multivariable analysis revealed that a neonate born with very low birth weight (1000-1499gm) had 3 times higher hazard of neonatal death compare to neonates born with normal birth weight (2500-3500 gm) (AHR: 3.02, 95 % CI: 1.11,8.25).Neonates who were born with gestational age less than 37 weeks had 3.7 times higher hazard of neonatal death than neonates who were born with gestational age greater than 37weeks,(AHR = 3.7;95 %CI:1.22,11.19).

Effect modification and Multicollinarity were assessed in this study, no confounding effect was observed. No covariates violated the proportional-hazard assumption test. For the residual test, it concludes that the final model fits the data very well. These residuals should have a standard censored exponential distribution with hazard ratio. The hazard function follows the 45° line very closely (Fig. 2).

The final Cox regression analysis model for the outcome of early neonatal death demonstrated. Its association with very low birth weight (1000-1499gm) (AHR = 3.02, 95 % CI: 1.11, 8.25) and Neonates who were born with gestational age less than 37 weeks (preterm) (AHR = 3.7; 95 %CI: 1.22, 11.19) (table 6).

Discussion
The aim of the study conducted is to assess survival and predictors of early neonatal death in neonatal intensive care unit in order to set health care services more focusing in maternal and child health in addition to strengthen NICU service and may be used to put different interventions.

In this study, ENMR was found to be higher (126.5 per 1000 live births) than the national average that is 29 per 1000 live births EDHS2016. The higher rate could be explained by the fact that this study was done in NICU those newborn babies in need of critical medical attention was admitted while the national average includes both high-risk new born babies and normally new born babies. This rate is similar with other studies conducted in Cameroon due to both studies conducted in NICU and with the same age group(32), but unlike this study ENMR is different in different studies like Sudan included neonates born in the study hospital and admitted to nursery unit with incidence rate of 6.6% and China 7.9% incidence rate conducted retrospectively in the rural community while this study included home delivery admitted to NICU and included the rural and urban residence (2,23,51).

This study showed that there is higher rate of mortality than data extracted from HDSS in Kersa /eastern Ethiopia which was 19.55 per 1000 and other countries like Brazil (33,51,60).The discrepancy could be explained in terms of the place where information was gathered. Different studies conducted before in Sudan, Iran, China, Brazil, Cameroon, Indonesia and Ethiopia had revealed that most neonatal deaths occurred in the first 24hr and in the first week of life which is similar to this study (2,4,14,22,23,29,30,32,51,52).These findings could be associated with prematurity and low birth weight in which the NICU set up was impair to manage these risk factors during this period.

Studies conducted in Gonder and Nigeria reported that most neonates died in their first week of life because of complication occurring during pregnancy but this study indicates most early neonatal death occurred because of preterm and very low birth weight this deference might be because of demographic characteristics of the respondents, poor quality of antenatal care, delay in identification and poor management of complications during pregnancy(14,31).

In this study relatively the major reason to early neonatal mortality is found 13 (40.6 %) Respiratory distress, 11(34.3 %) premature complication, 3 (9.3%) low birth weight, 3 (9.3%) asphyxia and 2 (6.25 %) Aspiration pneumonia, this is similar with finding of study from northern Ethiopia that was,
asphyxia, infection, and prematurity were the leading causes of death at 35, 23, and 23% respectively (61).

In this finding log rank test analysis result shows the covariates like residence, mother educational status, number of newborn, distance from health facility, Birth weight, Gestational age, Apgar score in one minute, sex, admission diagnosis and medication were statistically significant to survival or time to death. This is in line with study in Cameron which was Preterm birth, Asphyxia and acute respiratory remained significantly associated with neonatal mortality (32).

This study multivariable analysis identified that prematurity and very low birth weights were associated with increased hazard of neonatal death. These were contributing to ENM with AHR: 3.7 and 3.02 for premature and very low birth weight respectively. Preterm birth accounted for most early neonatal deaths and also preterm birth complications were the leading cause of death in all regions of the world (62). The characteristics of mothers whose VLBW babies had died showed the strong influence of the social component and access to care on perinatal outcomes, which is consistent with a recent systematic review (63).

This study has revealed that prematurity was the predominant cause for early neonatal mortality which is similar with different studies conducted before in Sudan, Saudi Arabia, Pakistan, Northeast Brazil, Southern Brazil, Indonesia and Eastern Ethiopia (2,3,5,13,29,30,33,51,52).

The current study finding showed that neonates with a very low birth weight experienced higher mortality. This finding is similar to studies conducted in Ethiopia and different parts of developing countries like Iran, Nigeria and Indonesia (4,15,52,61). The male predominance in this study is consistent with other studies done in Gonder; Sub Saharan Africa and Northern Ethiopia. This indicates that male neonates are more vulnerable during the neonatal period, a finding in agreement with the well described biological survival of girls in the neonatal period. It could also be as a result of preference for male child by some culture (14,15,20,28).

These findings showed that neonates born preterm with very low birth weight had a higher chance of death. This is similar to previous studies reported on preterm with very low birth weight related to high risks of ENM in Brazil (3,29).
This study showed that having low birth weight have a protective effect on ENM. Hence, this study indicated that managing low birth weight is possible, which may be related to timely admission to NICU and the focus of pediatricians on neonates with low birth weight and the NICU set up also appropriate to manage low birth weight neonates.

A systematic review from 60 low and middle income countries using population based nationally representative surveys revealed twins had around 3 times increased odds of death compared to singletons after adjusting for birth weight. A caesarian section was associated with a significant protective effect in twins. Institutional deliveries and increased access of caesarian sections may be considered for twin pregnancies in low- and middle income countries to decrease early adverse neonatal outcomes (19).

In accordance with this findings, in general, a study conducted in northern Brazil show that preterm and very low birth weight was associated with ENM (29). In this study the cumulative survival rate of early neonates at the end of the follow up were 86.96 % (95% CI: 0.82, 0.91). Overall, the study shows 32 (12.65 %) neonates died at first week of their life and this is higher than from Brazil which is 4.7% died in the same time period; this difference might be due to proximal causes, Low social standard, Lack of education, unplanned or unintended pregnancies and late attendance for Antenatal Care (64).

The strength of this study is that, it was assessed all predictors of ENM, data collection was also complete and reliable because it is a prospective cohort and the study area covers hospitals with high patient flow that those hospitals give service for all referred from all health institutions of Tigray, so we can conclude that it is representative for the entire region. One major limitation of the study was unavailable waiting room for mothers that lead unable to get them easy.

Conclusions
This study shows high incidences of ENMR and the median survival time was two days. Preterm birth and very low birth weight were the major predictors of early neonatal mortality. Multiple births were highly exposed to preterm births.

Recommendations
Governmental and Non-Governmental Organizations

TRHB and other stakeholders should give special emphasis to manage preterm birth and very low birth weight because both predictors and final causes of death related with preterm complications. Ensure essential equipment and commodities are consistently available

Institution level

Improved obstetric care, antenatal quality of service and identification of women who are likely to deliver less than 37 weeks of pregnancy and treatment with corticosteroids several days before delivery to prolong their pregnancy and speed up maturation of fetal lungs and further reduce incidence of prematurity

The institution should ensure the attendant of pediatricians in every delivery for timely resuscitation of babies at birth. This will go a long way to reduce high case fatality and morbidity related to neonatal mortality in the first few hours of life.

Community level

Create awareness for those multiple pregnant mothers to come to health facility before the onset of labor to reduce preterm delivery.

Kangaroo mother care for very low birth weight babies should be well informed and practiced in the community

Future studies also need to assess the level of awareness, treatment and control of these risk factors.

Abbreviations

ACSH: Ayder Comprehensive Specialized Hospital; ANC: Antenatal Care; CS: Cesarean Section; EDHS: Ethiopian Demographic Health Survey; ENM: Early Neonatal Mortality; ENMR: Early Neonatal Mortality Rate; EONS: Early Onset Neonatal Sepsis; GA: Gestational Age; HR: Hazard Ratio; HSTP: Health Sector Transformation Plan; MGH: Mekelle General Hospital; MNCH: Maternal, Neonatal, and Child health;

NICU: Neonatal Intensive Care Unit; NM: Neonatal Mortality; PI: Principal Investigator; RDS: Respiratory Distress Syndrome; R&w: Read and Write SCBU: Special Care Baby Unit; R&W: Read and Write SDGs: Sustainable Development Goals; TRHB: Tigray Regional Health Bureau; TT: Tetanus Toxoid (TT); U5M: Under Five Mortality; UNICEF: United Nations International and Children’s Emergency Fund and VLBW: Very Low Birth Weight

Declaration

Ethics approval and consent to participate

Ethical approval of the research was issued from the Research Ethics Review Committee of College of health Science, Mekelle University collage of health science to Ayder comprehensive specialized hospital and Mekelle general hospital, after getting permission from hospital administrations, the request letter was written for the concerned bodies of respective departments. Following this,
searching and obtaining of the selected samples’ medical record were processed with assigned person. Finally, strict care for the patients’ medical records and the confidentiality of records that can identify study participants was protected. These have been achieved through anonymity and by abandoning the individually identifiable information, which specifically refers to identity of patient like MRN and coding was used instead.

Ethical clearance was obtained from Mekelle University, College of Health Sciences Ethical review board. Permission letters were also sought from Tigray Regional Health Bureau. Written Informed consent from the mother was obtained after clear explanation of the purpose of the study.

Confidentiality and anonymity was maintained.

Consent to publish
I agree to rules and regulation of the BMC Pediatrics.

Availability of data and materials
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests
The authors declare that they have no competing interests.

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Authors’ contributions
AH conceived the research, wrote the draft manuscript, carried out the analysis and interpretation. LG drafted the manuscript and revised it critically in the design and analysis of the research. HT was involved mainly in statistical analysis, design and revising in draft of the manuscript. TH was involved in revising the design and analysis of the research.

All authors approved the final version of the manuscript

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Reference
1. Kliegman RM, Behrman RE, Jenson HB SBmn. Nelson Textbook of Pediatrics E-Book: Elsevier Health Sciences. 2016.

2. Board HS, Health C. Pattern and risk factors of early neonatal morbidity and outcome in Omdurman Maternity Hospital Nursery Unit. 2005;

3. Schindler T, Koller-smith L, Lui K, Bajuk B, Bolisetty S. Causes of death in very preterm infants cared for in neonatal intensive care units: a population-based retrospective cohort study. 2017;1–9.

4. Basiri B, Ashari FE, Shokouhi M, Sabzehei MK. Neonatal Mortality and its Main Determinants in Premature Infants Hospitalized in Neonatal Intensive Care Unit in Fatemieh Hospital., 2015;6(3).

5. Araf A, Alshehri MA. Predictors of neonatal mortality in the intensive care unit in Abha, Saudi Arabia. 2003;(September):1374–6.

6. Kanana RM, Tetui M, Mutebi A, Bua JN, Waiswa P, Kiwanuka SN, et al. The neonatal mortality and its determinants in rural communities of Eastern Uganda. Reprod Health. 2016;13(1):1–9.

7. Janet S. Early neonatal mortality and neurological outcomes of neonatal resuscitation in a resource-limited setting on the Thailand-Myanmar border: A descriptive study. 2018;1–8.

8. World Health Organization. Standard neonatal verbal autopsy questionnaire revised version. Geneva: WHO Publications; 2015.

9. Ansari WE, Rahman S. Neonatal Mortality: Incidence, Correlates and Improvement Strategies. Oliver CE, Karen OP, Ed INTECH. 2012;37–72.

10. Alebachew A, Waddington C. World Health Organization, Ethiopia Human resources for health reforms. 2015;4–5.

11. IGME UNIG for CME (UN). ‘Levels & Trends in Child Mortality: Report 2017, Estimates
17. Developed by the UN Inter-agency Group for Child Mortality Estimation’, United Nations Children’s Fund, New York,. 2017;11.

12. United Nations Children’s Fund, World Health Organization WBG. United Nations Children’s Fund, World Health Organization WBG. Levels & Trends in Child Mortality by the UN Inter-agency Group for Child Mortality Estimation. 2018;27:6.

13. Jehan I, Harris H, Salat S, Zeb A. Bulletin of the World Health Organization Neonatal mortality, risk factors and causes : a prospective population-based cohort study in urban Pakistan. 2018;7-10.

14. Abayneh Girma Demisse, Fentahun Alemu MAG and ZT. Patterns of admission and factors associated with neonatal mortality among neonates admitted to the neonatal intensive care unit of University of Gondar Hospital, Northwest Ethiopia. 2017;57-64.

15. U IE, Oyetunde MO. Pattern of Diseases and Care Outcomes of Neonates Admitted in Special Care Baby Unit of University College Hospital, Ibadan, Nigeria From 2007 To 2011. 2015;4(3):62-71.

16. Gebremedhin D, Berhe H, Gebrekirstos K. Risk Factors for Neonatal Sepsis in Public Hospitals of Mekelle City, North Ethiopia, 2015 : Unmatched Case Control Study. 2016;1-10.

17. Roba AA DD. Morbidities, Rate and Time Trends of Neonatal Mortality in Dilchora Referral Hospital, Dire Dawa, Ethiopia, 2012- 2017. Austin Med Sci Open. 2017;2(1).

18. Gerensea H. Trend and pattern of neonatal morbidity and mortality in Tigray Region, Ethiopia. 2017;1(January):1–5.

19. Bellizzi S, Sobel H, Betran AP, Sobel H. Early neonatal mortality in twin pregnancy : Findings from 60 low- and middle-income countries. 2018;8(1):1-14.

20. Willey BA, Schellenberg J. Newborn care behaviours and neonatal survival: evidence from sub - Saharan Africa. 2018;1-38.
21. Ali MA, Latif T, Taher MA. Morbidity pattern and hospital outcome of neonates admitted in secondary care level hospital in Bangladesh. Mymensingh Med J. 2009;18(2):136-41.

22. Mengesha HG, Wuneh AD, Lerebo WT, Tekle TH. Survival of neonates and predictors of their mortality in Tigray region, Northern Ethiopia: prospective cohort study. BMC Pregnancy Childbirth. 2016;1-13.

23. Li C, Yan H, Zeng L, Dibley MJ, Wang D. Predictors for neonatal death in the rural areas of Shaanxi Province of Northwestern China: a cross-sectional study. 2018;1-13.

24. Trends of Key Health Indicator in Tigray (EDHS 2000 to 2016).

25. Central AA and C. Mini Demographic and Health Survey. 2014;(August).

26. Enweronu-laryea CC, Nkyekyer K, Rodrigues OP. The impact of improved neonatal intensive care facilities on referral pattern and outcome at a teaching hospital in Ghana. 2008;(October 2003):561-5.

27. Report KI. FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA Demographic and Health Survey.

28. Wesenu M, Kulkarni S, Tilahun T. Modeling Determinants of Time-To-Death in Premature Infants Admitted to Neonatal Intensive Care Unit in Jimma University Specialized Hospital. Ann Data Sci. 2017;4(3):361-81.

29. Campos E, Castro M De, Jorge Á, Leite M, Fernanda M, Almeida B De. Perinatal factors associated with early neonatal deaths in very low birth weight preterm infants in Northeast Brazil. 2018;179:1-14.

30. Bertolozzi MR, Girotto E, Nursing H, Sciences M, Londrina UE De, Londrina UE De. Revista da Escola de Enfermagem da USP Determining factors for neonatal mortality in a city in the Southern Region of Brazil. 2018;1-8.
31. Ezeh OK. Trends and population-attributable risk estimates for predictors of early neonatal mortality in Nigeria, 2003—2013: a cross-sectional analysis. 2017;1-12.

32. Essomba N, Halle MP, Ngaba GP. Factors associated with early neonatal morbidity and mortality in an urban district hospital. 2016;(October).

33. Furquim M, Li DA, França I, Li J, De AAF. Risk factors for early neonatal. 2007;41(6).

34. Selemani M, Mwanyangala MA, Mrema S, Shamte A, Kajungu D, Mkopi A, et al. The effect of mother’s age and other related factors on neonatal survival associated with first and second birth in rural, Tanzania: Evidence from Ifakara health and demographic surveillance system in rural Tanzania. BMC Pregnancy Childbirth. 2014;14(1):1-9.

35. Ramaiya A, Kiss L, Baraitser P, Mbaruku G, Hildon Z. A systematic review of risk factors for neonatal mortality in Adolescent Mother’s in Sub Saharan Africa. 2014;1-6.

36. Yego F, Este CD, Byles J, Nyongesa P, Williams JS. A case-control study of risk factors for fetal and early neonatal deaths in a tertiary hospital in Kenya. 2018;1-15.

37. Abdullah A, Hort K, Butu Y, Simpson L. Risk factors associated with neonatal deaths: A matched case-control study in Indonesia. Glob Health Action. 2016;9(1):1-16.

38. Lukonnga E, Michelo C. Factors associated with neonatal mortality in the general population: Evidence from the 2007 zambia demographic and health survey (zdhs); a cross sectional study. Pan Afr Med J. 2015;20:1-8.

39. Thakur N, Saili A, Kumar A, Kumar V. Predictors of mortality of extremely low birthweight babies in a tertiary care centre of a developing country. Postgrad Med J. 2013;89(1058):679-84.

40. Berhan Y, Berhan A. A meta-analysis of selected maternal and fetal factors for perinatal mortality. Ethiop J Health Sci. 2014;24 Suppl:55-68.
41. Kozuki N, Sonneveldt E, Walker N. Residual confounding explains the association between high parity and child mortality. BMC Public Health. 2013;13(SUPPL.3):S5.

42. Akinyemi JO, Bamgboye EA, Ayeni O. Trends in neonatal mortality in Nigeria and effects of bio-demographic and maternal characteristics. BMC Pediatr. 2015;15(1):1-12.

43. Kozuki N, Walker N. Exploring the association between short/long preceding birth intervals and child mortality: Using reference birth interval children of the same mother as comparison. BMC Public Health. 2013;13(SUPPL.3):S6.

44. Singh A, Pallikadavath S, Ram F, Alagarajan M. Do antenatal care interventions improve neonatal survival in India? 2014;(September 2013):842-8.

45. Blencowe H, Lawn J, Vandelaer J, Roper M, Cousens S. Tetanus toxoid immunization to reduce mortality from neonatal tetanus. 2010;102-9.

46. Allanson ER, Muller M, Pattinson RC. Causes of perinatal mortality and associated maternal complications in a South African province: challenges in predicting poor outcomes. 2015;1-7.

47. Lawn JE, Zupan J, Begkoyian G, Knippenberg R. Chapter 27 Newborn Survival. 2018; (Dc):1-19.

48. Kadivar M, Sagheb S, Bavafa F, Moghadam L. Neonatal Mortality Risk Assessment in a Neonatal Intensive Care Unit (NICU). 2007;17(4):325-31.

49. Tran HT, Doyle LW, Lee KJ, Graham SM. A systematic review of the burden of neonatal mortality and morbidity in the ASEAN Region. WHO South-East Asia J Public Heal. 2012;1(3):239-48.

50. Kaboré R, Meda IB, Koulidiati J-LE, Millogo T, Kouanda S. Factors associated with very early neonatal mortality in Burkina Faso: A matched case-control study. Int J Gynecol Obstet. 2016;135(S1):S93-7.
51. Binyam N Desta, Nega Assefa, Tesfaye D Damte LOH. Neonatal Mortality and its risk factors in Eastern Ethiopia: A Prospective Cohort Study in Kersa Health and Demographic Surveillance System (Kersa HDSS). 2016;13(4):1–8.

52. Abdullah A, Hort K, Butu Y, Simpson L. Risk factors associated with neonatal deaths: a matched case—control study in Indonesia. 2018;9(1):1–25.

53. W.Henry Mosley LC. C. An analytical frame work for the study of child survival in developed countries. 2003;81(2):140.

54. EthioVisit.com. https://www.ethiovisit.com/tigray. 2018;(75):1–5.

55. Genessa Giorgi KK and MM. MCI social sector working paper series health needs assessment for Mekelle city, Ethiopia. 2009;(6).

56. Marchenko Y. Power analysis and sample-size determination in survival models with the new stpower command. 2007;

57. CL. MW. analytical framework for the study of child survival in developing countries Bull World Health Organ. 2003;81(2).

58. Chow ea. sample size (Use R!) Dirk F Moore (auth). applied Survival Analysis Using R-Springer International Publishing.

59. LP Rs. Stata survival analysis and epidemiological tables Reference manual release. 2011. 124 p.

60. Skoki F, Ba` D, Selimovi A, Hasanovi E, Muratovi S, Halilba` A. Association of Low Birth Weight Infants and Maternal Sociodemographic Status in Tuzla Canton during 1992—1995 War Period in Bosnia and Herzegovina. 2010;2010.

61. Mengesha HG, Sahle BW. Cause of neonatal deaths in Northern Ethiopia: a prospective cohort study. BMC Public Health. 2017;1–8.

62. Oza S, Lawn JE, Hogan DR, Cousens SN. Neonatal cause-of-death estimates for the early and late neonatal periods for 194 countries: 2000—2013. 2015;(October
2014):19–28.

63. Grandi C. Perinatal factors associated with neonatal mortality in very low birth weight infants: A multicenter study. 2016;114(5):426–33.

64. Zullini MT, Bonati M, Sanvito E. Survival at nine neonatal intensive care units in São Paulo, Brazil. 1997;2(5).

Tables

Table 1 Demographic and socio-economic characteristics of mothers whose early neonate admitted to NICU in Mekelle general and Ayder comprehensive specialized hospitals, Tigray, Ethiopia, 2018 (n=253)

| Characteristics          | Freq. | Per.  |
|--------------------------|-------|-------|
| Residence                |       |       |
| Urban                    | 157   | 62.06 |
| Rural                    | 96    | 37.94 |
| MA at first birth         |       |       |
| <20years                 | 58    | 22.91 |
| 20-24years               | 124   | 63.58 |
| >24years                 | 71    | 36.41 |
| MA on marriage           |       |       |
| < 18years                | 53    | 20.95 |
| ≥18 years                | 200   | 79.05 |
| Religion                 |       |       |
| Orthodox                 | 243   | 96.05 |
| Muslim                   | 6     | 2.37  |
| Other                    | 4     | 1.58  |
| Maternal marital status  |       |       |
| Married                  | 233   | 92.09 |
| Single                   | 20    | 7.90  |
| Mother Educational status|       |       |
| primary school           | 78    | 1.58  |
| unable to R&w            | 49    | 19.37 |
| Secondary                | 88    | 34.78 |
| Tertiary                 | 38    | 15.02 |
| Occupational status      |       |       |
| House wife               | 183   | 72.33 |
| Student                  | 10    | 3.95  |
| Own business             | 19    | 7.51  |
| Governmental             | 41    | 16.21 |

Table 2 Maternal related characteristics of early neonates admitted to NICU in Mekelle general and Ayder comprehensive specialized hospitals, Tigray, Ethiopia, 2018 (n=253)
| Characteristics                   | Freq. | %    |
|----------------------------------|-------|------|
| Number of new born               |       |      |
| Singleton birth                  | 228   | 90.12|
| Multiple birth                   | 25    | 9.88 |
| Gravidity                        |       |      |
| One pregnancy                    | 111   | 43.87|
| Two pregnancy                    | 67    | 26.48|
| ≥ Three pregnancy                | 75    | 29.64|
| History of Abortion              |       |      |
| Yes                              | 30    | 11.86|
| No                               | 223   | 88.14|
| No. of abortion                  |       |      |
| Zero                             | 223   | 88.14|
| One                              | 22    | 8.70 |
| Two                              | 8     | 3.16 |
| Mother health problem            |       |      |
| Yes                              | 28    | 11.07|
| No                               | 225   | 88.93|

Table 2 Characteristics of mothers whose early neonate admitted to NICU in Mekelle general and Ayder comprehensive specialized hospitals, Tigray, Ethiopia, 2018 (n=253) (Continued)

| Characteristics                              | Freq. | %    |
|----------------------------------------------|-------|------|
| Delivery complication                        |       |      |
| Yes                                          | 72    | 28.46|
| No                                           | 181   | 71.54|
| If Yes, No. of TT injection                  |       |      |
| ≥ 2 injection                                | 170   | 67.19|
| 1 injection                                  | 70    | 27.67|
| RH Factor                                     |       |      |
| Positive                                     | 243   | 96.05|
| Negative                                     | 10    | 3.95 |
| RVI Status                                    |       |      |
| None reactive                                 | 239   | 94.47|
| Reactive                                     | 14    | 5.53 |
| Use of ANC service                           |       |      |
| Yes                                          | 225   | 88.93|
| No                                           | 28    | 11.07|
| Number of ANC Visit                          |       |      |
| < 4 visits                                    | 67    | 26.48|
| ≥ 4 visits                                    | 186   | 73.52|
| Distance to HF                               |       |      |
| ≤ 10 km                                      | 171   | 67.59|
| > 4 km                                       | 82    | 32.41|
| Mode of delivery                             |       |      |
| SVD                                          | 178   | 70.36|
| Cesarean section                             | 75    | 29.64|
| Place of birth                               |       |      |
| Hospital                                     | 203   | 80.24|
| Health Center or Clinic                      | 39    | 15.42|
| Home                                         | 11    | 4.35 |
Table 3 Neonatal related characteristics of early neonates in NICU of Mekelle general and Ayder comprehensive specialized hospitals, Tigray, Ethiopia, 2018 (n=253)

| Characteristics                      | Freq. | %    |
|--------------------------------------|-------|------|
| Birth weight                         |       |      |
| NBW (2500-3500gm)                    | 141   | 55.73|
| LBW (1500-2499gm)                    | 67    | 26.48|
| VLBW (1000-1499gm)                   | 45    | 17.79|
| Gestational age                      |       |      |
| Term (≥37 weeks)                     | 151   | 59.68|
| Preterm (<37 weeks)                  | 102   | 40.32|
| Apgar score in one minute            |       |      |
| 7-10                                 | 129   | 50.99|
| <7                                   | 49    | 19.37|
| un known                             | 75    | 29.64|
| Sex                                  |       |      |
| Male                                 | 143   | 56.52|
| Female                               | 110   | 43.48|
| Initiation. of BF within one hr      |       |      |
| Yes                                  | 20    | 7.91 |
| No                                   | 79    | 31.23|

(Continue)
| Characteristics                  | Freq. | %   |
|---------------------------------|-------|-----|
| Admission diagnosis             | 79    | 31.23 |
| Hypothermia                     | 36    | 14.23 |
| Preterm                         | 51    | 20.16 |
| MMC                             | 22    | 8.70  |
| Others                          | 65    | 25.69 |
| Birth defect                    |       |      |
| Yes                             | 35    | 13.83 |
| No                              | 218   | 86.17 |
| Hospital type                   |       |      |
| ACSH                            | 202   | 79.84 |
| MGH                             | 51    | 20.15 |
| Kind of Medication              |       |      |
| Antibiotic                      | 139   | 54.94 |
| ABCs'                           | 37    | 14.62 |
| KMC                             | 22    | 8.70  |
| Radiate Warmer                  | 34    | 13.44 |
| Others                          | 21    | 8.3   |
| Outcome status                  |       |      |
| Alive                           | 221   | 87.35 |
| Death                           | 32    | 12.65 |
| Primary Cause of neonatal death |       |      |
| Respiratory distress            | 13    | 40.6  |
| Birth Asphyxia                  | 3     | 9.3   |
| Preterm Complication            | 11    | 34.3  |
| Aspiration Pneumonia            | 2     | 2.65  |
| L BW Complication               | 3     | 9.3   |

**Table 4** Survival analysis of early neonates during follow up time those who admitted to NICU in Mekelle general and Ayder comprehensive specialized hospitals, Tigray, Ethiopia, 2018 (n=253)

| Time Interval | Total | Death | Lost | Survival Probability% | (95% Conf.int.) |
|---------------|-------|-------|------|------------------------|----------------|
| 0-1           | 253   | 5     | 0    | 98.02                  | 95.32,99.17    |
| 1-2           | 248   | 7     | 0    | 95.26                  | 91.80,97.28    |
| 2-3           | 241   | 6     | 0    | 92.89                  | 88.94,95.46    |
| 4-5           | 235   | 1     | 0    | 92.49                  | 88.48,95.14    |
| 5-6           | 234   | 12    | 0    | 87.75                  | 83.03,91.22    |
| 6-7days       | 222   | 1     | 221  | 86.96                  | 81.97,90.65    |

**Table 5** Log rank test result of early neonates admitted to NICU in Mekelle general and Ayder comprehensive specialized hospitals, Tigray, Ethiopia, 2018 (n=253)
| Variable                              | Log rank($X^2$) | P-value |
|--------------------------------------|-----------------|---------|
| Residence                            | 2.25            | 0.1335  |
| Marital status                       | 0.14            | 0.7035  |
| Mothers age on marriage              | 0.56            | 0.4554  |
| Religion                             | 1.68            | 0.4306  |
| Mother educational status            | 4.47            | 0.2149  |
| Occupational status                  | 3.30            | 0.3480  |
| Age of mother at first birth         | 0.38            | 0.825   |
| Number of new born                   | 6.12            | 0.0134  |
| Birth interval                       | 0.01            | 0.9971  |
| Use of family planning               | 0.07            | 0.7902  |
| Method of family planning use        | 1.36            | 0.7159  |
| Gravidity                            | 1.11            | 0.5729  |
| Still birth                          | 0.06            | 0.8131  |
| Sibling mortality                    | 0.31            | 0.5787  |
| Mother diagnosis                     | 0.73            | 0.3914  |
| Type of diagnosis                    | 2.95            | 0.5669  |
| Delivery complication                | 0.56            | 0.4531  |
| Type of complication                 | 0.78            | 0.9784  |
| Tetanus antitoxin                    | 0.98            | 0.3232  |
| Number of TT injection               | 2.52            | 0.2829  |

**Table 5** Log rank test result of early neonates admitted to NICU in Mekelle general and Ayder comprehensive specialized hospitals, Tigray, Ethiopia, 2018 (n=253) (Continue)
| Variable                          | Log rank($X^2$) | P-valu |
|----------------------------------|-----------------|--------|
| RH Factor                        | 0.58            | 0.4465 |
| Initiation of BF within a hour   | 0.11            | 0.7409 |
| RVI Status                       | 1.15            | 0.2837 |
| Use of ANC service              | 0.99            | 0.3199 |
| Number of ANC Visit             | 0.45            | 0.5023 |
| Distance to Health Facility     | 3.42            | 0.0643 |
| Mode of delivery                | 0.33            | 0.5678 |
| Place of birth                  | 2.89            | 0.2356 |
| Delivery assistance             | 0.43            | 0.8060 |
| Birth weight                    | 54.84           | 0.0000 |
| Gestational age                 | 22.25           | 0.0000 |
| Apgar score in one minute       | 11.20           | 0.0037 |
| Sex                             | 2.30            | 0.1297 |
| Admission diagnosis             | 9.58            | 0.0480 |
| Birth defect                    | 0.49            | 0.4849 |
| Kind of Medication              | 8.05            | 0.0897 |

Table 6 Multivariable Cox-proportional hazard model on predictors of ENM in Mekelle general and Ayder comprehensive specialized hospitals
| Characteristic               | Un Adjusted HR | 95% CI         | Adjusted HR |
|-----------------------------|----------------|----------------|-------------|
| Residence                   |                |                |             |
| Urban                       | Ref.           |                |             |
| Rural                       | 1.68           | 0.84,3.36      |             |
| Mother                      |                |                |             |
| Primary school              | Ref.           |                |             |
| Un able to R&W              | .82            | 0.30,2.23      |             |
| Educational status          |                |                |             |
| Secondary school            | .53            | 0.20,1.38      |             |
| Tertiary                    | 1.51           | 0.60,3.75      |             |
| No. of New born             |                |                |             |
| Singleton birth             | Ref.           |                |             |
| Multiple birth              | 2.73           | 1.18,6.32      |             |
| Distance                    |                |                |             |
| ≤10 Km                      | Ref.           |                |             |
| >10Km                       | 1.89           | 0.94,3.79      |             |
| Birth Weight                |                |                |             |
| Normal BW(Ref.)             | Ref.           |                |             |
| Low B W                     | 0.41           | 0.09,1.88      | 0.23        |
| Very Low BW                 | 7.30           | 3.41,15.63     | 3.02        |
| GA                          |                |                |             |
| Term(Ref.)                  | Ref.           |                |             |
| Preterm                     | 5.83           | 2.52,13.49     | 3.69        |
| Apgar score in one minute   |                |                |             |
| Apgar 7-10                  | Ref.           |                |             |
| Apgar less                  | 3.13           | 1.43,6.86      |             |
| Unknown                     | 1.02           | 0.40,2.59      |             |
| Sex                         |                |                |             |
| Male                        | Ref.           |                |             |
| Female                      | 0.56           | 0.26,1.19      |             |

Figures
Figure 1

Kaplan Meir survival estimate on the survival time of early neonates admitted to NICU in Mekelle general and Ayder comprehensive specialized hospitals, Tigray, Ethiopia, January - March, 2018 (n=253)
Figure 2

Cox Snell residual Nelson-Aalen cumulative hazard graph on early neonates’ in NICU of Mekelle general and Ayder comprehensive specialized hospitals, Tigray region, Northern Ethiopia, 2018.