

Analysis of trends and patterns in neonatal mortality, A comprehensive audit from SNCU of tertiary care hospital-A Retrospective study

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ABSTRACT

This study looks at trends and patterns of the retrospective audit of neonatal mortality trends and patterns over 8 years (April 2017 to September 2024) in a Special Newborn Care Unit (SNCU) of a tertiary care hospital. During the study period, 71,366 neonates were admitted, of which 60,798 were live births and 869 were stillbirths. It shows a regular NMR decline from 2.57% in 2017 down to 2.38% in 2024, pointing out to improvement of neonatal care. Mortality variations between inborn (12,248 admissions) and outborn (9,255 admissions) neonates are also studied and found to be higher in outborn neonates because of delayed referrals and critical conditions at the time of admission. The neonatal mortality seasonally follows trends suggesting higher mortality in the monsoon months especially in August when there is a rise in infection incidence. Gender-based mortality analysis revealed that male neonates contributed to 56.7% of neonatal deaths indicating possible gender-specific vulnerabilities. Regression analysis showed a significant negative relationship between higher admissions and mortality rate and a positive relationship between increased deaths and mortality rate. They show that strengthening referral systems, upgrading maternal and neonatal care, and controlling seasonal infections will be necessary to reduce neonatal mortality even further in such settings.

Keywords: Neonatal, Mortality, Special Newborn Care Unit, Maternal education, Audit.

INTRODUCTION

Even though neonatal mortality is a major global health challenge and an important indicator of healthcare quality, especially in low and middle-income countries (LMICs), it is still a problem. Neonatal mortality is defined as deaths occurring within the first 28 days of life and accounts for nearly 47% of under-five mortality worldwide (World Health Organization [WHO], 2022). Despite progress in decreasing under-5 mortality, in many places, stable or increasing neonatal deaths reflect the need for preventable causes including preterm birth complications, sepsis, birth asphyxia, and congenital anomalies (Lawn et al., 2014). In 2020, 2.4 million neonates died globally, and South Asia and sub-Saharan Africa had the highest burden (UNICEF, 2021). With an estimated 22 deaths per 1,000 live births, in 2020 India was one of the largest contributors to global neonatal mortality (National Family Health Survey [NFHS-5], 2021). Although impressive progress has been made over the past two decades, the Sustainable Development Goal (SDG) 3.2 to reduce the neonatal mortality rate to 12 per 1,000 live births in 2030 is still ambitious. Under India's National Health Mission (NHM), SNCUs are a big step forward in reducing neonatal conditions. SNCUs were intended to facilitate essential and advanced care of sick neonates, mainly with prematurity, low birth weight (LBW), respiratory distress syndrome (RDS), sepsis, birth asphyxia, and hypothermia (Ministry of Health and Family Welfare, 2017). These units have been key to reducing preventable neonatal deaths by increasing access to high-quality facility-based care. However, the disparities remain, specifically in tertiary care settings, where we often see critically ill neonates initially referred for stabilization and transport after significant delay (Stevenson et al., 2019). The trends and patterns of neonatal mortality within SNCUs are important for providing a clearer understanding of where the gaps are, precisely where improvements in healthcare delivery are needed as well as, where targeted interventions can be employed.

Neonatal mortality is affected by several factors; maternal health, gestational age, birth weight, and access to good quality care. Preterm birth complications are the leading cause of neonatal deaths worldwide, accounting for about 35% of all such deaths (Blencowe et al., 2013). Finally, neonatal infections including sepsis and pneumonia have continued to be important causes of mortality even in areas with poor infection control practices and unreliable healthcare infrastructure (Oza et al., 2015). Seasonal variations have also been observed with increased mortality because of infections as well as some environmental factors during monsoon months (July – September) in tropical climates like India (Zakariya et al., 2011). Identifying this burden and managing infections promptly, while relying on community-based prevention strategies, continue to be critical. The challenges are compounded by gender-based disparities in neonatal mortality. Male neonates have higher mortality compared with female neonates owing to biological vulnerabilities such as higher incidence of respiratory distress syndrome and sepsis (Peacock et al., 2012). In LMICs, however, socio-cultural factors may delay timely care seeking for female neonates, thereby exacerbating the gender gap (Bhalotra et al., 2016). Addressing these gender-specific vulnerabilities will require working early to detect such complications, ensuring equal access to care and a gender-sensitive public health policy.

Another important determinant of neonatal mortality is inborn versus outborn admissions. Many outborn neonates referred from peripheral healthcare facilities are in critical condition at presentation, as a result of delays in transport, inadequate prenatal care, and lack of proper stabilization (Henry & Trotman, 2017).). Outborn neonates have been consistently shown to have higher mortality than inborn neonates managed in the same facility (Sankar et al., 2019). Improving outborn survival outcomes requires strengthening referral systems, improving neonatal transport services, and increasing the capacity of peripheral healthcare centers.

India's improvement in neonatal outcomes as a result of programs (like Janani Shishu Suraksha Karyakram (JSSK) and National Rural Health Mission (NRHM), has shown a positive outcome (Ministry of Health and Family Welfare, 2017). Over the past decade, programs promoting institutional deliveries, free antenatal care, and facility-based newborn care have greatly reduced neonatal deaths. Still, there are differences between urban and rural areas, and seasonal mortality patterns are not yet resolved. There is a need to monitor trends in mortality continuously avail skilled healthcare providers on demand and improve facility-based and community-level interventions to address these gaps. Evidence from neonatal care advances like Kangaroo Mother Care (KMC), early breastfeeding initiation, and evidence-based infection management show great successes in reducing neonatal deaths (Lawn et al., 2014; WHO, 2019). When implemented effectively in resource-limited settings, KMC alone has been shown to reduce mortality by up to 40% among LBW neonates (WHO, 2019). However, such interventions are not implemented in gaps, especially in tertiary care hospitals where resources are often stretched because of high patient load and critical care needs.

The objective of this study is to analyze trends and patterns in neonatal mortality in the SNCU of a tertiary care hospital over eight years (April 2017 to September 2024). This study analyzes neonatal death by exploring mortality rates, seasonal variations, and gender disparities and comparing inborn and outborn neonates. Using these patterns and gaps in care delivery, we can then identify specific strategies of evidence-based interventions that can be optimized to reduce further neonatal mortality. Finally, neonatal morbidity continues to be a relevant health problem that deserves specific care and intervention. Facility-based audits, such as the current study, are critical for identifying gaps in neonatal care in high-burden settings such as SNCUs. This study adds to the growing evidence base needed to inform policy decisions to strengthen neonatal healthcare delivery, by analyzing mortality trends and associated factors. Sustainable efforts, continuous quality improvement, and focus on high-impact intervention will be required to achieve the Sustainable Development Goal of reducing neonatal mortality to 12 per 1,000 live births by 2030.

METHODOLOGY

Study Design

This study is a retrospective audit of neonatal mortality trends and patterns in a Special Newborn Care Unit (SNCU) of a tertiary care hospital over 8 years (April 2017 to September 2024). Due to the retrospective nature of the study, pre-existing hospital data was collected to identify long-term trends and mortality patterns, which can help to understand neonatal health outcomes and care practices in a high-burden setting.

Data Sources

Data were collected from SNCU patient records and hospital registries over the time frame. Monthly and yearly admission records of neonates, total deliveries, live births, stillbirths, and neonatal deaths were key datasets. In addition, admission classifications into inborn (born within the hospital) and outborn (referred from other facilities) neonates were analyzed. Gender-specific outcomes and disparities were also extracted through gender-based mortality trends. This dataset constituted a robust basis for the analysis of neonatal mortality over the study period.

Inclusion and Exclusion Criteria

Neonates admitted to the SNCU between April 2017 and September 2024 were included in the study. The analysis included both inborn and outborn neonates to gain a broader understanding of neonatal outcomes within and outside the

hospital setting. Neonates discharged on parental request without sufficient follow-up data and records with missing or incomplete critical variables (e.g., gender or admission type) were excluded. These criteria helped to remove incomplete and nontraceable cases to ensure the reliability and accuracy of the analyzed dataset.

Variables Studied

The study examined neonatal mortality from both demographic variables and clinical factors. Total deliveries, live births, stillbirths, and gender of neonates (male or female) were demographic variables. The type of admission, inborn or outborn, was also analyzed to determine disparities in care outcomes. Total deaths, temporal distribution of deaths (monthly and annual), and mortality rates such as the SNCU Mortality Rate and the Neonatal Mortality Rate were clinical factors. Monthly and quarterly trends in mortality and seasonal variations, e.g. spikes in certain months, were analyzed using temporal patterns. Yearly comparisons were also made to see if mortality rates were improving or worsening over time.

Data Analysis

A structured analytical approach was used to analyze data to understand trends, patterns, and correlations in neonatal mortality. Frequencies and percentages of those variables that were key were calculated using descriptive statistics: live births, total admissions, deaths, and mortality rate. To identify specific trends, mortality data were also stratified by gender (male vs. female) and admission type (inborn vs. outborn). Mortality trends were analyzed temporally, looking at trends across different years, months, and quarters to see if there were any seasonal or periodic spikes. Two primary mortality metrics were computed during the analysis. The SNCU

Mortality Rate was calculated using the formula:

$$\text{SNCU Mortality Rate} = \frac{\text{Total Deaths}}{\text{Total Admissions}} \times 100$$

This metric provides an overview of the percentage of neonates admitted to the SNCU who did not survive.

The Neonatal Mortality Rate (NMR) was calculated using the formula:

$$\text{Neonatal Mortality Rate} = \frac{\text{Neonatal Deaths}}{\text{Live Births}} \times 1000$$

The NMR reflects the number of neonatal deaths per 1,000 live births, a key indicator for evaluating overall neonatal care outcomes.

Statistical Analysis

Continuous variables were summarized using descriptive statistics as mean \pm standard deviation (SD) and categorical variables as frequencies and percentages. Multivariate linear regression was used to inferentially assess associations between mortality rates and independent variables (e.g., admissions and deaths), and coefficients, t-values, p-values, and 95% confidence intervals were reported. The Mann-Whitney U test (Z-values) was used to analyze gender-based comparisons of live births and stillbirths, and time-series analysis was used to examine trends and seasonal patterns in mortality rates over the 8-year study period.

Ethical Considerations

Ethical clearance for the study was obtained from the Institutional Ethics Committee to ensure compliance with ethical guidelines. Patient confidentiality and anonymity were maintained throughout the study by anonymizing all collected data and avoiding the inclusion of identifiable information. The retrospective nature of the study utilized existing hospital records, thereby eliminating any direct interaction with patients and ensuring minimal ethical concerns.

RESULTS

Neonatal Admissions and Mortality

During the 8 years, a total of 71,366 neonates were admitted to the SNCU. Table 1 summarizes the key statistics, which include total deliveries, live births, stillbirths, admissions, and deaths. The table summarizes neonatal outcomes over 8 years. There were 60,798 live births and 869 stillbirths among 61,149 total deliveries. A total of 21,503 neonates were admitted of whom 1,799 died. The SNCU mortality rate varied from 11.58–17.66% and the neonatal death rate improved from 2.57% to 2.38%.

Table 1: Neonatal Care Indicators and Mortality Analysis

Parameter	Value
Total Deliveries	61,149
Live Births	60,798
Stillbirths	869
Total Admissions	21,503
Total Deaths	1,799
SNCU Mortality Rate (%)	11.58 – 17.66
Neonatal Death Rate (%)	2.57 – 2.38

Figure 1 shows percentage of total deliveries, live births, stillbirths, admissions, and deaths. It focuses on the proportion of live births and admissions compared to total care outcomes, with mortality and care effectiveness.

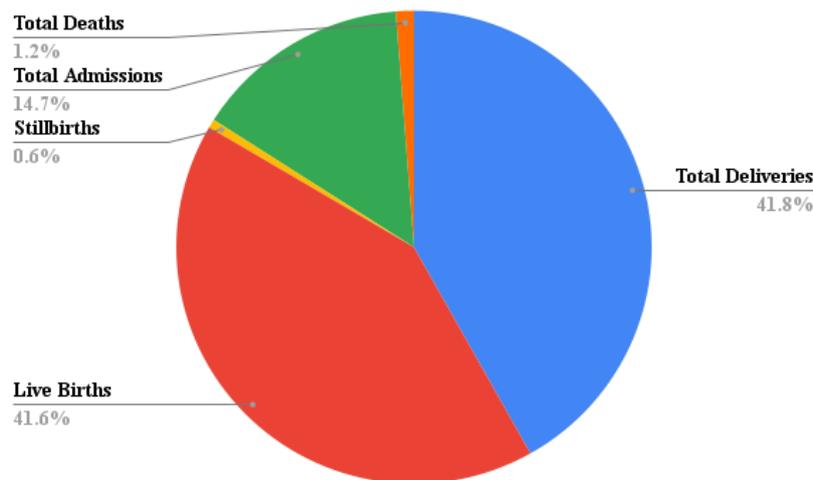


Figure 1: Distribution of Neonatal Care Statistics

The results show a steady decrease in the Neonatal Death Rate from 2.57% in 2017–18 to 2.38% in 2024, indicating improved neonatal outcomes.

Year-wise Trends in Neonatal Mortality

Table 2 summarizes neonatal admissions, deaths, and SNCU mortality rates for seven years. Admissions were between 1,055 and 2,893 annually and deaths dropped from 511 in 2017–2018 to 92 in 2023–2024. A substantial drop from 17.66% to 8.72% was observed in SNCU mortality which could be attributed to better care and health interventions for neonates.

Table 2: Neonatal Mortality Trends and Admission Statistics

Year	Admissions	Deaths	SNCU Mortality Rate (%)
2017–2018	2,893	511	17.66
2018–2019	2,417	280	11.58
2019–2020	2,585	391	15.12
2020–2021	1,402	182	12.98
2021–2022	1,592	195	12.25
2022–2023	2,111	194	9.19
2023–2024	1,055	92	8.72

Mortality Patterns: Inborn vs. born Neonates

The table 3 compares total admissions, deaths, and the proportion of deaths for inborn and outborn neonates. Inborn neonates accounted for 12,248 admissions and 1,065 deaths (59.2%), while outborn neonates had 9,255 admissions and

734 deaths (40.8%). The higher mortality proportion among inborn neonates reflects their critical health conditions and intensive care requirements.

Table 3: Comparison of Mortality Between Inborn and Outborn Neonates

Category	Total Admissions	Total Deaths	Proportion of Deaths (%)
Inborn Neonates	12,248	1,065	59.2%
Outborn Neonates	9,255	734	40.8%

Outborn neonates consistently exhibited higher mortality due to delayed referrals and critical conditions upon arrival. Seasonal illnesses during the monsoon months (July–September) further increased risks for both groups, particularly for outborn neonates.

Gender-based Mortality

This table illustrates the gender-wise distribution of neonatal deaths. Male neonates accounted for 1,019 deaths (56.7%), while female neonates accounted for 780 deaths (43.3%). The higher mortality proportion among male neonates highlights potential biological vulnerabilities and warrants further investigation into gender-specific neonatal health risks and outcomes.

Table 4: Gender-Based Distribution of Neonatal Mortality

Gender	Total Deaths	Proportion of Deaths (%)
Male Neonates	1,019	56.7%
Female Neonates	780	43.3%

Temporal Patterns and Seasonal Variations

The analysis of temporal patterns and seasonal variations in neonatal mortality highlights significant trends over the years. Mortality consistently peaked during the monsoon season (July to September) in all study years, with August repeatedly recording the highest number of deaths. This seasonal spike correlates with the prevalence of infections, such as sepsis and pneumonia, which are exacerbated by environmental conditions during the monsoon. In addition, the study revealed a steady annual decline in mortality rates, improving from 17.66% in 2017–2018 to 8.72% in 2023–2024 in table 4. These reductions reflect advancements in neonatal care, including enhanced infection control measures, improved clinical protocols, and early interventions provided in SNCUs.

Table 4: Seasonal Mortality Trends and Annual Improvements in Neonatal Care

Year	Mortality Rate (%)	Peak Mortality Month
2017–2018	17.66	August
2018–2019	11.58	September
2019–2020	15.12	August
2020–2021	12.98	April
2021–2022	12.25	September
2022–2023	9.19	July
2023–2024	8.72	August

Figure 2 reflects a sequential reduction in neonatal mortality rates from 17.66% in 2017–2018 to 8.72% in 2023–2024, showing the improvement in attendance, practices in the care of newborn, and the subsequent care outcomes.

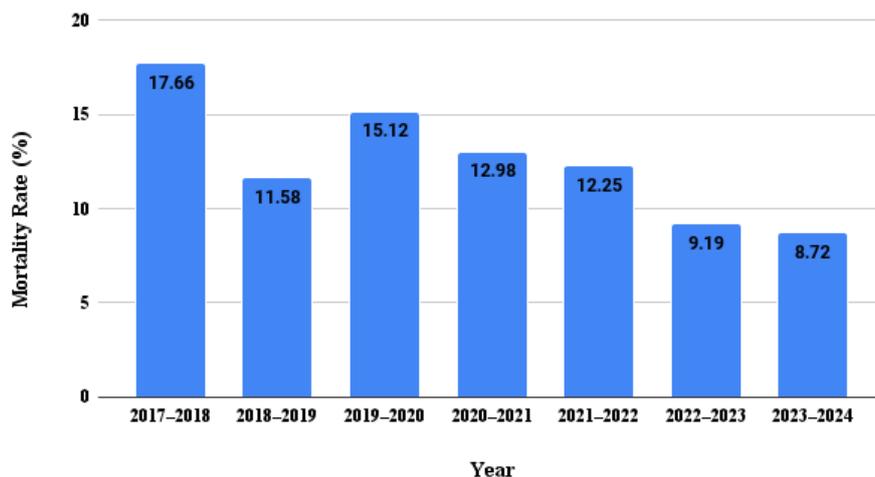


Figure 2: Annual Trends in Neonatal Mortality Rate (2017–2024)

Regression Analysis of Mortality Rate in Neonates

The results of a regression analysis of the relationship between neonatal mortality rates and two predictors, Admissions and Deaths, are presented in this table. The baseline mortality rate is the Intercept (10.9089, $p = 0.002$) when admissions and deaths are zero. There is a statistically significant negative relationship between the Admissions coefficient (-0.0042 , $p = 0.040$) which implies that higher admissions go along with a small decrease in mortality which might indicate better care availability in table 5. By contrast, the Death coefficient (0.0381 , $p = 0.005$) is significantly positively related (i.e., that as the mortality rate increases, so too does the number of deaths). The predictions are shown to be strongly predictive, and the narrow 95% confidence intervals reflect the reliability of the estimates.

Table 5: Regression Analysis Table

Coefficient	Estimate	Std. Error	t-value	P-value	95% Confidence Interval
Intercept	10.9089	1.447	7.539	0.002	[6.892, 14.926]
Admissions	-0.0042	0.001	-2.992	0.040	[-0.008, -0.000]
Deaths	0.0381	0.007	5.745	0.005	[0.020, 0.056]

Dependent Variable: Mortality Rate

Statistical Comparison of Neonatal Livebirths and Stillbirths by Gender

The table 6 shows a comparative statistical analysis of live births and stillbirths in male and female neonates (mean \pm standard deviation (SD)). Males (7742.86 ± 932.48) were slightly higher than females (7342.86 ± 840.35) for live births, but the difference was not statistically significant ($Z = 0.84$, $p = 0.42$). For stillbirths, males (120.00 ± 13.23) also had marginally higher values than females (110.00 ± 13.23), but this difference was not statistically significant ($Z = 1.41$, $p = 0.18$). These results indicate no gender-based differences in live births or stillbirth rates for neonates.

Table 6: Gender-Based Statistical Analysis of Live Births and Stillbirths

Category	Male (Mean \pm SD)	Female (Mean \pm SD)	Z-Value	P-Value
Livebirths	7742.86 ± 932.48	7342.86 ± 840.35	0.843	0.416
Stillbirths	120.00 ± 13.23	110.00 ± 13.23	1.414	0.183

Over the 8-year study period, significant improvements in neonatal care outcomes were observed, as reflected by a steady decline in mortality rates. This positive trend underscores the effectiveness of enhanced healthcare infrastructure, trained personnel, and the implementation of evidence-based practices. However, the data revealed consistent seasonal peaks in neonatal mortality during July to September, coinciding with the monsoon season. These seasonal variations highlight the need for targeted infection control measures and enhanced maternal care initiatives during high-risk periods. Additionally, the study found that outborn neonates consistently faced higher mortality rates compared to inborn neonates. This disparity emphasizes the urgent need for strengthening referral systems, ensuring timely transport, and improving prenatal care at peripheral healthcare facilities. Another critical observation was the higher mortality rate

among male neonates, which aligns with global findings. This gender disparity warrants further investigation into biological vulnerabilities and socio-cultural factors influencing care-seeking behaviors and outcomes. Addressing these challenges holistically is essential for sustaining progress in neonatal health.

DISCUSSION

Trends in neonatal mortality from April 2017 to September 2024 in the SNCU of a tertiary care hospital are analyzed in this study. Improvement in healthcare infrastructure, neonatal care, and maternal health services, resulted in a marked fall in neonatal mortality from 17.66% in 2017-2018 to 8.72% in 2023-2024. Policies for identifying and treating precipitating factors at early stages to avoid neonatal mortality and morbidity require trained personnel, timely interventions, and standardized protocols in line with national trends after the launch of facility-based newborn care (FBNC) programs (Lawn et al., 2005; Bhutta et al., 2014). Other evidence-based practices such as kangaroo mother care (KMC) and infection prevention strategies added strength to care (Kumar et al., 2009). Nevertheless, mortality always peaked during the monsoon season (July–September), with August and September being the worst months, as a result of infections such as sepsis, pneumonia, and diarrhea, which were aggravated by tropical climates. Neonatal mortality shows seasonal variations and targeted interventions, improved infection control, and maternal hygiene education are needed (Mishra & Agarwal, 2016).

Similar to earlier findings (Stevenson et al., 2021), outborn neonates had higher mortality than inborn admissions, due to delayed referrals, poor prenatal care, and critical conditions at presentation. Improvements in referral pathways, strengthening of peripheral systems, and equipping transport with life support systems can improve outcomes. Early interventions and better monitoring were beneficial for inborn neonates.

The gender disparity reported in studies of male neonates who accounted for 56.7 percent of deaths (Gudayu et al., 2019; Johansson et al., 2004) was detected. This trend is partly due to biological susceptibility to conditions such as respiratory distress syndrome (RDS) and sepsis, and socio-cultural factors that delay care for female neonates (Bhalotra et al., 2016). To address these disparities, gender-sensitive care and equitable access to healthcare are a must. Janani Shishu Suraksha Karyakram (JSSK) and FBNC (Ministry of Health and Family Welfare, 2017) have improved maternal and newborn care and reduced out-of-pocket costs while advocating for institutional delivery. Reducing neonatal mortality has also been successful through community-based interventions (Bang et al., 2000; Kumar et al., 2009). However seasonal mortality surges, infection-related deaths, and outborn care remain to be addressed.

Strategies to sustain reductions in neonatal mortality will require additional strengthening of SNCUs, monsoon infection prevention and control, referral systems, and neonatal transport. Maternity education and newborn care campaigns must also be scaled up, and community-based programs must be scaled up (Bang et al., 1999). The strength of this study is the 8-year analysis of SNCU data, which shows achievements and gaps. However it is a retrospective study, and information regarding maternal health, socioeconomic data, and specific causes of death were not available. These determinants need to be explored further in future prospective studies. Although considerable progress has been made, seasonal, gender, and outborn disparities still exist, calling for focused interventions to achieve national and global neonatal health goals.

CONCLUSION

The neonatal admissions and mortality trends over 8 years in a tertiary care hospital's SNCU were analyzed in this study which showed significant improvement in neonatal outcomes. The neonatal mortality rate decreased from 17.66% to 8.72% (in 2017–2018 and 2023–2024) demonstrating improvements in healthcare infrastructure, numbers of trained personnel, and evidence-based practices. The study shows a consistent seasonal peak in neonatal mortality during the monsoon months (July–September) and August in particular, associated with infections such as sepsis and pneumonia. The mortality was higher in outborn neonates (40.8%) than in inborn neonates (59.2%) mainly because of delayed referral and poor prenatal care. Gender-based analysis of neonatal deaths disclosed that male neonates contributed 56.7% to the neonatal deaths probably due to biological and sociocultural factors of the male gender. However, the study shows gaps in seasonal mortality control, infection prevention, and outborn neonate care. Further reduction of mortality rates will require strengthening referral systems, improving neonatal transport, and improving infection control measures, particularly during high-risk months. Gender-specific care and equitable access to healthcare are also needed to remove inequities in outcomes for the neonate.

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