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Cause – Specific Morbidity and Mortality of Neonates Admitted to the NICU at Al Bayda Medical Center

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Abstract:

This retrospective study aimed to describe admission characteristics, morbidity, and outcomes of neonates admitted to the NICU at Al-Bayda Medical Center (AMC), Libya, from August 2022 to July 2023. Among 4,619 live births, 475 (10.3%) neonates were admitted (1.7:1=male-to-female ratio = 1.7:1= 1.7:1). Most were term (73.6%), with mean birth weight 2,977 ± 728 g. The median hospital stay was 5.5 days. The commonest admission causes were hyperbilirubinemia (41%), transient tachypnea (31%), and sepsis (22%).The overall case-fatality rate was 11.8%; mortality was higher among males. Multivariate regression identified low birth weight (OR 0.82, $p < 0.001$), low 5-min APGAR (OR 0.65, $p < 0.001$), and shorter gestational age (OR 0.89, $p = 0.006$) as independent predictors of death. The leading causes of mortality were prematurity (55.4%) and HMD/RDS (48%).The study concluded that strengthening antenatal and neonatal care to prevent preterm birth and low APGAR is vital to reducing mortality.

Keywords: Neonatal Morbidity, Mortality, NICU, Libya, Prematurity, Predictors.

INTRODUCTION

The first month is the most crucial period for child survival. Globally, an estimated 2.5 million newborns die in the first month of life, approximately 7000 every day in 2017. Currently, an estimated 18 neonatal deaths per 1,000live births occur during the neonatal period (Hug et al., 2017)

Moreover, 98% of neonatal deaths occur in developing countries with a greater burden occurring in Sub-Saharan Africa (SSA). In this region, approximately one million infant deaths occur in the first month of life, which represents the highest neonatal mortality rate (NMR) among those countries participating in the Sustainable Development Goals (SDGs) and shows the least progress in reducing the NMR (Oza et al., 2014) The continued reduction in neonatal deaths is critical to progress towards achieving SDGs Every country is therefore challenged by the new UN Sustainable Development Goals to bring the neonatal mortality rates (NMR) down to 12 per 1000 live birth by 2030 (Sweileh, 2020).The majority of these deaths are caused by infectious diseases, intrapartum asphyxia, pregnancy-related complications, and premature births (Desalew et al., 2020). Maternal medical conditions are well recognized contributors to adverse neonatal outcomes through their effects on fetal growth, placental function, and intrapartum stability. Conditions such as hypertensive disorders of pregnancy, diabetes mellitus, anemia, infections, and premature rupture of membranes have been associated with prematurity, low birth weight, birth asphyxia, and increased risk of neonatal sepsis. These conditions may impair uteroplacental perfusion, increase fetal hypoxia, or predispose neonates to metabolic and respiratory complications, thereby increasing the likelihood of NICU admission and mortality (Desalew et al., 2020; Oza et al., 2014). Maternal illnesses can influence neonatal survival by increasing the risk of prematurity, low birth weight, birth asphyxia, and neonatal infections through impaired placental perfusion and fetal stress. Maternal health conditions have a direct impact on neonatal outcomes. Disorders such as hypertension, diabetes, anemia, and infections are associated with an increased risk of preterm birth, low birth weight, and birth asphyxia. These conditions may impair placental function and fetal oxygenation, leading to intrauterine growth restriction and metabolic or respiratory complications. Consequently, affected neonates are more likely to require NICU admission and have a higher risk of morbidity and mortality (Desalew et al., 2020; Liu et al., 2015).

Globally, most neonatal deaths are due to prematurity (36%) , infections (23%) , asphyxia (23%) , and congenital malformations (10%) (Liu et al., 2015). Between 1990 and 2017, the worldwide neonatal death rate decreased from36.6 fatalities per 1,000 live births in 1990 to 18 fatalities for every 1,000 live births in 2017 (Hug et al., 2019). In Libya, national neonatal mortality rate (NMR) estimates range from 14 to 18 deaths per 1,000 live births, with higher rates reported in the eastern region (Mansour, 2025).

MATERIALS AND METHODS

Study design: retrospective observational study

Study Setting: This study was conducted at Al-Bayda Medical Center (AMC), in AL Jabal AL Akhdar region ,this area has a population of 500,000.The center provides medical care to surrounding villages and serves as a first referral unit. The hospital provides free or highly subsidized care to these patients. Within the hospital, there is a 30-bed, level II NICU (intensive newborn care unit).The NICU is staffed by pediatricians, trained nursing staff and a team of counselors and has the capacity to provide supplemental oxygen, intravenous drugs, phototherapy for jaundice, neonatal resuscitation, warmers and ventilator support. Neonates are referred by the pediatricians to a higher center of care if surgical care is needed.

Data Source and Sample Size: Data were extracted from the NICU digital registry database for all consecutive admissions recorded between August 1, 2022, and July 31, 2023.)Among 4,619 live births, 475 (10.3%) neonates were admitted.

Exclusion criteria: neonates with incomplete records, those discharged within 24 hours against medical advice, and those referred before stabilization were excluded from the analysis.

Data Collection: The records of the NICU digital registry were analyzed to study variables such as demographic and clinical details recorded from admissions to Neonatal Department during the study period such as birth weight, gestational age, gender, type of admission, length of stay, details of the delivery including APGAR score, any complications during delivery and interventions done, and maternal medical history with concerning all risk factors and outcomes. There were four types of outcomes at the end of NICU stay which included*(i)* neonate discharged from NICU, *(ii)* died during care at NICU, *(iii)* referred to higher facilities or *(iv)* discharged against medical advice

(DAMA). Cause-specific case fatality rate and the trend of case fatality among neonates were also calculated.

Statistical Analysis: The data analysis was performed using SPSS version 27. All results were expressed as mean ± SD . Chi-Square and "t" test were used to determine significant associations, the level of significance was considered at ($p < 0.05$) . In addition to univariate tests, multivariate logistic regression analysis was performed to identify independent predictors of neonatal mortality, including birth weight, gestational age, and APGAR score. The level of significance was $p < 0.05$. Differences in proportions of cause-specific mortality were compared using Fisher's exact or Chi-square tests.

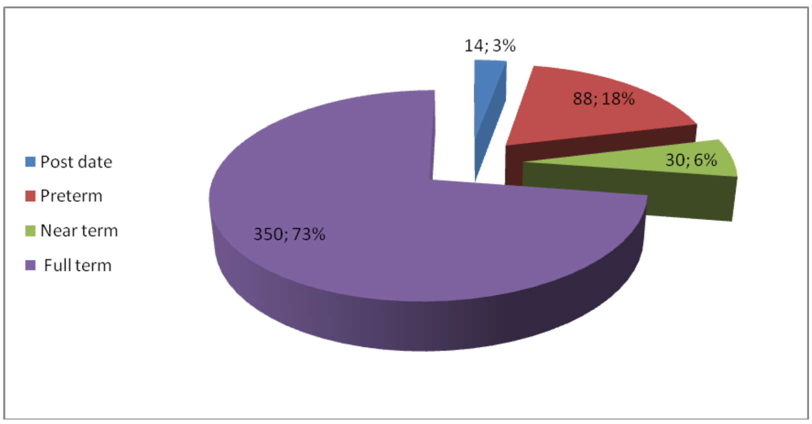
RESULTS

During the study period, there were 4,619 live births at AMC. A total of 475 neonates were admitted to the NICU, of whom 437 (92.0%) were inborn at AMC and 38 (8.0%) were referred from private facilities. More than half of the admitted neonates were male (63.4%). The majority were delivered by spontaneous vaginal delivery (57.3%), and most mothers had no documented medical comorbidities (84.0%). There were no statistically significant differences in admission characteristics between discharged neonates and those who died with respect to gender, type of facility, mode of delivery, or maternal illness (all $p > 0.05$), as shown in Table 1.

Table (1). shows the demographic data of participants (n=475)

Variable	Discharges (%)	Deaths (%)	Total admitted (%)	*P value*
Gender				
Male	261 (54.9%)	40 (8.4%)	301 (63.4%)	0.183
Female	158 (33.3%)	16 (3.4%)	174 (36.6%)	
Type of Facility				
Inborn (AMC)	382 (80.4%)	55 (11.6%)	437 (92.0%)	0.068
Outborn (private)	37 (7.8%)	1 (0.2%)	38 (8.0%)	
Mode of Delivery				
Spontaneous	234 (49.3%)	38 (8.0%)	272 (57.3%)	0.088
Cesarean	185 (38.9%)	18 (3.8%)	203 (42.7%)	
Maternal Illness				
Co-morbidity	67 (14.1%)	9 (1.9%)	76 (16.0%)	0.988
No co-morbidity	352 (74.1%)	47 (9.9%)	399 (84.0%)	

Regarding gestational age, 350 neonates (73.6%) were full term, 30 (6.3%) were near term, 81 (17.1%) were preterm, and 14 (2.9%) were post-date (Figure 1).



Figure(1). Distribution of studied neonates according to gestational age

Out of the 475 admitted neonates, 419 (88.2%) survived and were discharged, while 56 (11.8%) died during hospitalization, yielding a case fatality rate (CFR) of 11.8% (95% CI: 9.0–14.5%) (Figure 2).

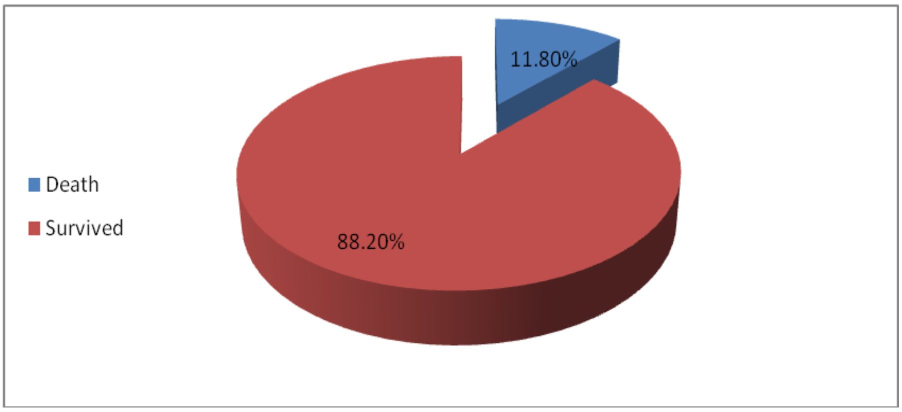


Figure (2). Distribution of the studied neonates according to mortality

The median hospital stay was 5.5 days (range: 1–18 days) in the discharge group compared to 3.5 days (range: 1–15 days) in the death group. This difference was not statistically significant (p = 0.598). Shorter hospital stays among neonates who died reflected earlier mortality rather than earlier discharge (Table 2).

Table (2). Comparison between the two study groups according to hospital stay p = Mann–Whitney U test

Outcome group	Median stay (days)	Range	P- value (Mann-Whitney U)
Discharges	5.5	(1-18)	0.598
Deaths	3.5	(1-15)	

The mean birth weight was significantly higher among discharged neonates (2976.6 ± 727.5 g) compared to those who died (1939.3 ± 964.8 g). Higher birth weight was strongly associated with improved survival ($p < 0.001$) (Table 3).

Table (3). Comparison between the two study groups according to birth weight

Outcome group	Mean birth weight (grams)	Standard deviation (SD)	p-value(t-test)
Discharges	2976.6	727.5	<.001*
Deaths	1939.3	964.8	

Similarly, the mean APGAR score was significantly higher in the discharge group (6.6 ± 1.7) than in the death group (4.8 ± 2.2). Higher APGAR scores were associated with better outcomes ($p < 0.001$) (Table 4).

Table (4). Comparison between the two study groups according to APGAR score

Outcome group	Mean APGAR score	Standard deviation (SD)	P- value (t-test)
Discharges	6.6	1.7	<.001*
Deaths	4.8	2.2	

On multivariate logistic regression analysis, higher birth weight, higher APGAR score, and longer gestational age were independently protective against neonatal mortality. Each 100-g increase in birth weight reduced the odds of death by 18% (adjusted OR = 0.82, 95% CI: 0.76–0.88), each one-point increase in APGAR score reduced the odds by 35% (adjusted OR = 0.65, 95% CI: 0.54–0.79), and each additional week of gestation reduced the odds of death by 11% (adjusted OR = 0.89, 95% CI: 0.82–0.97). All associations remained statistically significant (Table 5).

Table (5). Multivariate logistic regression predictors of neonatal mortality.

Clinical predictors	Adjusted OR(aOR)	95% Confidence Interval(CI)	p-value
Birth weight (per100 gincrease)	0.82	0.76–0.88	<0.001
APGAR score (per 1 point increase)	0.65	0.54–0.79	<0.001
Gestational age (per week increase)	0.89	0.82–0.97	0.006

Cause-Specific Morbidity

Among discharged neonates, the most common diagnoses were hyperbilirubinemia (41%), transient tachypnea of the newborn (TTN) (31%), and sepsis (21.9%). Other diagnoses included hyaline membrane disease (HMD) (11.9%), meconium aspiration syndrome (5.9%), and hypoxic–ischemic encephalopathy (HIE) (0.95%). As individual neonates could have more than one diagnosis, morbidity categories were not mutually exclusive (Table 6).

Cause-Specific Mortality

HMD was the most frequently reported condition associated with neonatal death (48.2%), followed by HIE (23.2%), pneumothorax (17.8%), hyperbilirubinemia (14.2%), sepsis (12.5%), TTN (12.5%), and meconium aspiration syndrome (7.1%). Multiple causes of death could be assigned to the same neonate; therefore, mortality categories were not mutually exclusive and cumulative percentages may exceed 100%. Reported causes represent contributing conditions associated with mortality rather than a single definitive primary cause. The 95% confidence intervals for selected causes of mortality were as follows: prematurity (46–65%), HMD/RDS (40–56%), and HIE (15–32%) (Table 6).

"It is important to emphasize that the mortality categories presented in Table 6 are not mutually exclusive, as neonatal death often results from a complex interplay of multiple clinical conditions. In our cohort, a single neonate frequently presented with several comorbid factors (e.g., prematurity complicated by HMD and sepsis), leading to cumulative percentages exceeding 100%. To provide better clarity, Table 6 now distinguishes between 'Primary' and 'Contributing' causes for each condition. These figures represent the frequency of all clinical conditions associated with neonatal death rather than a single definitive cause for each case, reflecting the clinical reality of neonatal intensive care."

Table (6). Frequency of Contributing Clinical Conditions Associated with Neonatal Death (n=56)

Clinical Condition	Deaths (n)	Percentage (%)	Nature of Condition	P-value
HMD/RDS	27	48.2%	Primary / Contributing	<0.001
HIE	13	23.2%	Primary / Contributing	<0.001
Pneumothorax	10	17.8%	Contributing	<0.001
Hyperbilirubinemia	8	14.2%	Contributing	<0.001
Sepsis	7	12.5%	Contributing	0.1
TTN	7	12.5%	Contributing	0.004
Meconium Aspiration	4	7.1%	Primary / Contributing	0.7

DISCUSSION

This study evaluated the clinical profile and outcomes of 475 neonates admitted to the NICU at Al Bayda Medical Center. Our findings revealed an overall neonatal mortality rate of 11.8% among the admitted neonates hence mortality rate in our study was comparatively low when compared to 15% (8), 16.4% (9) and 24.4% (7) from studies carried out in Burkina Faso , India and Libya re-sportively. Also lower than other studies done in Cameroon (15.7%) Vietnam (13.9 %) (10); (11) and other developing countries such as India (18.69%), Eastern Nepal (20.2%), Nigeria (18.8%) (12) & (13). Variations in study design, case mix, severity of illness at admission, and differences in healthcare infrastructure and socioeconomic conditions across regions may further account for discrepancies between mortality rates reported in different studies. Overall, these findings suggest that strengthening NICU capacity and quality of care can significantly reduce neonatal mortality even in resource-limited settings). Despite advancements in technologies and interventions made for improving the life of newborns, neonatal death remains serious public health problem in developing countries. Therefore, we conducted this study to determine the causes and predictors of neonatal mortality in the NICU in our center. Accordingly, the proportion of neonatal deaths representing case fatality rate was 11.8 %, hence mortality rate in our study was comparatively low when compared to15% (Kouéta et al., 2008), 16.4% (Oestergaard et al., 2011) and 24.4% (Mansour, 2025) from studies carried out in Burkina Faso , India and Libya respectively. Also lower than other studies done in Cameroon (15.7%) Vietnam (13.9 %) (Miles et al., 2017; Ndombo et al., 2017) and other developing countries such as India (18.69%), Eastern Nepal (20.2%), Nigeria (18.8%) (Elizabeth & Oyetunde, 2015; Prasad & Singh, 2011). Variations in study design, case mix, severity of illness at admission, and differences in healthcare infrastructure and socioeconomic conditions across regions may further account for discrepancies between mortality rates reported in different studies. Overall, these findings suggest that strengthening NICU capacity and quality of care can significantly reduce neonatal mortality even in resource-limited settings.

The current study showed that the median length of hospital stay was 5.5 days (range: 1–18) among discharged neonates and 3.5 days (range: 1–15) among those who died, with no statistically significant difference ($p = 0.598$). According to the study exclusion criteria, neonates discharged against medical advice (DAMA) were not included in the analysis, which may have led to an underestimation of the actual neonatal mortality rate. The mortality rate observed in this study was higher than that reported in Pakistan (9.6%) (14), which may be attributed to differences in follow-up duration, sample size, and the quality of antenatal care. The lack of a significant association between length of NICU stay and mortality suggests that hospitalization duration alone did not influence outcomes in this cohort; however, this finding should be interpreted cautiously in light of excluded DAMA cases and transferred neonates. Additionally, the higher male-to-female ratio observed in this study is consistent with findings from other studies worldwide (Ayaz & Saleem, 2010; Shams et al., 2010).

Regarding the current findings, the mean birth weight was higher in the discharge group (compared to the death group. Higher birth weight was associated with improved survival, and the difference was highly statistically significant. Higher APGAR scores were associated with better outcomes, and the difference was highly statistically significant ($p < 0.001$) Worldwide data consistently shows that the lower the birth weight, the higher the risk of a poor outcome which was observed in our study and is in agreement with literature (Mmbaga et al., 2012).

The most common disease entities treated at NICU were respiratory distress, Prematurity birth asphyxia (HIE), neonatal sepsis, and jaundice. The most relevant contributors to neonatal death are, consistent with the worldwide, prematurity, Respiratory Distress Syndrome and infection (World Bank,.2018).

In the current study, among discharged neonates, the most common diagnoses were hyperbilirubinemia (41%), transient tachypnea of the newborn (TTN) (31%), and sepsis (21.9%). Other diagnoses included hyaline membrane disease (HMD) (11.9%), meconium aspiration syndrome (5.9%), and hypoxic–ischemic encephalopathy (HIE) (0.95%). As individual neonates could have more than one diagnosis, morbidity categories were not mutually exclusive

HMD was the most frequently reported condition associated with neonatal death (48.2%), followed by HIE (23.2%), pneumothorax (17.8%), hyperbilirubinemia (14.2%), sepsis (12.5%), TTN (12.5%), and meconium aspiration syndrome (7.1%). Multiple causes of death could be assigned to the same neonate; therefore, mortality categories were not mutually exclusive and cumulative percentages may exceed 100%. Reported causes represent contributing conditions associated with mortality rather than a single definitive primary cause. The 95% confidence intervals for selected causes of mortality were as follows: prematurity (46–65%), HMD/RDS (40–56%), and HIE (15–32%) . Mortality differed significantly according to gestational age category, with higher mortality observed among preterm neonates compared to term and post-term neonates , which is in line with current global data (Blencowe et al., 2012; Lawn et al., 2005). Also, supported by reports and findings from the WHO, Northern Vietnam, India, Ghana, Nigeria, Cameroon, South Sudan, and Southern and Northern Ethiopia (Prasad & Singh, 2011).

A study conducted by (Al-Momani, 2020), which investigated patterns, outcomes, and determinants of neonatal mortality in the NICU, reported an overall survival rate of 91.9% and a mortality rate of 8.1%. The most common causes of admission were sepsis (27.3%) and respiratory distress syndrome (24.9%), which were also the leading contributors to mortality, with proportionate mortality rates of 27.7% and 35.6%, respectively. Birth asphyxia (13.1%) showed a relatively high mortality rate (15.3%). In contrast, TTN (6.5%), jaundice (10.7%), meconium aspiration (5.7%), and intrauterine growth restriction (4.2%) were associated with low mortality rates (≤2%), while congenital anomalies (3.8%) contributed to 6.9% of deaths. These findings are consistent with the current study, where mortality was also predominantly associated with sepsis and respiratory conditions.

The possible reason might be the fact that gestational age is strongly related to fetal maturity. As gestational age increases, the fetus's immune system matures, thereby reducing complications due to prematurity. Birth injury, infection, and complications of intrapartum events had a vital role in the survival of the early neonatal period. Birth injury is structural damage or a functional deterioration due to mechanical injury during labor and delivery (Ray et al., 2016). The study revealed that the risk of death due to birth injury was much higher compared to infection. This finding was consistent with studies conducted in Nigeria (Olugbade et al., 2016), India (Collins & Popek, 2018). This might be partly related to cranial injuries of the neonate, which result in hemorrhage, increasing the risk of encountering high intracranial pressure, coagulopathy, and hypovolemic shock.

In the present study, higher APGAR scores were significantly associated with improved neonatal survival, as surviving neonates had markedly higher mean scores than those who died. Multivariate logistic regression analysis identified higher birth weight, higher APGAR score, and longer gestational age as independent protective factors against neonatal mortality. Specifically, each 100-g increase in birth weight reduced the odds of death by 18% (adjusted OR = 0.82, 95% CI: 0.76–0.88), each one-point increase in APGAR score reduced the odds by 35% (adjusted OR = 0.65, 95% CI: 0.54–0.79), and each additional week of gestation reduced the odds by 11% (adjusted OR = 0.89, 95% CI: 0.82–0.97). All associations were statistically significant. These findings are consistent with previous studies conducted in Sweden (Cnattingius et al., 2020), China (Mu et al., 2021), which demonstrated that lower 5-minute APGAR scores are strongly associated with increased neonatal mortality, whereas higher scores predict better survival outcomes.

CONCLUSION

Overall neonatal mortality in the current study was associated with lower birth weight, lower APGAR scores, and shorter gestational age at birth.
Demographic and clinical characteristics of this study showed that no significant statistical difference in the morality regarding: gender, mode of delivery, type of parity maternal illness, and length of stay in the NICU.
HMD was the most frequently reported condition associated with neonatal death (48.2%), followed by HIE (23.2%), pneumothorax (17.8%), hyperbilirubinemia (14.2%), sepsis (12.5%), TTN (12.5%), and meconium aspiration syndrome (7.1%)..

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ETHICS

Ethical approval for this study was obtained from the Research Ethics Committee of Al-Bayda Medical Center in accordance with the regulations of the Libyan Board of Medical Specialties.
For all patients admitted to the neonatal unit of Al-Bayda Medical Center, the patient's family provided consent upon admission for any procedures carried out within the department.

Duality of interest: the authors declare no conflict of interest.

Author contributions: A. developed the theoretical formalism. B supervised the project. A, C, and D performed the analytic calculations and performed the numerical simulations. All authors read, reviewed, and approved the final manuscript.

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