Article published online: 2023-07-19



# Common Causes and Risk Factors for Neonatal Death in NICU in Tobruk Medical Center between July 2018 and July 2019, Libya

Eman F.A. Altarhouni[1] Zinelabedin Mohamed[2] Nama Alhouni[3]

[1] Pediatric Department, Faculty of Medicine, Tobruk University, Tobruk, Libya
[2] Department of Internal Medicine, Faculty of Medicine, Tobruk University, Tobruk, Libya
[3] Pediatric Department, Faculty of Medicine, Benghazi University, Benghazi, Libya

**Address for correspondence** Zinelabedin Mohamed, MSc, Department of Internal Medicine, Faculty of Medicine, Tobruk University, Tobruk, Libya (e-mail: Zen_zen47@yahoo.com).

Libyan Int Medical Univ J 2023;8:31–38.

## Abstract

**Background** Of the 130 million babies born worldwide each year, an estimated 4 million die during the neonatal period. Of the total global neonatal mortality, 99% occurs in low- and middle-income countries, particularly in Africa and South Asia. The current study was designed to calculate the neonatal mortality rate (NMR), analyze the causes of neonatal deaths, and examine risk factors contributing to neonatal deaths in the neonatal unit of Tobruk Medical Center (TMC).

**Methods** A case-control study was conducted on 180 newborns divided into two groups admitted to the neonatal intensive care unit (NICU) on the same day of delivery. The first group included 90 newborns who died before day 28 and the second group included 90 newborns who survived until the time of discharge and were selected randomly. The data of the patients were collected from the medical records of newborns admitted to the neonatal unit at TMC between July 2018 and July 2019. All data in this study were statistically analyzed using SPSS 23.0 for Windows (SPSS Inc., Chicago, IL, United States).

**Results** The NMR among the studied neonates was 12.3 per 1,000 live births, and the death rate was 16.36% per 1,000 admissions. The most common causes of mortality were premature birth (55, 61%), birth asphyxia (18, 20%), and congenital anomalies (10, 11.2%). Less than 50% of the dead patients were on a mechanical ventilator. Premature birth and low birth weight patients are strong predictors of neonatal mortality; normal vaginal delivery had a higher risk of mortality than the other methods of delivery. Gender, maternal blood group, maternal age, and past obstetrical and medical history had no positive correlation with mortality except for antepartum hemorrhage.

**Conclusion** The study found that the rate of neonatal mortality is similar to that of other hospitals in developing countries and the most common cause of neonatal death was premature birth, and premature birth and low birth weight were the main risk factors for death.

**Keywords**
- neonatal mortality
- neonatal death
- risk factors
- Tobruk Medical Center
- Libya

**DOI** https://doi.org/10.1055/s-0043-1770994.
**ISSN** 2519-139X.



Thieme Medical and Scientific Publishers Pvt. Ltd., A-12, 2nd Floor, Sector 2, Noida-201301 UP, India

ملخص المقال باللغة العربية

تحديد الأسباب الشائعة وعوامل الخطر لوفاة حديثي الولادة في العناية المركزة في مركز طبرق الطبي، ليبيا.



**المؤلفون:**

إيمان التَرهوني[1]، زين العابدين محمد[2]، نعمة الهوني[3].

1- قسم طب الأطفال، كلية الطب، جامعة طبرق، طبرق، 2 –قسم الأمراض الباطنة - كلية الطب - جامعة طبرق – طبرق 3- قسم طب الأطفال، كلية الطب، جامعة بنغازي، بنغازي، ليبيا.

**المؤلف المسؤول:** زين العابدين **البريد الإلكتروني:** Zen_Zen47@yahoo.com



**الخلفية:** من بين 130 مليون طفل يولدون في جميع أنحاء العالم كل عام، يموت ما يقدر بنحو 4 ملايين خلال فترة حديثي الولادة. تحدث 99٪ من إجمالي وفيات الأطفال حديثي الولادة في العالم في البلدان المنخفضة والمتوسطة الدخل، لا سيما في أفريقيا وجنوب آسيا.

**الهدف:** تم تصميم الدراسة الحالية لحساب معدل وفيات حديثي الولادة، وتحليل أسباب الوفيات، وفحص عوامل الخطر التي تسهم في وفيات الأطفال حديثي الولادة في وحدة العناية المركزة لحديثي الولادة في مركز طبرق الطبي.

**الطرق:** تم جمع بيانات المرضى من السجلات الطبية للأمهات والأطفال حديثي الولادة الذين تم قبولهم في وحدة حديثي الولادة ووحدة العناية المركزة لحديثي الولادة في مركز طبرق الطبي بين يوليو 2018م ويوليو 2019م. أجريت الدراسة بأثر رجعي على 180 مولوداً جديدًا مقسمين إلى مجموعتين متساويتين. ضمت المجموعة الأولى 90 من الأطفال حديثي الولادة الذين تم إدخالهم إلى وحدة العناية المركزية وتوفوا قبل اليوم 28 من الولادة (مجموعة وفيات حديثي الولادة)، بينما ضمت المجموعة الثانية 90 من الأطفال حديثي الولادة الذين تم اختيارهم عشوائيًا والذين نجوا حتى وقت الخروج (مجموعة أحياء حديثي الولادة). تم جمع البيانات عن جميع الولادات ووفيات الولدان وأسبابها وخصائص الأمهات. تم تحليل البيانات باستخدام SPSS 23.0 تم وصف البيانات باستخدام المعدلات والنسب المئوية أو المتوسط±الانحراف المعياري. تمت مقارنة النسب المئوية باستخدام اختبار كي المربع أو اختبار فيشر، وتمت مقارنة المتوسط باستخدام اختبار ستيودنت ت. اعتبرت قيمة p <0.05 ذات دلالة إحصائية.

**النتائج:** بلغ معدل وفيات حديثي الولادة الخاضعين للدراسة 12.3 لكل 1000 ولادة حية. كانت الأسباب الأكثر شيوعًا للوفاة هي الولادة المبكرة (61٪) والاختناق عند الولادة (20٪) والتشوهات الخلقية (11.2٪). أقل من خمسين بالمائة من المرضى المتوفين كانوا تحت جهاز التنفس الصناعي. كانت الولادة المبكرة وانخفاض الوزن عند الولادة من المؤشرات القوية لوفيات الأطفال حديثي الولادة. كان الولدان المولودين عن طريق الولادة المهبلية الطبيعية أكثر تعرضًا للوفاة بمقدار 1.5 مرة من أولئك الذين ولدوا بطرق أخرى، بينما كان الأطفال المولودين عن طريق الولادة القيصرية الاختيارية أقل تعرضًا لوفيات الولدان بحوالي 3 مرات. لم يكن لعمر الأم، وفصيلة دمها والولادات السابقة والتاريخ المرضي كارتفاع ضغط الدم والسكر أي تأثير كبير على معدل وفيات الأطفال حديثي الولادة. كان النزف قبل الولادة أعلى بمقدار 8.8 مرة بين مجموعة وفيات الولدان منه في مجموعة الأحياء حديثي الولادة.

**الاستنتاجات:** وجدت الدراسة أن معدل وفيات الأطفال حديثي الولادة مماثل لمعدل الوفيات في البلدان النامية. كان السبب الأكثر شيوعًا لوفاة حديثي الولادة مع القدرة التنبؤية القوية هو الولادة المبكرة وانخفاض الوزن عند الولادة. كان النزف قبل الولادة عامل الأم الوحيد الذي ساهم بشكل كبير في وفيات الولدان.



**الكلمات المفتاحية:** وفيات حديثي الولادة، وفيات الأطفال، عوامل الخطر، مركز طبرق الطبي، ليبيا.


## Introduction

Of the 130 million babies born worldwide each year, an estimated 4 million die during the neonatal period. Of these deaths, 50% occur within the first 24 hours of life. The risk of dying during the neonatal period is greatest toward the early stages of birth and gradually decreases over the next few days.[1]

Of these 4 million, 3 million deaths occur in the early neonatal period (0–6 days). A child's risk of death is almost 15 times higher in the first 28 days of life than at any other time before the first birthday.[2] Of total global neonatal mortality, 99% occurs in low- and middle-income countries, particularly in Africa and South Asia, where less progress has been made in reducing neonatal mortality.[2] According to a 2008 global study, the leading causes of neonatal mortality are complications of premature birth, asphyxia at birth, sepsis, infections, and pneumonia. These causes are to some extent preventable and well addressed in high-income countries, resulting in reduced neonatal mortality rates (NMRs). However, the inevitable causes due to genetic and biological factors such as preterm birth and congenital anomalies still predominate and lead to neonatal deaths in these countries.[3] Globally, neonatal death has decreased by an average of 1.8% per year, much slower than under-5 mortality (2.2%). In East Asia, the region of the world with the largest decline in under-5 mortality, neonatal deaths accounted for 57% of under-5 mortality in 2011. Newborn mortality accounts for more than 50% of under-5 mortality in South Asia, and almost 30% of all newborn deaths worldwide occurred in India alone in the same year. Sub-Saharan Africa accounts for 38% of global neonatal mortality and the highest NMR of 34/1,000 live births in 2011. As a result, this region has made the least progress in reducing under-5 mortality.[4] In 2016, 2.6 million deaths, approximately 46% of all under-5 deaths, occurred in the neonatal period, with nearly 7,000 neonatal deaths per day. The majority of neonatal deaths are concentrated in the first day and week, with about a million deaths on the first day and nearly a million deaths in the next 6 days.[5] The high NMR remains a problem in developing countries, where the economic situation and poor planning of health services have resulted in little significant progress in neonatal care.[6] Although recent advances in medical technology and innovations in the quality of care of preterm babies have increased their life expectancy, particularly for newborns weighing less than 1,000 g (extremely low birth weight newborn), the frequency of complications associated with premature birth remains high.[7] Identifying and understanding factors such as prenatal care, mode of delivery, and labor can lead to a reduction in neonatal mortality. Studies conducted to assess the impact of these variables on neonatal mortality may have used descriptive designs, meaning they could not explain the association.[8] It is useful to identify the risk factors that predict early infant mortality, particularly those that have the potential to be intervened with modest resources.[9] The current study was the first study conducted in TMC to evaluate NMR and highlight the risk factors and common causes of neonatal deaths compared with other developing countries.

## Methods

### Study Design and Settings

A case-control study was conducted at the neonatal intensive care unit (NICU) in Tobruk Medical Center (TMC) between July 2018 and July 2019 after ethical clearance from the Research Ethics Committee of Tobruk University.

### Study Population

The study was done between two groups of newborns. The first group included 90 newborns who died before day 28 and the second group included 90 newborns who survived until the time of discharge and were selected randomly from the (460) alive patients. Those patients admitted with birth complications to the neonatal unit on the same day of delivery, who delivered either inside or outside the hospital to women aged 15 to 49 years. The newborn patients who were not admitted to the NICU on the same day of delivery were excluded from the study.

 

### Data Collection

Demographic data of the patients were collected from the records of newborns admitted to the NICU at TMC including gestational age, sex, place of delivery, primary diagnosis, birth weight, duration of stay inside the unit, history of resuscitation, use of mechanical ventilation, maternal infection, history of premature rupture of membrane (PROM), antepartum hemorrhage, prolonged labor, use of instrumentation during delivery, age at death, and the cause of death. Maternal sociodemographic data included mother's age, blood group, obstetrical history including history of abortion, neonatal death, history of a previous newborn with congenital anomaly, premature birth, and history of consanguinity. Medical history includes chronic illnesses such as hypertension (HTN), diabetes mellitus (DM), hypothyroidism, and any other chronic diseases.

The total number of admissions during the study period was obtained from patient records, while the total number of live births in TMC was obtained from the hospital's statistics department. The NICU of TMC provides services for newborns of high-risk pregnancies and emergency cases delivered inside and outside the hospital. The quality of work inside the unit for 24 hours was divided into two shifts. Each shift included two doctors and one nurse. The unit is monitored daily by pediatric specialists and seniors and the total number of incubators was 14 incubators with many cribs and 2 mechanical ventilators.

### Statistical Analysis

All data in this study were collected, tabulated, and statistically analyzed using Statistical Package for the Social Sciences (SPSS) 23.0 for Windows (SPSS Inc., Chicago, IL, United States). The mean, standard deviation, and (range) were used to describe quantitative data, and absolute frequencies (number) and relative frequencies were used to describe qualitative data (percentage). The *t*-test was used to compare normally distributed variables for two groups of neonates. Percentages of categorical variables were compared using the chi-squared test or Fisher's exact test, where appropriate. All tests were two-sided; a p-value $< 0.05$ was considered statistically significant (S), and *p*-value $\geq 0.05$ was considered statistically nonsignificant (NS). The confidence interval (CI) was set at 95%. The odds ratio (OR) was used to estimate the risk. To draw the receiver operating characteristic (ROC) curve, the true positive rate (sensitivity) is plotted on the (y) axis and the false-positive rate (specificity) on the (x) axis.

## Results

This study includes two groups of newborns admitted to the NICU on the same day of delivery. The first group included 90 newborns who died before day 28, and the second group included 90 newborns who survived until the time of discharge. Males were predominant in number (52) and percent of mortality (57.8%) compared to females (38 and 42.2%, respectively) in the neonatal death group, as well as in the neonatal survival group where the males were predominant in number (55) and percent (61.1%) compared to females (35 and 38.9%, respectively. There was a statistically nonsignificant difference between the studied groups regarding gender. The mean body weight was $1.869 \pm 0.85$ kg (range: 0.56–4.42 kg) in the neonate death group, which was lower than that in the survival neonatal group where the mean was $2.903 \pm 0.75$ kg (range: 0.935–4.855 kg), with a statistically significant difference at $p < 0.0001$. There is a positive correlation between gestational age and neonatal mortality, as the risk of mortality increases when gestational age decreases. ►**Table 1** displays the gestational age per week of both neonatal groups, where the mean gestational age was $32.97 \pm 4.89$ weeks (range: 22–42 weeks) in the neonatal death group, which was lower than that in the survival neonatal group where the mean was $37.1 \pm 2.8$ (range: 32–41 weeks), with a statistically significant difference at $p = 0.0001$.

The percent of neonatal deaths from the total number of neonates (550) admitted to the intensive care unit (ICU) was 16.36% and the NMR was calculated from the total number of

**Table 1** Characteristics of the neonatal deaths group and neonatal survival group (each group $n = 90$)

| Variables | Studied groups | | | | $\chi^2$ | *p*-value |
|---|---|---|---|---|---|---|
| | Neonatal deaths group | | Neonatal survival group | | | |
| | *n* | % | *n* | % | | |
| **Sex** | | | | | | |
| Females | 38 | 42.2 | 35 | 38.9 | 0.21 | 0.65 |
| Males | 52 | 57.8 | 55 | 61.1 | | |
| **Weight (kg)** | | | | | | |
| Mean ± SD<br>Range | $1.869 \pm 0.85$<br>0.56–4.42 | | $2.903 \pm 0.75$<br>0.935–4.855 | | $u = 7.3$ | 0.0001 |
| **Gestational age per week** | | | | | | |
| Mean ± SD<br>Range | $32.97 \pm 4.89$<br>22–42 | | $37.1 \pm 2.8$<br>32–41 | | $t = 6.9$ | 0.0001 |

Abbreviations: $\chi^2$, chi-squared test; *f*, Fisher's exact test; SD, standard deviation; *u*, Mann–Whitney *U* test; *f*, Fisher's exact test.
Note: $p < 0.05$ is considered significant and $p > 0.05$ is nonsignificant.

 

**Table 2** Neonatal mortality rate per 1,000 live births

| Items | *N* |
|---|---|
| Live births<br>Deaths | 7,300<br>90 |
| Neonatal mortality rate at a certain period and time per 1,000 live births | 12.3 per1,000 |

live births in the hospital (7,300) to be 12.3 per 1,000 live births (►**Table 2**; ►**Fig. 1**).

In all, 45.6% of the neonatal death group were on mechanical ventilators, while others were not connected to the mechanical ventilators (54.4%).

There was a statistically nonsignificant difference regarding maternal past obstetric history, which included a history of abortion, neonatal death, congenital anomalies, premature birth and consanguinity, and clinical history including HTN, DM, and other chronic diseases of both studied groups, with $p > 0.05$ (►**Table 3**).

The occurrence of antepartum hemorrhage was 8.8 times higher among the neonate deaths group than in the neonate survival group ($p < 0.0001$). Neonates born via normal vaginal delivery (NVD) were 1.5 times more exposed to death than those born via other methods among the studied sample with $p = 0.017$, while neonates born via elective caesarian were less exposed to neonatal deaths ($p = 0.003$). The other circumstances of labor such as maternal infection, PROM, prolonged labor, use of instruments, and the site of delivery had no statistical significance between the two groups (►**Table 4**).

Most of the neonatal deaths occurred in the first 7 days of life with a mean age at death per day of the neonatal death group of $2.69 \pm 3.62$ (range: 1–27 days). The main causes of neonatal deaths were premature birth (61.1%), followed by birth asphyxia (20.0%), congenital anomalies (11.2%), and pneumothorax (4.4%; ►**Table 5**).

The areas under the ROC curve for birth weight were (AUROC = 0.814; 95% CI: 0.752–0.876), and the sensitivity and specificity obtained to a birth weight ≤2.5 kg as a cutoff value were 65.5 and 86.7%, respectively, for the prediction of neonate's risk of dying with an accuracy of 76.1%. About gestational age, the areas under the curve were AUROC = 0.74; 95% CI: 0.67–0.817. The sensitivity and specificity obtained to gestational age ≤32.5 weeks as a cutoff value were 50.0 and 95.6%, respectively, for the prediction of neonates at risk of dying with an accuracy of 72.8%. This means birth weight was a risk factor for neonates at risk of dying, while gestational age was a fair predictor of neonates at risk of dying (►**Table 6**).

## Discussion

The majority of NICU admissions were hospital born and referred from private clinics compared to those who came from home. During the study period, about 81.1% of neonatal deaths were hospital-born babies and 18.9% were referred from a private clinic. The total number of live births in TMC for the study period between July 2018 and July 2019 was 7,300, NICU admissions were 550 patients, and the total number of death was 90. The percent of neonatal deaths from neonatal admission to ICU was 16.36%, which is higher than that recorded in Benghazi Children's Hospital in a study conducted over 2 years from 2013 to 2014, where the mortality rate among the total admissions of newborns was 6.7%.[10] Specifically, our study aimed to calculate the NMR, which was 12.3 per 1,000 live births. This is almost similar to the NMR in a prospective study conducted in Jordan in 2015 in which a total of 327 newborns ≥20 weeks of gestation died in the neonatal period; the NMR was 14.9 per 1,000 live births.[11] However, our mortality rate is much lower than that of African countries, as in a retrospective cohort study conducted in Southern Ethiopia, a total of 964 neonates were included in the study out of a total of 5,889 live births. There were 159 neonatal deaths, and the NMR was 27 per 1,000.[12]

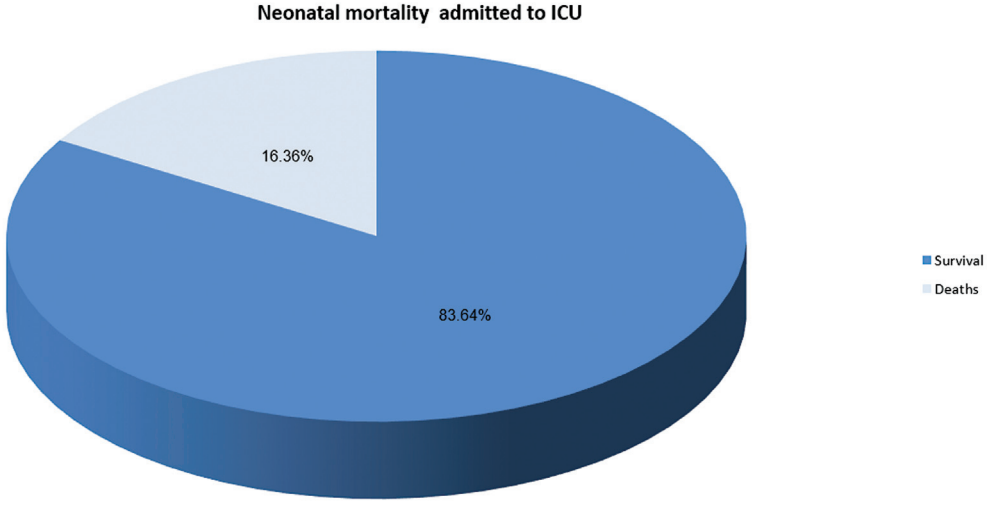


**Fig. 1** Pie chart illustrating the percentage of neonatal mortality among the neonates admitted to neonatal intensive care unit (NICU).

 

**Table 3** Past obstetric and clinical history of mothers in both studied groups (each group $n = 90$)

| Variables | Studied groups | | | | $\chi^2$ | *p*-value |
|---|---|---|---|---|---|---|
| | Neonatal deaths group | | Neonatal survival group | | | |
| | *n* | % | *n* | % | | |
| **History of abortion** | | | | | | |
| Yes | 27 | 30.0 | 25 | 27.8 | 0.11 | 0.87 |
| No | 63 | 70.0 | 65 | 72.2 | | |
| **History of neonatal death** | | | | | | |
| Yes | 5 | 5.6 | 2 | 2.2 | *f* | 0.44 |
| No | 85 | 94.4 | 88 | 97.8 | | |
| **History of HTN** | | | | | | |
| Yes | 7 | 7.8 | 5 | 5.6 | 0.36 | 0.55 |
| No | 83 | 92.2 | 85 | 94.4 | | |
| **History of DM** | | | | | | |
| Yes | 3 | 3.3 | 0 | 0 | *f* | 0.25 |
| No | 87 | 96.7 | 90 | 100.0 | | |
| **Other chronic diseases** | | | | | | |
| Yes | 3 | 3.3 | 1 | 1.1 | *f* | 0.62 |
| No | 87 | 96.7 | 89 | 98.9 | | |
| **Premature birth** | | | | | | |
| Yes | 4 | 4.4 | 1 | 1.1 | *f* | 0.37 |
| No | 86 | 95.6 | 89 | 98.9 | | |
| **Congenital anomalies** | | | | | | |
| Yes | 3 | 3.3 | 0 | 0 | *f* | 0.25 |
| No | 87 | 96.7 | 90 | 100.0 | | |
| **Consanguinity** | | | | | | |
| Yes | 3 | 3.3 | 0 | 0 | *f* | 0.25 |
| No | 87 | 96.7 | 90 | 100.0 | | |

Abbreviations: $\chi^2$, chi-squared test; DM, diabetes mellitus; *f*, Fisher's exact test; HTN, hypertension.
Note: $p > 0.05$ is considered nonsignificant.

In our study, there was a strong association between neonatal mortality and gestational age, with mortality increasing when gestational age decreased. The mean gestational age in the neonatal death group was $32.97 \pm 4.89$ weeks (range: 22–42 weeks), which was lower than that of the survival neonatal group where the mean gestational age was $37.1 \pm 2.8$ weeks (range: 32–41 weeks), with a statistically significant difference at $p = 0.0001$. This finding is similar to a previous study in Johannesburg, South Africa, in 2016 in which premature birth was the leading cause of admission (54.4%) and death (39%).[13]

In this study, most neonatal deaths occurred in the first week with a mean age at death of $2.69 \pm 3.625$ days. A similar finding was reported in a Jordan study, in which about 79% of all neonatal deaths occurred in the first week with more than 42% of death on the first day after birth.[11]

Regarding body weight, the mortality rates for preterm infants with very low and extremely low birth weights in developing countries remain high, largely due to respiratory insufficiency.[14] Simple, specific measures can be used to reduce mortality among this group. These measures include prophylactic use of a steroid for mothers, use of antibiotics in PROM, early control of maternal infections, early breastfeeding, prevention of hypothermia, early introduction of surfactant, and hospital-based kangaroo mother care.[14]

A meta-analysis review found that hospital-based kangaroo mother care (skin-to-skin contact) implemented within the first week of life for stable preterm and low birth weight neonates was effective and could reduce neonatal mortality by up to 51%.[14]

Our study revealed that low birth weight is a risk factor for mortality. The mean body weight was $1.869 \pm 0.85$ kg (range: 0.56–4.42kg) in the neonatal death group, which was lower than that in the survival neonatal group where the mean was $2.903 \pm 0.75$ kg (range: 0.935–4 kg), with a statistically significant difference of $p < 0.0001$. Similarly, the low birth weight of neonates (<2,500 g) accounted for higher rates of admissions and deaths.[15] There was a statistically nonsignificant difference

**Table 4** Comparison between the studied groups regarding circumstances of labor (each group $n = 90$)

| Variables | Studied groups | | | | $\chi^2$ | *p*-value | Odds ratio (95%CI) |
|---|---|---|---|---|---|---|---|
| | Neonatal deaths group | | Neonatal survival group | | | | |
| | *n* | % | *n* | % | | | |
| **Antepartum hemorrhage** | | | | | | | |
| Yes | 15 | 16.7 | 2 | 2.2 | 10.9 | 0.001 | 8.8 (1.93–81) |
| No | 75 | 83.3 | 88 | 97.8 | | | |
| **PROM** | | | | | | | |
| Yes | 12 | 13.3 | 19 | 21.1 | 1.91 | 0.17 | |
| No | 78 | 86.7 | 71 | 78.9 | | | |
| **Prolonged labor** | | | | | | | |
| Yes | 2 | 2.2 | 0 | 0 | *f* | 0.49 | |
| No | 88 | 97.8 | 90 | 100.0 | | | |
| **Using instrument at labor** | | | | | | | |
| Yes | 1 | 1.1 | 0 | 0 | *f* | 0.99 | |
| No | 89 | 98.9 | 90 | 100.0 | | | |
| **Site of labor** | | | | | | | |
| Home<br>Private clinic<br>Hospital | 0<br>17<br>73 | 0<br>18.8<br>81.2 | 2<br>8<br>80 | 2.2<br>8.8<br>88.8 | 5.52 | 0.06 | |
| **Mode of delivery** | | | | | | | |
| NVD | 53 | 58.9 | 37 | 41.1 | 5.69 | 0.017 | 1.5 (1.06–1.94) |
| U.CS | 24 | 26.7 | 25 | 27.8 | 0.03 | 0.43 | 0.94 (0.49–1.8) |
| E.C/S | 13 | 14.4 | 28 | 31.1 | 7.1 | 0.003 | 0.37 (0.18–0.78) |
| **Infection** | | | | | | | |
| Yes | 36 | 40.0 | 34 | 37.8 | 0.094 | 0.94 | |
| No | 54 | 60.0 | 56 | 62.2 | | | |

Abbreviations: $\chi^2$, chi-squared test; CI, confidence interval; *f*, Fisher's exact test; NVD, normal vaginal delivery; PROM, premature rupture of membrane; U.CS, urgent ceasarian section; E.C/S, elective ceasarian section; Mann–Whitney *U* test.
Note: $p < 0.05$ is considered significant and $p > 0.05$ is nonsignificant.

**Table 5** Percent and frequency of distribution for the causes of death and the age at death at NICU ($n = 90$)

| Variables | *N* (90) | (%) |
|---|---|---|
| **Age at death (d)** | | |
| Mean ± SD<br>Range | 2.69 ± 3.625<br>1–27 | |
| **Causes of death** | | |
| Premature birth | 55 | 61.1 |
| Birth asphyxia | 18 | 20.0 |
| Congenital anomalies | 10 | 11.2 |
| Pneumothorax | 4 | 4.4 |
| Anemia | 1 | 1.1 |
| IUGR | 1 | 1.1 |
| Down syndrome: neonatal sepsis | 1 | 1.1 |

Abbreviations: IUGR, intrauterine growth restriction; NICU, neonatal intensive care unit; SD, standard deviation.

between the studied groups regarding gender, although the admission and death were higher among the males (52 [57.8%]) than females (38 [42.2%]). These study findings are similar to the results in other studies like the South African study in 2011 and the Benghazi Hospital study in 2015 where the males were predominant in admission and death.[15,16]

Our results revealed that the most common causes of neonatal death were premature birth (61.1%), birth asphyxia (20.0%), congenital anomaly (11.2%), and pneumothorax (4.4%).

These findings were in line with a Johannesburg study that found premature birth–related, perinatal asphyxia, infection, and congenital abnormalities to be the leading causes of neonatal death.[13]

Less than fifty percent (45. 6%) of newborns in neonatal death group were on a mechanical ventilator; the remaining patients needed mechanical ventilators, but they were not available at that time.

The main goal of this study was to determine whether maternal demographic, past obstetrical, and medical characteristics were associated with neonatal mortality in TMC in the

 

**Table 6** Performance of birth weight and gestational age in predicting mortality in the neonatal intensive care unit ($n = 90$)

| | Cut off | Neonatal | | Sensitivity (%) | Specificity (%) | Accuracy (%) | AUC (CI 95%) | *p* |
|---|---|---|---|---|---|---|---|---|
| | | Deaths | Survival | | | | | |
| Birth weight (kg) | ≤2.5<br>>2.5 | 59<br>31 | 12<br>78 | 65.5 | 86.7 | 76.1 | 0.81<br>(0.752–0.876) | 0.0001 |
| Gestational age (wk) | ≤32.5<br>>32.5 | 45<br>45 | 4<br>86 | 50 | 95.6 | 72.8 | 0.74<br>(0.67–0.817) | 0.0001 |

Abbreviation: AUC, area under the curve; CI, confidence interval.

period from July 2018 to July 2019. These characteristics included maternal age, blood group, history of premature birth, congenital anomaly, history of abortion, PROM, maternal infection, consanguinity, history of neonatal death, antepartum hemorrhage, history of prolonged labor, and instrumentation. All these characteristics, except the history of antepartum hemorrhage and mode of delivery, were statistically nosignificant between the two groups. The occurrence of antepartum hemorrhage was 8.8 times higher in the neonatal death group than in the neonatal survival group ($p < 0.0001$).

Regarding the mode of delivery, neonates born via NVD were 1.5 times more exposed to neonatal deaths than those born via other methods among the studied sample with $p < 0.017$, while neonates born via elective caesarian section were less exposed to neonatal deaths with $p < 0.003$.

According to the performance of birth weight and gestational age in predicting mortality in the NICU, the sensitivity and specificity obtained to a birth weight ≤2.5 kg as a cutoff value were 65.5 and 86.7%, respectively, for the prediction of infants at risk of dying. About gestational age (AUROC = 0.74; 95% CI: 0.67–0.817), sensitivity and specificity in neonates with gestational age ≤32.5 weeks were 50.0 and 95.6%, respectively, for the prediction of infants at risk of dying. This means birth weight was a risk factor for death, while gestational age was a fair predictor of infants at risk of dying.

## Conclusions

The study found that the rate of neonatal mortality is similar to that of other hospitals in developing countries. The most common cause of neonatal death at TMC was premature birth, and premature birth and low birth weight were the major risk factors for death. Substantial efforts to improve the quality of health care services, providing an adequate number of trained nurses in newborn care, improved neonatal resuscitation, and supervision and training of medical doctors could help reduce neonatal mortality.

### Availability of Data and Materials

Some of the data that support the findings of this study are provided in the charts included in the manuscript. Other data may be available on request from the corresponding author concerning the ethical and legal restrictions, while some patient-sensitive data are not publicly available due to participant privacy/consent restrictions.

### Funding

None.

### Conflict of Interest

None declared.

## References

1 World Health Organization. Newborn health epidemiology [Internet]. 2013. Accessed March 20, 2023 at: http://www.who.int/maternal_child_adolescent/epidemiology/newborn/en/index.html#content and https://apps.who.int/iris/bitstream/handle/10665/259269/WHO-MCA-17.07-eng.pdf;sequence=1

2 World Health Organization. Newborn death and illness [Internet]. [Updated September 2011; cited February 2, 2013]. Accessed March 20, 2023 at: http://www.who.int/pmnch/media/press_materials/fs/fs_newborndealth_illness/en/ and https://www.who.int/news-room/fact-sheets/detail/levels-and-trends-in-child-mortality-report-2021

3 Shiffman J. Issue attention in global health: the case of newborn survival. Lancet 2010;375(9730):2045–2049

4 United Nations Children's Fund. Levels & Trends in Child Mortality. New York: UNICEF; 2012. Accessed March 20, 2023 at: http://www.unicef.org.uk/Documents/Publications/UNICEF_2012_IGME_child_mortality_report.pdf and https://www.who.int/publications/m/item/levels-and-trends-in-child-mortality-report-2021

5 World Health Organization.Global Health Observatory (GHO) data: child mortality and causes of death [Online]. Accessed July 31, 2018 at: http://www.who.int/gho/child_health/mortality/neonatal_text/en/ and accessed March 20, 2023 at: https://www.who.int/data/gho/data/themes/topics/indicator-groups/indicator-group-details/GHO/causes-of-child-death

6 Kliegman R, Behrman RE, Jenson HBHB. Neonates. In: Nelson Textbook of Pediatrics. 19th ed. Philadelphia, PA: Elsevier/Saunders; 2011:519–630

7 World Health Organization.Care of the preterm and/or low-birth-weight newborn [Internet]. 2013. Accessed March 20, 2023 at: http://www.who.int/maternal_child_adolescent/topics/newborn/care_of_preterm/en/ and https://www.who.int/publications-detail-redirect/9789240058262

8 Debelew GT, Afework MF, Yalew AW. Determinants and causes of neonatal mortality in Jimma Zone, Southwest Ethiopia: a multilevel analysis of prospective follow up study. PLoS One 2014;9(09):e107184

9 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. BMC Public Health 2015;15(01):387

10 Rajab A, Elnasfi SF, Elfakhri A, et al. Characteristics and causes of neonatal mortality in hospitalized cases at Benghazi Children's Hospital 2013–2014. Asian Journal of Pediatric Research 2020;3:37–42

 

11 Batieha AM, Khader YS, Berdzuli N, et al. Level, causes and risk factors of neonatal mortality, in Jordan: results of a national prospective study. Matern Child Health J 2016;20(05):1061–1071
12 Orsido TT, Asseffa NA, Berheto TM. Predictors of neonatal mortality in neonatal intensive care unit at referral hospital in Southern Ethiopia: a retrospective cohort study. BMC Pregnancy Childbirth 2019;19(01):83
13 Moundzika-Kibamba JC, Nakwa FL. Neonatal mortality at Leratong Hospital. SAJCH 2018;12(01):24–28
14 Lawn JE, Mwansa-Kambafwile J, Horta BL, Barros FC, Cousens S. "Kangaroo mother care" to prevent neonatal deaths due to preterm birth complications. Int J Epidemiol 2010;39(Suppl 1):i144–i154
15 Hoque M, Haaq S, Islam R. Causes of neonatal admissions and deaths at a rural hospital in KwaZulu-Natal, South Africa. South Afr J Epidemiol Infect 2011;26(01):26–29
16 Alharam ZM, Elsaeti I, Alferjani M. Neonatal mortality in the neonatal intensive care unit at Benghazi Pediatric Hospital– Libya. Al-Mukhtar Journal of Sciences 2020;35(04):284–293

 