Survival Status and Predictors of Mortality Among Preterm Neonates in Southwest Ethiopia: A Retrospective Cohort Study

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Abstract

**Background:** Prematurity is a global public health priority linked with high neonatal morbidity and mortality. There is limited evidence regarding preterm neonatal mortality and its predictors to inform programs and policies in Ethiopia. The aim of this study was therefore to assess survival status and predictors of mortality among preterm neonates admitted to the neonatal intensive care unit of Jimma University Medical Center.

**Methods:** Facility-based retrospective cohort study was conducted from March 11 to April 20, 2020, among 505 randomly selected preterm neonates admitted to the Neonatal Intensive Care Unit (NICU) of Jimma University Medical Center (JUMC). Data were collected from medical records and registers using a structured data collection checklist. Data were entered into Epi-Data 3.1, exported to, and analyzed with STATA version 15. Kaplan Meir method and log-rank test were used to estimate survival time, and compare survival experience. Cox-regression analysis was fitted to identify predictors of time to death. The assumption of the proportional hazard model was checked using Schoenfeld residual test. Adjusted hazard ratio (AHR) with its 95% confidence interval (CI) and corresponding p-value <0.05 was set to declare statistical significance.

**Result:** In this study, 127 (25.1%) neonates died with neonatal mortality rate of 28.9 deaths per 1,000 neonate-days [95%CI: 24.33, 34.46]. About 103 (81.1%) deaths occurred during early neonatal period. Antenatal steroid use [AHR=0.55, 95%CI: 0.34, 0.90], obstetric complications [AHR=1.84, 95%CI: 1.20, 2.82], gestational age increment by week [AHR= 0.81, 95%CI: 0.75, 0.87], respiratory distress syndrome [AHR=1.52, 95%CI: 1.01, 2.29], neonatal sepsis [AHR=1.71, 95%CI: 1.18, 2.49], perinatal asphyxia [AHR=2.44, 95%CI: 1.33, 4.49], and receiving kangaroo-mother care [AHR=0.48, 95%CI: 0.30, 0.77] were predictors of preterm neonatal mortality.

**Conclusion:** Preterm neonatal mortality rate was high. Most neonatal deaths occurred in the early neonatal period. Predictors of preterm neonatal mortality were antenatal steroid use, obstetric complications, gestational age increment by week, respiratory distress syndrome, neonatal sepsis, perinatal asphyxia, and receiving kangaroo-mother care. Hence, early detection and management of obstetric and neonatal complications, use of antenatal steroids, kangaroo-mother care, and ensuring a continuum of care should be strengthened to increase preterm neonatal survival.

**Background**

Preterm birth, births earlier than 37 weeks of gestational age, is a global public health priority that is linked with high neonatal morbidity and mortality, mainly in developing countries (1-4). The preterm birth rate is increasing and great inequalities exist in a quality, access to care, and survival across countries (1). The risk of dying is highest in the first four weeks of life for all babies, but preterm babies are acutely so and they need special care just to remain alive (1, 3).
Globally, the preterm birth rate is estimated at fifteen million every year, and this number is rising (1). Prematurity is the first leading cause of neonatal mortality as well as the second leading cause of death among children below the age of five years, globally. It is also the world's most common cause of multiple threats to health in the short and long term (1, 3). Nearly eighty percent of preterm birth occurred in Asia and Sub-Saharan Africa (SSA) (5).

More than 35% of all neonatal mortality globally results from preventable and treatable preterm birth complications (3, 4, 6). Nearly one million neonates die each year from preterm birth complications (7). The survival chance of preterm neonates varies significantly based on where they were born. More than 75% of preterm babies could be saved with the feasible and cost-effective practice of quality care, and further reductions are possible with intensive neonatal care (1, 4).

The consequence of being born preterm extend beyond the neonatal period. They need proper care and treatment as they face greater risks of lifetime disability as well as a deprived quality of life (1, 7). Moreover, mothers of preterm neonates experience significant psychological distress and families also endure substantial financial hardship (8-10). Prematurity is associated with higher healthcare costs, particularly within the first year after birth, suggesting that the implementation of appropriate programs and strategies to prevent premature delivery is beneficial from a medical as well as a healthcare expenses perspective (11).

Different findings identified mainly that mother and her neonate socio-demographic factors, maternal medical-related factors, and obstetric and gynecologic related factors as the predictors of mortality among preterm neonates (12-36). Ethiopia was one of the top ten countries with a high burden of preterm births globally. In Ethiopia, more than three hundred thousand neonates were born prematurely every year, and the rate of preterm birth was 12% (5, 37). The Ethiopian government showed its effort to improve the survival of neonates, mainly preterm neonates, through the inclusion of high-impact life-saving neonatal interventions (38). Despite these efforts, prematurity is the first leading cause of neonatal mortality and the fourth leading cause of mortality among children below the age of five in Ethiopia (39, 40). Hence, prematurity should be addressed to curb neonatal death globally and attain sustainable development goals (SDGs) (5).

There is a dearth of recent evidence on survival status and predictors of preterm neonatal mortality to inform programs and policies in Ethiopia, particularly in a study area. This significantly limits understanding of the extent and depth of the problem for evidence-based intervention. It is a dual agenda to prevent preterm delivery and address the survival gap of preterm neonates which necessitates comprehensive research to end the preventable deaths of neonates and children below five years. Hence, this study aimed to assess survival status and predictors of mortality among preterm neonates admitted to neonatal intensive care unit in Jimma University Medical Center in Southwest Ethiopia. The study will help health care providers to identify main predictors of preterm neonatal mortality and intervention areas, and in the timely detection of high-risk babies to give maximum efforts for their survival.
Methods

Study design and setting

An institution-based retrospective cohort study was conducted among a cohort of preterm neonates who were admitted to the neonatal intensive care unit (NICU) at JUMC from March 11 to April 20, 2020. JUMC is found in Jimma town at 352 kilometers away from Addis Ababa, the capital city of Ethiopia, in the southwestern part of the country. JUMC is the only tertiary and comprehensive specialized teaching hospital in the southwest of Ethiopia and currently provides a range of services for approximately 15 million people. The NICU unit is one of the intensive care unit services currently in operation at the hospital which has 26 neonatal and 16 kangaroo-mother care beds. The unit also has 20 radiant warmers, four continuous positive airway pressure (CPAP), six photo-therapy machines, oxygen concentrator machines, pulse oximetry, glucometer, and neonatal resuscitation equipment. Advanced procedures such as exchange transfusions and lumbar punctures are performed at the unit. On average, nearly 1,500 neonates are admitted annually to NICU of JUMC. The functional capability of JUMC is level three NICU which is organized with personnel and equipment to provide continuous life support and inclusive care for high-risk neonates and those with complex and critical illnesses (41).

Population

The source population for this study was all preterm neonates admitted to the NICU of JUMC from January 1, 2017, to December 30, 2019. All those randomly selected preterm neonates admitted to the NICU of JUMC from January 1, 2017, to December 30, 2019, and fulfilling the eligibility criteria were the study population. All alive-born preterm neonates at admission who were registered on the neonatal registry book from January 1, 2017, to December 30, 2019, in the NICU of JUMC were included in the study. However, preterm neonates with incomplete information on medical records regarding outcome status, a time when neonates were admitted to NICU, and a time when death or censoring occurred were excluded.

Sample size determination and sampling procedure

The sample size was determined for survival analysis by considering preterm neonates who have jaundice at admission using STATA™ Version 15 statistical software based on the following assumptions: 5% level of significance (a) (two-sided), 80% power, adjusted hazard ratio (AHR) of 1.62 for preterm neonates who have jaundice at admission, the overall probability of preterm neonatal death (d) of 0.288 (18), and 0.5 variabilities of covariates of interest. It was assumed that no subjects were anticipated to withdraw from the follow-up, and a 10% contingency was added for incomplete records. Hence, the total sample size for this study was 516. The medical registration number (MRN) of preterm neonates over three year period from January 1, 2017, to December 30, 2019, was taken from the NICU log-book to create a sampling frame. A computer-generated simple random sampling technique was employed to select 516 participants into the study as follows: The sampling frame that was created using the MRN was entered into SPSS version 25 software. Then, a 516 sample was selected randomly.
using SPSS select case procedure. Medical records of preterm neonates attached to selected MRN were reviewed, and those records that met the eligibility criteria were included in the analysis.

**Measurement**

History of bad obstetric and/or gynecologic outcomes was assessed by categorizing into ‘Yes’ or ‘No’ questions. We considered ‘Yes’ if the mothers of neonate had a history of neonatal death, stillbirth, or other obstetric and/or gynecologic outcomes and ‘No’ if the mothers of neonate had no history of neonatal death, stillbirth, or other obstetric and/or gynecologic outcomes (42). Maternal antenatal steroids use was assessed by ‘Yes’ or ‘No’ question. Considered ‘Yes’ if intramuscular or intravenous steroid administered to the mother during current pregnancy at any time before delivery and ‘No’ if an intramuscular or intravenous steroid was not administered (43). Similarly, obstetric complication during the current pregnancy was assessed by ‘Yes’ or ‘No’ questions, which was considered present if the mother had obstetric complications like preeclampsia, polyhydramnios, fetal distress, premature rupture of membrane (PROM), or other complications during the current pregnancy (44). Gestational age (GA) at birth (in a week) was estimated based on the first day of a women's last menstrual period and/or ultrasound estimation. It was categorized according to the World Health Organization (WHO) as ‘extremely preterm’ if GA at birth <28 weeks, ‘very preterm’ if GA at birth 28 to <32 weeks, and ‘moderate to late preterm’ if GA at birth 32 to <37 weeks (41). Birth weight (in grams) was measured using a standard beam balance and recorded in the medical record. It was categorized according to WHO as ‘extremely low birth weight’ if <1000 grams, ‘very low birth weight’ if 1000-1499 grams, ‘low birth weight’ if 1500-2499 grams, ‘normal weight’ if 2500-3999 grams, and ‘macrosomia’ if the birth weight of neonate ≥4000 grams (41). A weight class for gestational age was classified into appropriate for gestational age (AGA) if the birth weight was between 10-90%, large for gestational age (LGA) if birth weight was >90%, and small for gestational age (SGA) if birth weight was <10% for particular gestation age (41). Survival status is an outcome of the neonate during follow-up from the medical records and considered as ‘death’ if neonate died during follow-up, as ‘lost to follow-up’ if the mother or caregiver was not available and unable to reach with their address. It was considered as ‘Withdrawal’ if the mother refused the follow-up due to inconvenience, as ‘referred’ if the neonate was referred to other institutions for better management, and ‘alive’ if the preterm neonate survival was assured at the last follow-up period (44). Censored is defined as preterm neonates who were alive at the end of follow-up, lost to follow-up, withdrawal, and referred to other health institutions without knowing the outcome status (44). Survival time is the measure of the follow-up time (in days) from the date of admission in the NICU up to date of death, censored, or the end of the study (28th day of life) (33). Time-to-death is the death of a preterm neonate on a specific day in the first 28 days of life (44).

**Data collection tool and procedures**

The data were collected from preterm neonatal medical records and registers by three trained bachelor's degree holder midwives and supervised by one bachelor’s degree holder senior nurse. A data collection checklist adapted from the Global Neonatal Database data collection form for Ethiopian Neonatal
Network (43) was used to collect the data. Modifications were made on the checklist based on the NICU registration format, and through reviewing relevant literature. The starting point for follow-up was the first NICU admission date and followed until the last neonatal period (28th days of life), which was the endpoint of the study.

Data quality was assured by careful designing of the data collection checklist, recruiting data collectors, and supervisor who have previous experience. The data collection checklist was pretested on 26 randomly selected records (5% of the sample size) before the commencement of the actual study and amendments were taken on the checklist based on pretest findings. Training for two days was given on principles of research ethics, data collection checklist, and procedures for data collectors and a supervisor. Data collectors were supervised closely by the supervisor on daily basis throughout the data collection period.

**Data analysis**

Data were cleaned, coded, and entered into Epi-Data version 3.1, and analysis was done using STATA version 15.0 after exporting the data. An exploratory analysis was carried out to check the levels of missing values, the presence of outliers, and extreme values. Descriptive statistics such as frequencies, percentages, summary measures, and rates were computed to describe categorical and continuous variables as supposed necessary. Death of neonate was an event of interest: coding was ‘0’ for censored and ‘1’ for death. The overall neonatal mortality rate (incidence density) was calculated by dividing the number of preterm neonates who died during the follow-up period by the total neonate-days at risk of observation. Kaplan-Meier (KM) method was used to estimate median survival time, and compare survival experience between categories of variables. Moreover, Log-rank (mantel-cox) test was conducted to assess a statistical significance in survival experience at p-value<0.05.

Cox proportional hazard regression analysis was used to identify predictors of time to death. A bivariable cox-regression analysis was fitted first, and variables with P-value <0.25 in this analysis entered into the multivariable cox-regression analysis. To identify independent predictors of time to death, a stepwise backward likelihood ratio method was used to fit a multivariable cox-regression analysis. A more parsimonious model was chosen by looking at the partial log-likelihood ratio (LR) test ($X^2= 88.13, p$-value <0.0001), and model with the lowest Akaike's Information Criteria score (AIC=1408.17) and Bayesian Information Criteria (BIC=1454.64) score. Adjusted hazard ratio (AHR) with its 95% confidence interval and the p-value were used to determine the strength of association. Variables with a p-value <0.05 in the final model were considered as significant predictors of the time to death of preterm neonates.

The proportional hazard assumption was checked by Schoenfeld residual test and was satisfied (Global test $X^2=5.13, P$-value=0.92), and also detailed Schoenfeld residual test met the assumption. Multicollinearity was checked by looking at the variance inflation factor (VIF) and the highest observed VIF-value was 2.06, indicating that there was no multicollinearity threat. Covariates were tested for interaction effect by adding an interaction term into the model and no interaction effect was
observed (p-value ≥0.05 for interaction term). The goodness of model fitness was evaluated by using the Cox-Snell residual test. In this study, the Nelson-Aalen cumulative hazard function follows the 45° diagonal line very closely, indicating that it almost has an exponential distribution with a hazard rate of one. Hence, for the residual test, it was possible to conclude that the final model fits the data very well.

Results

Socio-demographic characteristics

In this study, a total of 516 preterm neonate medical records were reviewed, and 505 records that met eligibility criteria were included in the analysis. Near to nine-tenth of neonates, 433 (85.7%), had less than 24 hours of age at admission and more than half, 279 (55.2%), of them were males. The median age of the mother was 27 years with an interquartile range (IQR) of 8 and most mothers of the neonates, 398 (78.8%), were in the age group of 20-34 years. Nearly two-third, 339 (67.1%), of neonates were rural residents (Table 1).

Table 1
Socio-demographic characteristics of preterm neonates and their mothers at NICU of JUMC, Jimma, Southwest Ethiopia, 2020 (N=505).

| Variable                  | Category | Death N (%) | Censored N (%) | Frequency (N=505) | Percentage (%) |
|---------------------------|----------|-------------|----------------|------------------|----------------|
| Neonatal age at admission | <24 hour | 109 (25.2)  | 324 (74.8)     | 433              | 85.7           |
|                           | 1-6 day  | 17 (26.6)   | 47 (73.4)      | 64               | 12.7           |
|                           | ≥7 day   | 1 (12.5)    | 7 (87.5)       | 8                | 1.6            |
| Sex of neonate            | Male     | 74 (26.5)   | 205 (73.5)     | 279              | 55.2           |
|                           | Female   | 53 (23.5)   | 173 (76.5)     | 226              | 44.8           |
| Age of the mother (year)  | <20      | 3 (30.0)    | 7 (70.0)       | 10               | 2.0            |
|                           | 20-34    | 93 (23.4)   | 305 (76.6)     | 398              | 78.8           |
|                           | ≥35      | 31 (32.0)   | 66 (68.0)      | 97               | 19.2           |
| Residence                 | Rural    | 87 (25.7)   | 252 (74.3)     | 339              | 67.1           |
|                           | Urban    | 40 (24.1)   | 126 (75.9)     | 166              | 32.9           |
Maternal medical, and obstetric and gynecologic characteristics

Near to one-fourth (13.1%) of the mothers had known or been diagnosed with a medical disease, and more than nine-tenths of the mothers, 467 (92.5%), had antenatal care visits during the current pregnancy. Regarding the type of birth, more than a quarter (28.7%) of mothers had multiple types of pregnancy. Nearly one-fourth (23.4%) of mothers had a history of bad obstetric and/or gynecologic outcomes. Almost a quarter, 124 (24.6%), of the mothers had used antenatal steroids during the current pregnancy. Nearly three-fourth, 372 (73.7%), of the mothers had spontaneous onset of labor and the majority of the delivery, 462 (91.5%), had a cephalic presentation. Two-third, 336 (66.5%), of the mothers had a spontaneous vaginal delivery and 389 (77%) of delivery occurred at the hospital. Almost half, 250 (49.5%), of the mothers had an obstetric complication during the current pregnancy (Table 2).
Table 2
Maternal medical, and obstetric and/or gynecologic characteristics of a study participant in NICU of JUMC, Jimma, Southwest Ethiopia, 2020 (N=505).

| Variable                                                      | Category | Death N (%) | Censored N (%) | Frequency (N=505) | Percent (%) |
|---------------------------------------------------------------|----------|-------------|----------------|-------------------|-------------|
| Known or diagnosed medical diseases                           | Yes      | 20 (30.3)   | 46 (69.7)      | 66                | 13.1        |
|                                                               | No       | 107 (24.4)  | 332 (75.6)     | 439               | 86.9        |
| Febrile illness or disease                                    | Yes      | 11 (33.3)   | 22 (66.7)      | 33                | 6.5         |
|                                                               | No       | 116 (24.6)  | 356 (75.4)     | 472               | 93.5        |
| Anemia                                                        | Yes      | 7 (33.3)    | 14 (66.7)      | 21                | 4.2         |
|                                                               | No       | 120 (24.8)  | 364 (75.2)     | 484               | 95.8        |
| Others medical diseases*                                       | Yes      | 3 (15.8)    | 16 (84.2)      | 19                | 3.8         |
|                                                               | No       | 124 (25.5)  | 362 (74.5)     | 486               | 96.2        |
| Gravidity                                                     | I        | 38 (22.4)   | 132 (77.6)     | 170               | 33.7        |
|                                                               | II-IV    | 64 (25.4)   | 188 (74.6)     | 252               | 49.9        |
|                                                               | ≥V       | 25 (30.1)   | 58 (69.9)      | 83                | 16.4        |
| Antenatal care visit                                          | Yes      | 108 (23.1)  | 359 (76.9)     | 467               | 92.5        |
|                                                               | No       | 19 (50.0)   | 19 (50.0)      | 38                | 7.5         |
| Birth type                                                    | Single   | 91 (25.3)   | 269 (74.7)     | 360               | 71.3        |
|                                                               | Multiple | 36 (24.8)   | 109 (75.2)     | 145               | 28.7        |
| History of bad obstetric and/or gynecologic outcome**         | Yes      | 38 (32.2)   | 80 (67.8)      | 118               | 23.4        |
|                                                               | No       | 89 (23.0)   | 298 (77.0)     | 387               | 76.6        |
| Variable                        | Category | Death N (%) | Censored N (%) | Frequency (N=505) | Percent (%) |
|--------------------------------|----------|-------------|----------------|-------------------|-------------|
| History of neonatal death      | Yes      | 23 (33.8)   | 45 (66.2)      | 68                | 13.5        |
|                                | No       | 104 (23.8)  | 333 (76.2)     | 437               | 86.5        |
| History of stillbirth          | Yes      | 9 (26.5)    | 25 (73.5)      | 34                | 6.7         |
|                                | No       | 118 (25.0)  | 353 (75.0)     | 471               | 93.3        |
| History of abortion            | Yes      | 9 (28.2)    | 23 (71.8)      | 32                | 6.3         |
|                                | No       | 118 (24.9)  | 355 (75.1)     | 473               | 93.7        |
| Antenatal steroid use          | Yes      | 22 (17.7)   | 102 (82.3)     | 124               | 24.6        |
|                                | No       | 105 (27.6)  | 276 (72.4)     | 381               | 75.4        |
| Mode of delivery               | SVD      | 79 (23.5)   | 257 (76.5)     | 336               | 66.5        |
|                                | Assisted | 3 (14.3)    | 18 (85.7)      | 21                | 4.2         |
|                                | C/S      | 45 (30.4)   | 103 (69.6)     | 148               | 29.3        |
Table 2
Maternal medical, and obstetric and/or gynecologic characteristics of a study participant in NICU of JUMC, Jimma, Southwest Ethiopia, 2020 (N=505) (Continued).

| Variable                  | Category          | Death N (%) | Censored N (%) | Frequency (N=505) | Percent (%) |
|---------------------------|-------------------|-------------|----------------|-------------------|-------------|
| Cause of onset of labor   | Spontaneous       | 89 (23.9)   | 283 (76.1)     | 372               | 73.7        |
|                           | Induced           | 12 (29.3)   | 29 (70.7)      | 41                | 8.1         |
|                           | C/S               | 26 (28.3)   | 66 (71.7)      | 92                | 18.2        |
| Presentation              | Cephalic          | 116 (25.1)  | 346 (74.9)     | 462               | 91.5        |
|                           | Non-cephalic      | 11 (25.6)   | 32 (74.4)      | 43                | 8.5         |
| Place of delivery         | Hospital          | 97 (24.9)   | 292 (75.1)     | 389               | 77.0        |
|                           | Health center     | 20 (23.3)   | 69 (76.7)      | 90                | 17.8        |
|                           | Home              | 9 (34.6)    | 17 (65.4)      | 26                | 5.2         |
| Obstetric complications   | Yes               | 75 (30.0)   | 175 (70.0)     | 250               | 49.5        |
|                           | No                | 52 (20.4)   | 203 (79.6)     | 255               | 50.5        |
| Preeclampsia              | Yes               | 23 (28.8)   | 57 (71.2)      | 80                | 15.8        |
|                           | No                | 104 (24.5)  | 321 (75.5)     | 425               | 84.2        |
| Eclampsia                 | Yes               | 8 (32.0)    | 17 (68.0)      | 25                | 5.0         |
|                           | No                | 119 (24.8)  | 361 (75.2)     | 480               | 95.0        |
| Fetal distress            | Yes               | 26 (32.1)   | 55 (67.9)      | 81                | 16.0        |
|                           | No                | 101 (23.8)  | 323 (76.2)     | 424               | 84.0        |
| PPROM                     | Yes               | 20 (32.3)   | 42 (67.7)      | 62                | 12.3        |
|                           | No                | 107 (24.2)  | 336 (75.8)     | 443               | 87.7        |
| Abruption placenta        | Yes               | 6 (18.7)    | 26 (81.3)      | 32                | 6.3         |
|                           | No                | 121 (25.6)  | 352 (74.4)     | 473               | 93.7        |
| Variable                        | Category | Death N (%) | Censored N (%) | Frequency (N=505) | Percent (%) |
|--------------------------------|----------|-------------|----------------|-------------------|-------------|
| Placenta previa                | Yes      | 8 (34.8)    | 15 (65.2)      | 23                | 4.6         |
|                                | No       | 119 (24.7)  | 363 (75.3)     | 482               | 95.4        |
| Chorioamnionitis               | Yes      | 9 (32.1)    | 19 (67.9)      | 28                | 5.5         |
|                                | No       | 118 (24.7)  | 359 (75.3)     | 477               | 94.5        |
| Other complications***         | Yes      | 10 (41.7)   | 14 (58.3)      | 24                | 4.8         |
|                                | No       | 117 (24.3)  | 364 (75.7)     | 481               | 95.2        |

*Diabetes mellitus, HIV/AIDS, cardiac disease, renal disease, and STIs.

**Neonatal death, stillbirth, abortion, and intrauterine fetal death.

***Cord prolapse, oligohydramnios, polyhydramnios, postpartum hemorrhage, and prolonged labor.

**Neonatal related characteristics**

Almost four-fifth, 399 (79%), of the neonates were moderate preterm, and more than two-third, 349 (69%), of neonates had low birth weight. The majority of the neonates, 482 (95.4%), had AGA at birth. Nearly four-fifth, 399 (79%), of neonates had a fifth-minute APGAR score ≥ 7. Out of the cohort, 454 (89.9%) had not initiated breastfeeding within one hour of birth. Regarding the method of feeding, 351 (69.5%) neonates were fed through a nasogastric tube. More than three-fourth, 397 (78.6%), of neonates were diagnosed with hypothermia followed by respiratory distress syndrome (295 (58.4%)), hypoglycemia (167 (33.1%)), neonatal sepsis (151 (29.9%)), jaundice (122 (24.2%)), and perinatal asphyxia (40 (7.9%)). Almost three-fourth, 383 (75.8%), of neonates were heated with radiant warmer and 155 (30.7%) received kangaroo-mother care. More than three-fifth, 301 (59.6%), of neonates received nasal CPAP, 113 (22.4%) phototherapy, and nearly one-third, 159 (31.5%), of them were resuscitated with bag and mask (Table 3).
Table 3  
Neonatal related characteristics of preterm neonate admitted to NICU of JUMC, Jimma, Southwest Ethiopia, 2020 (N=505).

| Variable                                           | Category                        | Death | Censored | Total  | Percent |
|----------------------------------------------------|---------------------------------|-------|----------|--------|---------|
|                                                     |                                 | N (%) | N (%)    | (N)    | (%)     |
| Gestational age at birth (week)                     | <28                             | 14 (70.0) | 6 (30.0) | 20     | 4.0     |
|                                                     | 28- <32                         | 34 (39.5) | 52 (60.5) | 86     | 17.0    |
|                                                     | 32- <37                         | 79 (19.8) | 320 (80.2) | 399 | 79.0     |
| Birth weight (in gram)                              | <1000                           | 15 (62.5) | 9 (37.5) | 24     | 4.8     |
|                                                     | 1000 - <1500                    | 40 (36.7) | 69 (63.3) | 109 | 21.6     |
|                                                     | 1500 - <2500                    | 69 (19.8) | 280 (80.2) | 349 | 69.0     |
|                                                     | ≥2500                           | 3 (13.0) | 20 (87.0) | 23    | 4.6     |
| Weight class for gestational age                    | AGA                             | 122 (25.3) | 360 (74.7) | 482 | 95.4     |
|                                                     | SGA                             | 5 (29.4) | 12 (70.6) | 17 | 3.4     |
|                                                     | LGA                             | 0 (0.0) | 6 (100.0) | 6 | 1.2     |
| Fifth minute APGAR score                            | <7                              | 41 (38.7) | 65 (61.3) | 106 | 21.0     |
|                                                     | ≥7                              | 86 (21.6) | 313 (78.4) | 399 | 79.0     |
| Initiation of breastfeeding within one hour of birth | Yes                             | 5 (9.8) | 46 (90.2) | 51 | 10.1     |
|                                                     | No                              | 122 (26.9) | 332 (73.1) | 454 | 89.9     |
| Method of feeding                                   | Breast sucking                  | 26 (18.6) | 114 (81.4) | 140 | 27.7     |
|                                                     | NGT                             | 99 (28.2) | 252 (71.8) | 351 | 69.5     |
|                                                     | Cup feeding                     | 2 (14.3) | 12 (85.7) | 14 | 2.8     |
| Neonates with hypothermia                           | Yes                             | 102 (25.7) | 295 (74.3) | 397 | 78.6     |
|                                                     | No                              | 25 (23.1) | 83 (76.9) | 108 | 21.4     |
| Variable                                      | Category | Death N (%) | Censored N (%) | Total (N) | Percent (%) |
|-----------------------------------------------|----------|-------------|----------------|------------|-------------|
| Neonates who had respiratory distress syndrome | Yes      | 93 (31.5)   | 202 (68.5)     | 295        | 58.4        |
|                                              | No       | 34 (16.2)   | 176 (83.8)     | 210        | 41.6        |
|                                              |          |             |                |            |             |
| Neonates who had neonatal sepsis             | Yes      | 51 (33.8)   | 100 (66.2)     | 151        | 29.9        |
|                                              | No       | 76 (21.5)   | 278 (78.5)     | 354        | 70.1        |
|                                              |          |             |                |            |             |
| Neonates who had perinatal asphyxia          | Yes      | 17 (42.5)   | 23 (57.5)      | 40         | 7.9         |
|                                              | No       | 110 (23.7)  | 355 (76.3)     | 465        | 92.1        |
| Variable                                           | Category | Death N (%) | Censored N (%) | Total N (%) | Percent (%) |
|---------------------------------------------------|----------|-------------|----------------|-------------|-------------|
| Neonates with hypoglycemia                        | Yes      | 47 (28.1)   | 120 (71.9)     | 167         | 33.1        |
|                                                   | No       | 80 (23.7)   | 258 (76.3)     | 338         | 66.9        |
| Neonates who had anemia                           | Yes      | 10 (29.4)   | 24 (70.6)      | 34          | 6.7         |
|                                                   | No       | 117 (24.8)  | 354 (75.2)     | 471         | 93.2        |
| Neonates who had jaundice                         | Yes      | 45 (36.9)   | 77 (63.1)      | 122         | 24.2        |
|                                                   | No       | 82 (21.4)   | 301 (78.6)     | 383         | 75.8        |
| Neonates who had a congenital malformation        | Yes      | 8 (36.4)    | 14 (63.6)      | 22          | 4.4         |
|                                                   | No       | 119 (24.6)  | 364 (75.4)     | 483         | 95.6        |
| Neonates who had apnea of prematurity              | Yes      | 8 (50.0)    | 8 (50.0)       | 16          | 3.2         |
|                                                   | No       | 119 (24.3)  | 370 (75.7)     | 489         | 96.8        |
| Neonates diagnosed with any other problems*       | Yes      | 3 (10.3)    | 26 (89.7)      | 29          | 5.7         |
|                                                   | No       | 124 (26.1)  | 352 (73.9)     | 471         | 94.3        |
| Neonates received kangaroo mother care            | Yes      | 22 (14.2)   | 133 (85.8)     | 155         | 30.7        |
|                                                   | No       | 105 (30.0)  | 245 (70.0)     | 350         | 69.3        |
| Neonates received nasal CPAP                      | Yes      | 85 (28.2)   | 216 (71.8)     | 301         | 59.6        |
|                                                   | No       | 42 (20.6)   | 162 (79.4)     | 204         | 40.4        |
| Neonates resuscitated with bag and mask           | Yes      | 43 (27.0)   | 116 (73.0)     | 159         | 31.5        |
|                                                   | No       | 84 (24.3)   | 262 (75.7)     | 346         | 68.5        |
| Variable                                      | Category | Death N (%) | Censored N (%) | Total (N) | Percent (%) |
|----------------------------------------------|----------|-------------|----------------|-----------|-------------|
| **Neonates received phototherapy**           | Yes      | 36 (31.9)   | 77 (68.1)      | 113       | 22.4        |
|                                              | No       | 91 (23.2)   | 301 (76.8)     | 392       | 77.6        |
| **Neonates heated with radiant warmer**      | Yes      | 98 (25.6)   | 285 (74.4)     | 383       | 75.8        |
|                                              | No       | 29 (23.8)   | 93 (76.2)      | 122       | 24.2        |

*Meningitis, ophthalmic neonatorum, necrotizing enterocolitis, pulmonary hypertension, HIV exposed, meconium aspiration syndrome, hospital-acquired infection, and birth trauma.

### Survival status of preterm neonate

During the follow-up, 127 (25.1%) (95% CI: 21.42, 29.17) preterm neonates died. Among all death, 15.7% (95% CI: 9.89, 23.27) died in the first 24 hours of life, and 81.1% (95% CI: 73.20, 87.50) of deaths occurred within 7 days of life. Out of the cohort, 352 (69.7%) improved and were discharged to home, 15 (3%) lost to follow-up, 6 (1.2%) referred to other hospitals, and the remaining 5 (1%) were withdrawal from the follow-up. Among the cohort, 378 (74.9%) (95% CI: 70.83, 78.58) neonates survived during the follow-up period.

A cohort contributed a total of 4,386 neonate days at risk of observation. The overall neonatal mortality rate (incidence density) of the cohort was 28.9 deaths per 1,000 neonate-days (95% CI: 24.33, 34.46). The neonatal mortality rate (NMR) was 67.3 deaths per 1,000 neonate-days in the first 24 hours of life (95% CI: 48.11, 94.23). Early NMR (death within seven days of life) was 40 deaths per 1,000 neonate-days (95% CI: 33.08, 48.33); however, the late NMR was 11.7 deaths per 1,000 neonate-days (95% CI: 7.55, 18.13).

### Overall survival function

Preterm neonates were followed for different follow-up periods: a minimum of 1 day and a maximum of 28 days. The overall median length of follow-up was 7 (IQR=8) days. The cumulative survival probability at the end of follow-up was 54.94% (95% CI: 41.83, 66.27). The cumulative probability of survival at the end of the first, seventh, 14th, and 21st days was 93.27% (95% CI: 90.71, 95.14), 76.89% (95% CI: 72.73, 80.51), 71.8% (95% CI: 66.79, 76.19), and 66.96% (60.54, 72.58), respectively. The median survival time was undetermined since to estimate median survival time at least 50% of the neonates have to experience death during the follow-up period. But, only 25.1% of neonates had experienced death in this study. The overall mean survival time was 20.42 neonate days (95% CI: 19.27, 21.56).

The overall survival probability of preterm neonates during the follow-up period was presented by a step-down Kaplan Meier survival curve (Figure 1). The graph went down increasingly over the first seven days,
showing a lower probability of preterm neonatal survival. However, in the latter days of the follow-up, the graph continued to decrease slightly indicating that the likelihood of preterm neonatal death is declined.

**Survival function and comparison of survival experience**

Preterm neonates born from mothers who used antenatal steroids during current pregnancy had higher survival experience compared to their counterparts ($X^2=5.17$, P-value=0.023) (Figure 2). Likewise, preterm neonates who received kangaroo-mother care (KMC) had a higher survival experience than neonates who didn’t receive KMC ($X^2=14.18$, P-value=0.0002) (Figure 7).

However, preterm neonates born from mothers with obstetric complications during current pregnancy had lower survival experience than their counterparts ($X^2=11.71$, P-value=0.001) (Figure 3). Neonates having respiratory distress syndrome (RDS) at admission had lower survival experience than those neonates without RDS ($X^2=11.14$, P-value=0.001) (Figure 4). Preterm neonate with neonatal sepsis at admission had lower survival experience than their complements ($X^2=7.55$, P-value=0.006) (Figure 5). Neonates diagnosed with PNA at admission had lower survival experience than their counterparts ($X^2=7.51$, P-value=0.003) (Figure 6).

**Predictors of preterm neonatal mortality**

In bivariable cox-regression analysis; the age of the mother, ANC visit, history of bad obstetric and/or gynecologic outcome, antenatal steroid use, place of delivery, obstetric complications, gestational age at birth, birth weight, fifth minute APGAR score, initiation of breastfeeding within one hour of birth, respiratory distress syndrome, neonatal sepsis, perinatal asphyxia, jaundice, and receiving kangaroo-mother care were found significant at P-value <0.25. These variables were entered into multivariable Cox regression analysis to determine predictors for time to death.

In multivariable Cox-regression analysis; an antenatal steroid use during the current pregnancy, obstetric complication during the current pregnancy, an increment in gestational age at birth, receiving kangaroo-mother care, having respiratory distress syndrome, neonatal sepsis, and perinatal asphyxia at admission were found to be statistically significant independent predictors for time to death of preterm neonates (P-value <0.05) (Table 4).
Table 4
Bivariable and multivariable Cox-regression analysis for predictors of preterm neonatal mortality in NICU of JUMC, Jimma, Southwest Ethiopia, 2020 (N=505).

| Predictors                                                                 | Outcome status | CHR [95% CI] | P-value | AHR [95% CI] | P-value |
|----------------------------------------------------------------------------|----------------|--------------|---------|--------------|---------|
|                                                                            | Death          | Censored     |         |              |         |
| Age of the mother                                                         |                |              |         |              |         |
| <20 year                                                                  | 3              | 7            | 1.50 [0.47, 4.73] | 0.49 |
| 20-34 year                                                                | 93             | 305          | 1       |              | 0.087   |
| ≥35 year                                                                  | 31             | 66           | 1.43 [0.95, 2.15] | 0.087 |
| Antenatal care visit during the current pregnancy                         |                |              |         |              |         |
| Yes                                                                       | 108            | 359          | 1       |              | 0.001   |
| No                                                                        | 19             | 19           | 2.25 [1.38, 3.67] | 0.001 |
| History of bad obstetric and/or gynecologic outcomes                      |                |              |         |              |         |
| Yes                                                                       | 38             | 80           | 1.33 [0.91, 1.95] | 0.14 |
| No                                                                        | 89             | 298          | 1       |              |         |
| Antenatal steroid use during the current pregnancy                        |                |              |         |              |         |
| Yes                                                                       | 22             | 102          | 0.59 [0.38, 0.94] | 0.028 |
| No                                                                        | 105            | 276          | 1       |              | 0.018   |
| Place of delivery                                                         |                |              |         |              |         |
| Hospital                                                                  | 97             | 292          | 1       |              | 0.87    |
| Health center                                                             | 20             | 69           | 1.04 [0.65, 1.67] | 0.14 |
| Home                                                                      | 9              | 17           | 1.68 [0.84, 3.33] | 0.14 |
| Obstetric complications during the current pregnancy                       |                |              |         |              |         |
| Yes                                                                       | 75             | 175          | 1.44 [1.01, 2.05] | 0.045 |
| No                                                                        | 52             | 203          | 1       |              | 0.005   |
| Gestational age at birth (in week)                                        |                |              |         |              |         |
|                                                                            | 0.83 [0.77, 0.89] | <0.001       | 0.81 [0.75, 0.87] | <0.001 |
| Birth weight (in gram)                                                    |                |              |         |              |         |
| Predictors | Outcome status | CHR [95% CI] | P-value | AHR [95% CI] | P-value |
|------------|----------------|--------------|---------|--------------|---------|
|            | Death | Censored |            |              |         |
| <1000      | 15    | 9        | 5.02 [1.40, 17.40] | 0.011    |         |
| 1000-<1500 | 40    | 69       | 2.19 [0.68, 7.09]  | 0.19     |         |
| 1500-<2500 | 69    | 280      | 1.44 [0.45, 4.57]  | 0.54     |         |
| ≥2500      | 3     | 20       | 1        |          |         |
Table 4
Bivariate and multivariable Cox-regression analysis for predictors of preterm neonatal mortality in NICU of JUMC, Jimma, Southwest Ethiopia, 2020 (N=505) (Continued).

| Predictors                        | Outcome status | CHR [95% CI]       | P-value | AHR [95% CI]       | P-value |
|-----------------------------------|----------------|--------------------|---------|--------------------|---------|
|                                   | Death          | Censored           |         |                    |         |
| Fifth minute APGAR score          |                |                    |         |                    |         |
| <7                                | 41             | 65                 | 1.86 [1.28, 2.70] | 0.001
| ≥7                                | 86             | 313                | 1       |                    |         |
| Breastfeeding initiated within one hour of birth |        |                    |         |                    |         |
| Yes                               | 5              | 46                 | 1       |                    | 0.046   |
| No                                | 122            | 332                | 2.50 [1.02, 6.09] |          |
| Neonates who had respiratory distress syndrome |            |                    |         |                    |         |
| Yes                               | 93             | 202                | 1.90 [1.29, 2.82] | 0.001
| No                                | 34             | 176                | 1       |                    | 0.045   |
| Neonates who had neonatal sepsis  |                |                    |         |                    |         |
| Yes                               | 51             | 100                | 1.62 [1.14, 2.31] | 0.008
| No                                | 76             | 278                | 1       |                    | 0.005   |
| Neonates who had perinatal asphyxia |             |                    |         |                    |         |
| Yes                               | 17             | 23                 | 1.99 [1.19, 3.32] | 0.009
| No                                | 110            | 355                | 1       |                    | 0.004   |
| Neonates who had jaundice         |                |                    |         |                    |         |
| Yes                               | 45             | 77                 | 1.63 [1.13, 2.34] | 0.009
| No                                | 82             | 301                | 1       |                    |         |
| Neonates who received kangaroo mother care |         |                    |         |                    |         |
| Yes                               | 22             | 133                | 0.43 [0.27, 0.68] | <0.001
| No                                | 105            | 245                | 1       |                    | 0.002   |

1: Reference group, CHR: Crude hazard ratio, AHR: Adjusted hazard ratio, and CI: Confidence interval

At any time during the follow-up period, preterm neonates born from mothers who used antenatal steroids during current pregnancy had 45% fewer hazard of death compared to neonates born from mothers who didn’t use antenatal steroids (AHR=0.55; 95% CI:0.34, 0.90). Preterm neonates born from mothers with an obstetric complication during current pregnancy had nearly two times higher hazard of death compared
to those who were born from mothers without obstetric complication throughout the study period (AHR=1.84; 95% CI: 1.20, 2.82).

As the gestational age of preterm neonates at a birth increase by one week, the hazard of death decrease by 19% at any time during the follow-up period (AHR= 0.81; 95% CI: 0.75, 0.87). Preterm neonates who had respiratory distress syndrome (RDS) had 1.52 times more hazard of death than those without RDS throughout the follow-up period (AHR=1.52; 95% CI: 1.01, 2.29). Preterm neonates who had neonatal sepsis had about 1.71 times greater hazard of death than neonates without neonatal sepsis at any time during the follow-up period (AHR=1.71; 95% CI: 1.18, 2.49).

Preterm neonates who had perinatal asphyxia had 2.44 times more hazard of death compared to those neonates without perinatal asphyxia throughout the follow-up period (AHR=2.44; 95% CI: 1.33, 4.49). Preterm neonates who received kangaroo mother care had 52% lesser hazard of death as compared to those preterm neonates who didn't receive kangaroo-mother care throughout the follow-up period (AHR=0.48; 95% CI: 0.30, 0.77).

**Discussion**

This study showed that 25.1% of neonates died during the follow-up with an overall neonatal mortality rate of 28.9 deaths per 1,000 neonate days. This finding is consistent with studies reported from Iran 27.4% and 28.7% (14, 34), and Nigeria 27.7% (17). Moreover, this finding is in line with studies reported from Gonder 25.2% and 32.9 deaths per 1000 neonate-days (18, 19), and Addis Ababa 25.3% and 29.7% (15, 32).

However, this finding is higher than studies reported from Australia 7.7% (45), China 8.8% and 1.9% (21, 22), and Uganda 8% (35). This discrepancy between studies might be explained by variation in a study setting as there might be a high quality of neonatal care in Australia and China. A study from Australia was conducted in a hospital with a level four NICU while this study was conducted in a hospital with a level three NICU. Preterm neonates born in developed countries like Australia and China might receive improved care during pre-pregnancy, pregnancy, antepartum, and postnatal periods. Partly, this disparity might result from a difference in sample size, study design, and those reported studies were multicenter studies.

Conversely, this study finding is lower than studies reported from India 33.5% (46), and Jimma, Ethiopia 34.9% (33). This discrepancy might result from variation in study design as a study reported from India was multicenter prospective studies conducted on a large sample size. The inconsistency with finding from Jimma might be due to variation in the timing of the study as there was some improvement in antenatal and delivery care from a skilled provider, and institutional delivery (39). Partly, this might result from the fact that NICU is organized in a good manner, and access to trained health care providers increased comparatively since special attention was given to preterm neonates by national neonatal and child survival strategy (38). This finding indicates that preterm neonates are still highly at risk of death, and ongoing commitment and interventions need to be considered by giving special emphasis on
identified predictors and continuum of care to meet the SGDs and national target of reducing neonatal mortality.

In this study, early NMR (40 per 1,000 neonate-days) was higher as compared to late NMR (11.7 per 1,000 neonate-days). This finding is consistent with studies reported from Jordan (47), and Gonder, Ethiopia (18). This might be attributed to the reason that most of the preterm neonatal mortality in the resource-limited setting is related to practice during the intrapartum and immediate postpartum period, the need for intensive medical care, and timely referral of high-risk neonates. But, this finding is lower than the study conducted in Addis Ababa (32). This inconsistency could be due to a study from Addis Ababa was a multicenter prospective study conducted on a small sample and it is a setting that receives high-risk neonates referred from different regions of the country. The finding of this study shows the need to focus preterm neonatal survival interventions more on the intrapartum as well as the immediate postpartum period, and early neonatal periods.

In the current study, preterm neonates born from mothers who used antenatal steroids had a lesser hazard of mortality than those neonates born from mothers who did not use antenatal steroids. This finding is in line with studies reported in the United States (20) and China (21, 22). This could be explained by the fact that the administration of steroids for mothers who had imminent preterm delivery enhances fetal lung maturity and decreases the risk of developing respiratory distress syndrome and intraventricular hemorrhage, and consequently might reduce the risk of neonatal death (48). In this study, preterm neonates born from mothers who had an obstetric complication during their current pregnancy had a higher hazard of neonatal death compared to their counterparts. This finding is comparable with studies reported from Bangladeshi (26), Gonder (27), and Tigray, Ethiopia (44). This might be explained by the fact that obstetric complications affect the pregnancy status and placental blood transfusion, and can result in preterm delivery with subsequent preterm-related life-threatening complications which might increase the hazard of neonatal death (49).

In this study, an increment in gestational age at birth by one week decreases the hazard of preterm neonatal deaths by 19%. This finding is in line with studies reported from the United States (12), China (21), Gonder (18), and Addis Ababa, Ethiopia (32). A possible reason for this might be as the gestational age of the neonates at birth increases, the maturity of the fetus will be enhanced, and the risk of developing life-threatening complications related to prematurity decreases and which might contribute to a reduced risk of preterm neonatal death.

In the current study, preterm neonates who had respiratory distress syndrome (RDS) had a greater hazard of neonatal mortality compared to their counterparts. This finding is consistent with studies reported from different parts of Ethiopia: Gondar (27), Debre Markos (31), Addis Ababa (15), and Jimma (33). This might be because of similarities in settings that lack postnatal surfactant administration. Partly, it could be explained by the fact that preterm neonates had immature lungs, and might consequently develop life-threatening complications like a respiratory failure. Different kinds of literature reported that respiratory distress syndrome was the primary cause of preterm neonatal death (14, 50).
In this study, preterm neonates who had neonatal sepsis had a higher hazard of neonatal mortality than preterm neonates without neonatal sepsis. This finding is in line with studies reported from Addis Ababa (15), and Jimma (33). This might result from the fact that preterm neonates were more likely to be born with or acquire an infection because they had immature immune defenses supplemented with poor calorie intake, and might increase the risk of death (51).

In the current study, preterm neonates who had perinatal asphyxia (PNA) had a greater hazard of neonatal mortality than those preterm neonates without PNA. This finding is consistent with studies reported from China (22), Gonder (18, 19, 24), Woliata Sodo (23), Addis Ababa (52), and Jimma, Ethiopia (33, 36). This consistency might be elucidated by similarity in study design, and follow-up period. This finding might be supported by the fact that PNA can lead to hypoxia with subsequent acidosis, leading to hypotension and hypoxic-ischemic encephalopathy, which further compromise oxygen delivery to the brain and might increase the risk of death.

In the present study, a preterm neonate who received kangaroo-mother care (KMC) had a 52% lesser hazard of neonatal mortality compared to preterm neonates who did not receive KMC. This finding was in line with studies reported from Uganda (35), and Gonder, Ethiopia (18). This consistency might be due to the similarity of the study setting, study design, and sample size. The finding was reaffirmed by the fact that receiving KMC protects neonates from the risk of hypothermia by decreasing body surface area to the external environment. Partly, it might also be explained by the fact that KMC promotes early initiation of breastfeeding, and may be used even when babies on formula-fed, which helps to prevent hypoglycemia. Moreover, KMC helps to reduce neonatal mortality by protecting them from sepsis (53–56).

Even though this study has many strengths, it has also some limitations. Some important predictors of preterm neonatal mortality like maternal educational status, maternal nutritional status, birth interval, birth order, duration of rupture of membrane, and first-minute APGAR score were not explored.

**Conclusion**

In the current study, the overall preterm neonatal mortality rate was found high. Most preterm neonatal mortality occurred in the early phase of the neonatal period, which seeks due attention to meet the national newborn and child survival and SDGs goal in Ethiopia. Obstetric complications during the current pregnancy, respiratory distress syndrome, neonatal sepsis, and perinatal asphyxia at admission were found to be independent risk factors of preterm neonatal mortality. However, antenatal steroid use during the current pregnancy, an increment in gestational age at birth, and receiving kangaroo-mother care were independent preventive predictors of preterm neonatal mortality. Hence, it is better to give special emphasis and close follow-up for preterm neonates, especially during the early neonatal period and is also better to strengthen obstetrics care to prevent or reduce obstetric complications and prematurity, use of antenatal steroids for women having an imminent preterm delivery, early diagnosis and management of obstetric as well as neonatal complications. Furthermore, encouraging and
supporting mothers or caregivers to practice kangaroo-mother care, and ensuring a continuum of care are crucial to enhance preterm neonatal survival.

**Abbreviations**

AHR: Adjusted Hazard Ratio; APGAR: Appearance, Pulse, Grimace, Activity, and Respiration, CHR: Crude Hazard Ratio; CPAP: Continuous Positive Airway Pressure; C/S: Caesarean section, GA: Gestational Age; HIV/AIDS: Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome; IQR: Interquartile range; JUMC: Jimma University Medical Center; NGT: Nasogastric tube, NICU: Neonatal Intensive Care Unit; PROM: Premature Rupture of Membrane; SDGs: Sustainable Development Goals; SSA: Sub-Saharan Africa.

**Declarations**

**Ethics approval and consent to participate**

Ethical approval for the study was obtained from the Institutional Review Board (IRB) of Jimma University, Institute of Health with a reference number of IRB000/01/2020 before its commencement. The aim of the study was explained and informed written consent was obtained from Jimma University Medical Center's medical director for getting the necessary information and record reviews. To ensure confidentiality, identifiers of preterm neonates and health care providers who examined the neonate were not recorded on the data collection checklist, and all checklists were handled confidentially and discarded at the end of the study safely.

**Consent for publication**

Not applicable

**Availability of data and materials**

Data will be available upon request from the corresponding author.

**Competing interests**

The authors declare that they have no competing interests.

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**Authors’ contributions**
TMT: Involved in the conception, designing methods, data analysis, interpretation of the findings, write-up of the findings, and drafting of the manuscript. LD and HM: Participated in designing, data analysis, interpretation of the findings, and write-up of the findings. All authors have read and approved the manuscript.

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**Figures**
Figure 1

Overall Kaplan–Meier estimate of survival probability since admission among preterm neonates admitted to the NICU of JUMC, Jimma, Southwest Ethiopia, 2020.
Figure 2

KM curve to compare survival experience across antenatal steroids use status among preterm neonates admitted to the NICU of JUMC, Jimma, Southwest Ethiopia, 2020.
Figure 3

KM curve to compare survival experience across obstetric complication status among preterm neonates admitted to the NICU of JUMC, Jimma, Southwest Ethiopia, 2020.
**Figure 4**

KM curve to compare survival experience across respiratory distress syndrome status among preterm neonates admitted to the NICU of JUMC, Jimma, Southwest Ethiopia, 2020.

Kaplan-Meier survival estimates by respiratory distress syndrome at admission

Log-rank test ($X^2=11.14$, P-value = 0.001)
Figure 5

KM curve to compare survival experience across neonatal sepsis status among preterm neonates admitted to the NICU of JUMC, Jimma, Southwest Ethiopia, 2020.
Figure 6

KM curve to compare survival experience across perinatal asphyxia status among preterm neonates admitted to the NICU of JUMC, Jimma, Southwest Ethiopia, 2020.

Log-rank test ($X^2 = 7.51$, P-value = 0.003)
Figure 7

KM curve to compare survival experience across categories of KMC among preterm neonates admitted to the NICU of JUMC, Jimma, Southwest Ethiopia, 2020.