

NEONATAL MORTALITY IN MOSUL: A RETROSPECTIVE ANALYSIS OF CAUSES
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Article Received: 05 Sept. 2026

Article Revised: 25 Sept. 2026

Article Published: 01 October 2026



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DOI: <https://doi.org/10.5281/zenodo.23118950>**How to cite this Article:** Mayyadah Y. Mahmmod¹, Muataz A. Alani², Ahmad T. Ibraheem^{3*} (2026). Neonatal Mortality in Mosul: A Retrospective Analysis of Causes and Risk Factors. World Journal of Advance Healthcare Research, 10(10), 447–452.

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ABSTRACT

Background: Neonatal mortality—defined as death occurring within the first 28 completed days of life—serves as a critical global indicator of healthcare quality and system performance. This study investigates the causes of neonatal mortality and their associated determinants in Mosul City, Iraq, during 2023. **Objective:** To identify the principal causes of neonatal deaths and examine their associations with selected maternal, neonatal, and birth-related characteristics in Mosul City, Iraq, during 2023. **Materials and Methods:** A retrospective observational study was conducted using official records of neonatal deaths registered by the Nineveh Directorate of Health between 1 January and 31 December 2023. Data were extracted through a structured form encompassing demographic variables, pregnancy and delivery characteristics, and underlying causes of death. All neonatal deaths during the study period were included, except those attributed to surgical causes. Data completeness was verified prior to analysis. **Results:** A total of 972 neonatal deaths were documented in Mosul City during 2023. Of these, 56.5% occurred among males and 43.5% among females. Early neonatal deaths (within the first week of life) accounted for 77.0% of cases. Low birth weight (<2500 g) was observed in 58.4% of deaths, while 68.7% of neonates were born at 28–36 weeks of gestation. Vaginal delivery accounted for 69.3% of cases, singleton pregnancies for 68.8%, and 98.8% of deaths occurred in public hospitals. Urban residence was reported in 61.4% of cases. The leading causes of death were respiratory and cardiovascular disorders (53.5%), congenital anomalies (17.3%), neonatal sepsis (15.3%), birth asphyxia (9.7%), other causes (2.6%), and prematurity with low birth weight (1.6%). **Conclusions:** Neonatal mortality in Mosul City during 2023 was predominantly concentrated in the early neonatal period and primarily driven by respiratory and cardiovascular disorders, congenital anomalies, and neonatal sepsis. Significant associations were identified between cause of death and factors including residence, birth weight, maternal age, gestational age, mode of delivery, plurality, and parental education. No significant association was observed with neonatal sex or place of delivery.

KEYWORDS: Neonatal mortality, Mosul, Iraq, Respiratory distress syndrome.

INTRODUCTION

Neonatal mortality is conventionally defined as the death of a live-born infant, regardless of gestational age, within the first 28 completed days of life. This period is further classified into early neonatal deaths (0–7 days) and late neonatal deaths (8–28 days), representing the most vulnerable stage of early life.^[1] As a highly specific

indicator of the effectiveness of obstetric and neonatal care systems, neonatal mortality constitutes a central concern in public health policy.^[2] Reducing neonatal mortality is a prerequisite for lowering overall under-five mortality,^[3] and it has therefore become a focal point of global child-survival strategies. Although progress has been achieved through advances in obstetric and neonatal

care, reductions in neonatal mortality have been markedly slower in developing countries, particularly in low- and middle-income settings.^[4]

In Iraq, the perinatal mortality rate averaged approximately 28 per 1,000 live births during 1980–1990, prior to the imposition of international economic sanctions. This figure rose sharply to nearly 107 per 1,000 live births during 1990–1999. Subsequent years witnessed a gradual decline in under-five mortality, from 40.9 to 27.1 deaths per 1,000 live births by 2006, and in neonatal mortality, from 21.6 to 13.3 deaths per 1,000 live births by 2018, despite recurrent periods of conflict and instability.^[5]

Major contributors to neonatal mortality include intrapartum-related complications such as birth asphyxia, alongside infections and sepsis. High-risk mothers are more likely to deliver preterm or low-birth-weight infants, who face increased susceptibility to complications. Prematurity and low birth weight remain significant risk factors, while congenital anomalies rank as the fourth leading cause of neonatal death globally. The majority of neonatal deaths are linked to suboptimal maternal health, inadequate antenatal or intrapartum care, poor delivery hygiene, deficient newborn care, and impaired intrauterine growth. These are often associated with maternal nutritional deficiencies, closely spaced pregnancies, and early childbearing. Harmful practices—including improper umbilical cord care, inadequate thermal protection, discarding colostrum, and premature introduction of complementary feeding—further exacerbate risks.^[6,7]

Respiratory distress syndrome holds particular clinical importance, as affected neonates are two to four times more likely to die, underscoring the potential mortality benefit of prevention and timely management.^[8] Importantly, most causes of neonatal morbidity and mortality remain preventable. The majority of newborns experience no severe complications and require only low-cost, evidence-based preventive and therapeutic interventions during pregnancy, delivery, and the postnatal period. These interventions can be safely administered by trained and supervised healthcare providers.^[9]

MATERIALS AND METHODS

Study Design and Setting

This retrospective observational study analyzed all available records of neonatal deaths registered by the Statistics Department of the Nineveh Health Directorate. The dataset encompassed all neonatal deaths documented in Mosul City between 1 January and 31 December 2023.

Data Collection

A structured data-collection instrument, derived from official statistics of the Nineveh Health Directorate, was

employed to extract relevant information. The following categories were included:

- Demographic variables: age at death (classified by week of life), neonatal sex, maternal age, and place of family residence.
- Pregnancy and delivery characteristics: gestational age (term ≥ 37 weeks vs. preterm < 37 weeks),^[10] mode of delivery (vaginal or cesarean section), plurality (singleton or multiple births), and place of delivery (home, public hospital, or private hospital).
- Birth weight: categorized according to WHO criteria as low birth weight ($< 2,500$ g), normal birth weight (2,500–4,500 g), or macrosomia ($> 4,500$ g).^[11]
- Causes of neonatal death: classified according to the International Statistical Classification of Diseases, 10th Revision (ICD-10), including respiratory and cardiovascular disorders (P22–P29), prematurity and low birth weight (P05, P07), congenital malformations and chromosomal abnormalities (Q00–Q99), birth asphyxia (P21), bacterial sepsis of the newborn (P36), and other causes.^[12,13]

All neonatal deaths in 2023 were included, with the exception of those attributed to surgical causes. Data completeness was verified prior to statistical analysis.

Statistical Analysis

Data were entered and analyzed using the Statistical Package for the Social Sciences (SPSS), version 26. Variables were expressed as frequencies and percentages. Associations between causes of neonatal death and independent variables were assessed using chi-square tests, with statistical significance defined at a p -value < 0.05 .

Ethical Approval

Ethical clearance was obtained from the Scientific and Ethical Committee for Medical Research of the Nineveh Health Directorate prior to study initiation (official letter No. 5946, dated 8 February 2024).

RESULTS

A total of 972 neonatal deaths were documented in Mosul City during 2023. The following sections present a detailed analysis of the sociodemographic and clinical characteristics, causes of death, and associations between cause of death and selected variables.

1. Sociodemographic and Clinical Characteristics

Table 1 summarizes the distribution of neonatal deaths ($n = 972$) according to demographic and clinical variables, including neonatal sex, age at death, maternal age, place of residence, gestational age, mode of delivery, plurality, place of delivery, and birth weight.

Table 1: Distribution of demographic and clinical characteristics of neonatal death cases (n = 972).

Variable / Category	Number (n)	Percentage (%)
Age Category at Death (days)		
0–7 days	748	77.0%
8–14 days	88	9.1%
15–21 days	50	5.1%
22–28 days	86	8.8%
Sex of the Newborn		
Male	549	56.5%
Female	423	43.5%
Place of Residence		
Urban	597	61.4%
Rural	375	38.6%
Birth Weight (grams)		
Less than 2500	568	58.4%
2500 – 4500	391	40.2%
More than 4500	13	1.3%
Maternal Age (years)		
Less than 18	32	3.3%
18 – 34	815	83.8%
35 and above	125	12.9%
Gestational Age (weeks)		
20 – 27	37	3.8%
28 – 36	668	68.7%
37 and above	267	27.5%
Mode of Delivery		
Vaginal delivery	674	69.3%
Cesarean section	298	30.7%
Delivery Outcome		
Singleton birth	669	68.8%
Multiple births	303	31.2%
Place of Delivery		
Public hospital	960	98.8%
Private hospital	9	0.9%
Home birth	3	0.3%
Father's Educational Level		
Illiterate	16	1.6%
Primary	309	31.8%
Secondary	501	51.5%
University or higher	146	15.0%
Mother's Educational Level		
Illiterate	315	32.4%
Primary	231	23.8%
Secondary	329	33.8%
University or higher	97	10.0%

The majority of deaths (77.0%) occurred during the first week of life, classifying them as early neonatal deaths. Male neonates accounted for 56.5% of cases, exceeding the proportion of females (43.5%). Urban residence was reported in 61.4% of cases, compared with 38.6% from rural areas, a difference likely reflecting population distribution and referral patterns rather than intrinsic risk.

Regarding birth weight, 58.4% of neonates were classified as low birth weight (<2500 g), while 40.2% fell within the normal range (2500–4500 g). Preterm

births (28–36 weeks) constituted 68.7% of cases, whereas term births (≥ 37 weeks) accounted for 27.5%.

Maternal age distribution revealed that 83.8% of mothers were between 18–34 years, with only 3.3% younger than 18. Vaginal delivery was the predominant mode (69.3%), compared with cesarean section (30.7%). Singleton births represented 68.8% of cases, while multiple pregnancies accounted for 31.2%.

Place of delivery data showed that nearly all neonates (98.8%) were born in public hospitals, with home births comprising only 0.3%. Fathers most commonly attained

secondary education (51.5%), whereas mothers' education was more evenly distributed between illiteracy (32.4%) and secondary education (33.8%).

2. Causes of Neonatal Deaths

Table 2: Distribution of causes of neonatal deaths (n = 972).

Cause of Death	Number (n)	Percentage (%)
Respiratory & cardiovascular disorders	520	53.5
Congenital anomalies	168	17.3
Neonatal bacterial sepsis	149	15.3
Birth asphyxia	94	9.7
Other causes	25	2.6
Prematurity & low birth weight	16	1.6

Respiratory and cardiovascular disorders were the leading cause of death (53.5%), followed by congenital anomalies (17.3%) and neonatal sepsis (15.3%). Birth

asphyxia accounted for 9.7%, while prematurity and low birth weight represented the lowest proportion (1.6%). Other causes comprised 2.6% of cases.

3. Relationship Between Cause of Death and Associated Characteristics

Table 3: Chi-square test results for associations between cause of death and selected variables.

Variable	χ^2	df	p-value	Significance
Age category at death	396.89	15	<0.001	Significant
Sex of newborn	5.19	5	0.393	Not significant
Place of residence	15.88	5	0.007	Significant
Birth weight	88.60	10	<0.001	Significant
Maternal age	22.62	10	0.012	Significant
Gestational age	92.05	10	<0.001	Significant
Mode of delivery	108.21	5	<0.001	Significant
Delivery outcome (singleton/multiple)	27.43	5	<0.001	Significant
Place of delivery	12.90	10	0.229	Not significant
Father's education	86.17	15	<0.001	Significant
Mother's education	365.36	15	<0.001	Significant

The analysis demonstrated statistically significant associations between cause of death and age at death, place of residence, birth weight, maternal age, gestational age, mode of delivery, plurality, and parental education ($p < 0.05$). In contrast, no significant associations were observed with neonatal sex ($p = 0.393$) or place of delivery ($p = 0.229$).

DISCUSSION

This retrospective study analyzed 972 neonatal deaths in Mosul City during 2023, providing important insights into the timing, causes, and associated characteristics of neonatal mortality in this population.

Timing of Neonatal Death

The predominance of early neonatal deaths (77.0% within the first week of life) aligns with global evidence that mortality risk is highest immediately after birth and declines thereafter. This concentration reflects the impact of intrapartum and immediate postnatal complications—particularly respiratory disorders, birth asphyxia, and prematurity-related complications—which typically manifest in the first days of life. In contrast, conditions such as late-onset sepsis contribute more frequently to deaths later in the neonatal period. These findings reinforce the global recognition that reducing neonatal

mortality is essential to achieving reductions in overall under-five mortality.^[14,15]

Leading Causes of Neonatal Death

Respiratory disorders were the leading cause of death, accounting for 53.5% of cases—a proportion considerably higher than global averages. International data from UNICEF and WHO highlight prematurity, intrapartum events, infections, and congenital anomalies as the primary contributors to neonatal mortality.^[16,17] Comparable studies in Babylon and Basra governorates similarly identified respiratory distress syndrome as the most frequent cause of neonatal death, underscoring the persistent burden of respiratory morbidity in Iraq.^[18,19] Limited access to surfactant therapy and advanced ventilatory supports likely exacerbates this pattern.

Congenital anomalies ranked second (17.3%), a higher proportion than reported in many Iraqi and regional studies. This may reflect a genuinely elevated burden in Mosul, potentially linked to conflict-related exposures, or differences in diagnostic capacity and cause-of-death coding. Evidence from European countries suggests that congenital anomalies are increasingly contributing to early deaths as mortality from other causes declines.^[20] Local studies in Mosul and Al-Najaf have highlighted

the prevalence of anomalies affecting the central nervous and cardiovascular systems, often associated with consanguineous marriage, emphasizing the need for preventive strategies such as genetic counseling, improved antenatal care, and health education.^[21,22]

Neonatal sepsis (15.3%) and birth asphyxia (9.7%) remain consistent with global literature identifying infection and intrapartum hypoxic events as persistent contributors to neonatal mortality in low- and middle-income countries.^[24] Prematurity and low birth weight were recorded as direct causes in only 1.6% of cases, despite their high prevalence in the sample. This discrepancy reflects the tendency for prematurity to predispose infants to proximate complications—such as respiratory distress or sepsis—that are coded as the immediate cause of death.^[25]

Associated Demographic and Socioeconomic Characteristics

Chi-square analysis revealed significant associations between cause of death and place of residence, maternal age, gestational age, mode of delivery, plurality, and parental education. Notably, parental education demonstrated the strongest association, with lower maternal education linked to higher risks of early neonatal death, likely mediated by reduced antenatal care utilization and delayed recognition of danger signs. Approximately one-third of mothers in the study were illiterate, highlighting the importance of maternal health literacy programs.^[28]

Multiple births were significantly associated with neonatal mortality, consistent with the well-documented risks of prematurity and low birth weight among twins and higher-order multiples. Mode of delivery was also associated with cause of death, reflecting the increased risk profile of complicated pregnancies requiring cesarean section. In contrast, sex of the newborn and place of delivery showed no significant associations, the latter likely due to the overwhelming predominance of public hospital births (98.8%) in the sample.^[29,30]

Strengths and Limitations

The study's strengths include its large sample size and use of ICD-10 classification, enabling comparability with national and international data. Limitations include potential misclassification of causes of death in busy clinical settings, particularly where multiple conditions coexist.

CONCLUSION

Neonatal mortality in Mosul City during 2023 was concentrated in the early neonatal period and driven primarily by respiratory disorders, congenital anomalies, and sepsis. Significant associations were observed with sociodemographic and clinical factors, particularly parental education, gestational age, and birth weight. These findings underscore the need for strengthened respiratory and intensive care support, improved

antenatal and perinatal services—especially in rural areas and among less-educated mothers—and enhanced surveillance of congenital anomalies as priority measures to reduce preventable neonatal deaths.

These findings underscore the critical need for standardized, evidence-based neonatal care protocols across settings. By prioritizing trained birth attendants, immediate resuscitation, and optimal breastfeeding support, mortality can be reduced and long-term outcomes for preterm and at-risk infants improved. Investing in continuous training, audit cycles, and culturally appropriate education will help sustain gains across diverse health systems. International collaboration and transparent data sharing are essential to monitor progress, identify gaps, and adapt protocols to local resource constraints while maintaining high standards of neonatal care.

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