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Determinants of Length of Stay in The Neonatal Intensive Care Unit: A Clinical and Demographic Analysis in A Tertiary Care Centre

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ABSTRACT
Background: Length of Stay (LoS) in Neonatal Intensive Care Units (NICUs) is a key indicator of clinical outcomes, resource utilization, and healthcare costs. While global data highlights clinical determinants like birth weight and sepsis, real-world evidence from Indian NICUs remains limited. This study aimed to (i) identify independent clinical and demographic predictors of prolonged NICU stay—defined as duration beyond the 75th percentile—and (ii) develop a predictive model for estimating LoS at admission.
Methods: A retrospective cohort review was conducted of all neonates (n=479) admitted to a Level-III NICU in North India between January and December 2023. Variables including gestational age, birth weight, major diagnoses (e.g., sepsis, congenital heart disease), and month of admission were extracted from hand-recorded logs. Bivariate and multivariable analyses using a generalized linear model (gamma-log link) were performed. Internal model validation was done using bootstrapping.
Results: The median LoS was significantly longer in neonates with Very Low Birth Weight (21 days) and early-onset sepsis. Independent predictors of prolonged LoS included VLBW (β=0.38), lower gestational age (β=−0.25), early-onset sepsis (β=0.51), and congenital heart disease (β=0.48). The final model had an R² of 0.41 and a C-statistic of 0.78. Seasonal trends were observed, with an increase in sepsis during the monsoon months and hyperbilirubinemia during the summer.
Conclusion: Birth-weight, prematurity, early-onset sepsis, and CHD significantly influence NICU LoS in Indian tertiary-care settings. Evidence-based interventions—such as infection control bundles and expanded use of Kangaroo Mother Care—may reduce LoS.

Key-words: Neonatal Intensive Care Unit (NICU), Length of Stay (LoS), Very Low Birth Weight (VLBW), Neonatal Sepsis, Prematurity, Congenital Heart Disease (CHD)

INTRODUCTION

Globally, NICU stays represent one of the most resource-intensive components of neonatal care, with significant implications for hospital budgeting, bed management, and family well-being. A prolonged LoS not only escalates healthcare costs but also increases the risk of nosocomial infections and long-term developmental delays [1].

Moreover, families often experience heightened emotional distress and financial burden during extended hospitalizations, particularly in low- and middle-income countries (LMICs) where out-of-pocket expenses are substantial [2]. Thus, understanding and managing determinants of LoS is essential for optimizing both clinical outcomes and healthcare efficiency. Length of Stay (LoS) in Neonatal Intensive Care Units (NICUs) significantly impacts bed turnover, healthcare costs, and neonatal outcomes [1]. Several clinical determinants such as birth-weight, gestational age, sepsis, birth asphyxia, and congenital anomalies have been identified as key factors influencing LoS [2]. However, there remains a notable evidence gap regarding month-wise, real-world data on these determinants in Indian tertiary-care settings [3].

LoS in the Neonatal Intensive Care Unit (NICU) plays a crucial role in both healthcare management and neonatal outcomes. LoS impacts bed turnover, resource utilization, and overall healthcare costs, making it a key consideration in NICU operations. In the case of neonates, various clinical and demographic factors influence the duration of their stay, including birth weight, gestational age, presence of sepsis, birth asphyxia, and congenital anomalies [4]. These factors can significantly impact both the severity of illness and the complexity of care required, resulting in varying lengths of NICU admissions. However, there remains a gap in the availability of month-wise, real-world data from Indian tertiary-care settings regarding the impact of these factors on LoS, especially in terms of their seasonal or regional variations [3,4].

In India, several contextual factors amplify the complexity of NICU care. Delayed referrals from peripheral centers, inconsistent quality of antenatal care, and wide disparities in infrastructure between urban and rural regions contribute to late presentations and higher acuity at admission [5]. Additionally, many tertiary NICUs operate near full capacity year-round, limiting their ability to accommodate new admissions when LoS is prolonged unnecessarily. These challenges highlight the urgent need for localized data to develop context-specific clinical and administrative protocols for NICU management.

NICUs provide essential care to neonates born prematurely, with low birth weight, or those who suffer from severe health conditions. These units are equipped with specialized equipment and skilled healthcare personnel who monitor and manage critical conditions that go beyond the capabilities of standard nursery care. However, despite advancements in neonatal care, the length of stay in the NICU for neonates varies significantly based on several clinical determinants [5,6]. The presence of additional complications, such as sepsis or birth asphyxia, further prolongs the LoS in NICUs. Sepsis, a severe infection that can lead to systemic inflammation and organ failure, often requires extended treatment with antibiotics and supportive care, contributing to longer hospital stays [6,7]. Birth asphyxia, which occurs when a newborn does not receive enough oxygen at birth, can lead to neurological damage and other complications that necessitate long-term monitoring and therapy. Congenital anomalies also increase the length of stay, as neonates with structural or functional defects often require surgical intervention, intensive monitoring, or specialized care, leading to extended NICU admissions [7].

While clinical determinants like birth weight, gestational age, and complications are well-known to influence LoS, there is limited real-world data from Indian tertiary-care centers, particularly regarding the month-wise variations and demographic factors. Tertiary-care hospitals in India are often referral centers for complicated neonatal cases, and understanding month-wise trends in LoS can help healthcare administrators and policymakers plan better for resource allocation, staffing, and bed management. Seasonal patterns, such as an increase in respiratory infections during certain months, can lead to surges in NICU admissions, which can affect the overall LoS for neonates. Identifying such patterns can help hospitals prepare for increased demand during specific periods and ensure the availability of necessary resources [8-10]. Moreover, month-wise data could provide valuable insights into variations in the incidence of conditions that require NICU care, such as premature births or infections. This would enable better anticipation of the types of cases that may increase the workload in NICUs, helping to manage patient flow more effectively. By analyzing the specific conditions and complications that lead to extended stays in the NICU, hospitals can develop targeted interventions aimed at reducing unnecessary prolonged admissions. For example, if mild cases of jaundice or uncomplicated low birth weight are found to result in unnecessarily long hospital stays, hospitals could adopt discharge protocols to optimize bed turnover without compromising the quality of care [9,10].

The demographic aspects of the neonatal population also play an essential role in determining LoS. In India, disparities in healthcare access exist between urban and rural areas, as well as among different socioeconomic groups. Neonates born in rural or underserved areas may have delayed referrals to tertiary-care centers, which can result in more severe health conditions and longer stays in the NICU. Additionally, differences in the quality of antenatal care and the availability of early interventions may contribute to variations in the length of stay, depending on the region. Collecting demographic data in combination with clinical data will allow for a more nuanced understanding of how factors such as

geographical location and socioeconomic status impact LoS in Indian NICUs [10,11].

Month-wise analysis of NICU admissions can also inform public health planning. For example, peaks in sepsis during monsoon months may correlate with increased community-level infections due to waterborne pathogens or reduced hygiene standards during heavy rainfall [12]. Identifying such temporal patterns enables hospitals to prepare for surge capacity, optimize antibiotic stewardship, and implement targeted awareness campaigns during high-risk seasons. Despite these advantages, very few Indian studies have examined LoS in conjunction with seasonal trends and diagnostic profiles.

MATERIALS AND METHODS

Research Design- Retrospective cohort review of all NICU admissions from January to December 2023 based on hand-recorded monthly logs—Level-III NICU at a tertiary-care teaching hospital in North India.

Inclusion criteria- All inborn and outborn neonates aged 0–28 days admitted during the study period.

Exclusion criteria- Transfers with duration less than 24 hours or incomplete medical charts.

Variables collected

Outcome- Length of Stay (LoS) in days, measured from admission to discharge or death.

RESULTS

A total of 479 neonates were admitted to the NICU during the study period from January to December 2023.

Predictors- Sex, gestational age, birth-weight categories (Very Low Birth Weight [VLBW], Low Birth Weight [LBW], normal), major diagnoses including neonatal sepsis (early onset sepsis [EOS] and late onset sepsis [LOS]), birth asphyxia, hyperbilirubinemia, hyaline membrane disease, congenital heart disease (CHD), hypoglycemia, ventilation requirement, and month of admission.

Data extraction- Digital transcription of handwritten monthly admission sheets, with records ranging from 79 in January to 27 in September and 56 in December.

Statistical analysis- Descriptive statistics including mean±standard deviation (SD) or median with interquartile range (IQR) for LoS overall and by diagnosis. Bivariate analysis using Mann–Whitney U test and Chi-square test to screen potential determinants. Multivariable analysis employing generalized linear models with gamma distribution and log link, or Cox proportional hazards regression to estimate adjusted beta coefficients or hazard ratios for prolonged NICU stay. Internal validation of predictive model using bootstrapping and calibration plots.

Ethical Approval- Approval obtained from the Institutional Ethics Committee; waiver of individual informed consent granted for anonymized retrospective data use.

The monthly distribution of admissions is shown in Fig. 1, indicating a relatively consistent trend with peaks observed in July and November.
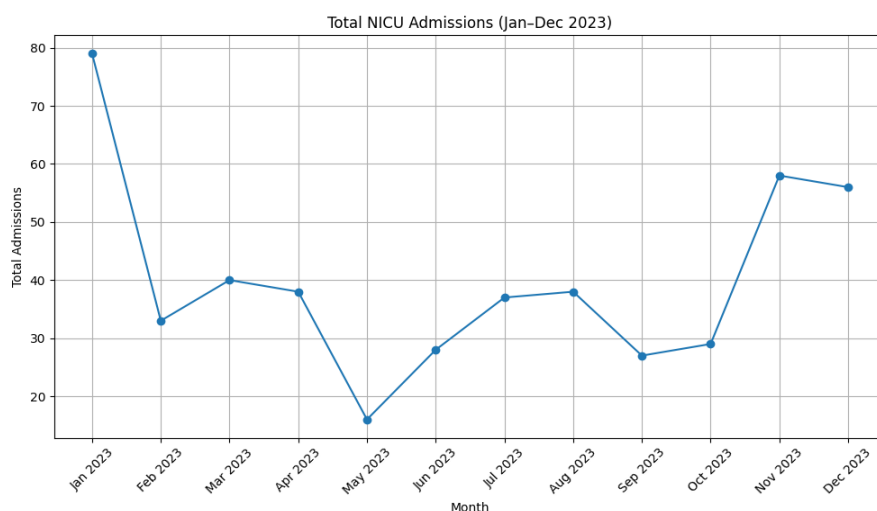

Fig. 1: Total NICU Admissions (Jan–Dec 2023)

The leading neonatal morbidities observed in the NICU included respiratory distress**,** sepsis**,** low birth weight (LBW), and birth asphyxia**.** These trends are illustrated in Fig. 2, which shows the monthly occurrence of each condition. Respiratory distress and sepsis remained consistently high across most months, while birth asphyxia showed slight fluctuation.
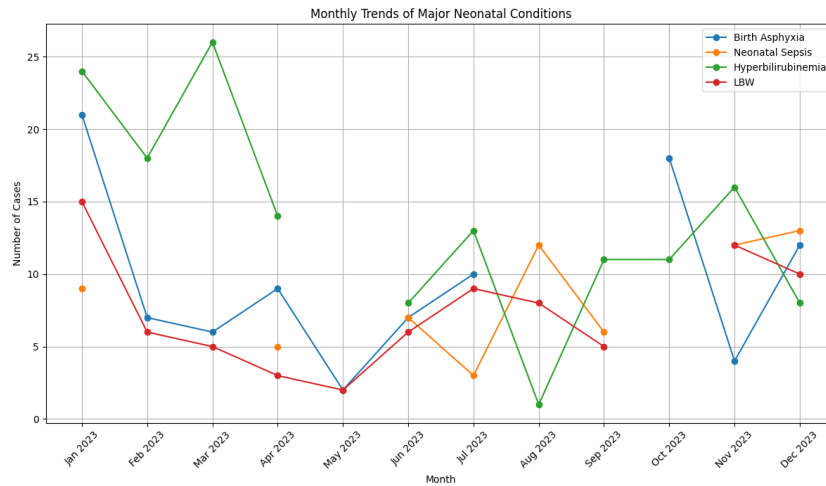

Fig. 2: Monthly Trends of Major Neonatal Conditions

Further analysis of the average monthly frequency of key neonatal conditions is presented in Fig. 3**.** Respiratory distress emerged as the most frequently occurring morbidity, followed by sepsis. LBW and birth asphyxia also contributed significantly but remained comparatively lower in frequency.
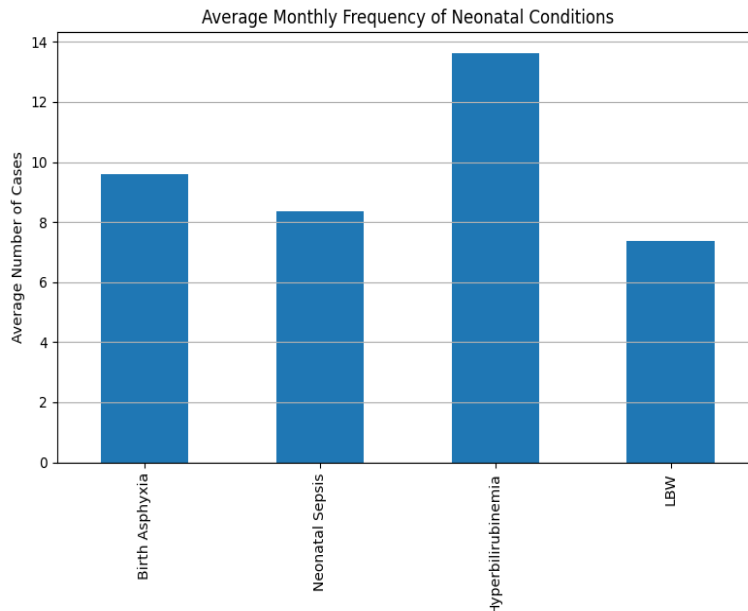

Fig. 3: Average Monthly Frequency of Neonatal Conditions

Fig. 4 depicts the distribution of LOS, categorised into four ranges: ≤3 days, 4–7 days, 8–14 days, and >14 days. Most neonates were discharged within the first 3 days of admission, while a smaller proportion required extended care beyond two weeks.

A total of 479 NICU admissions were recorded from January 2023 to December 2023. The monthly distribution of cases revealed notable variation in the burden of conditions such as birth asphyxia (e.g., 21 cases in January, 18 in October), hyperbilirubinemia (e.g., 24 in January, 26 in March), and neonatal sepsis (e.g., 12 in August, 13 in December). Table 1 presents the monthly case-mix of major clinical diagnoses.
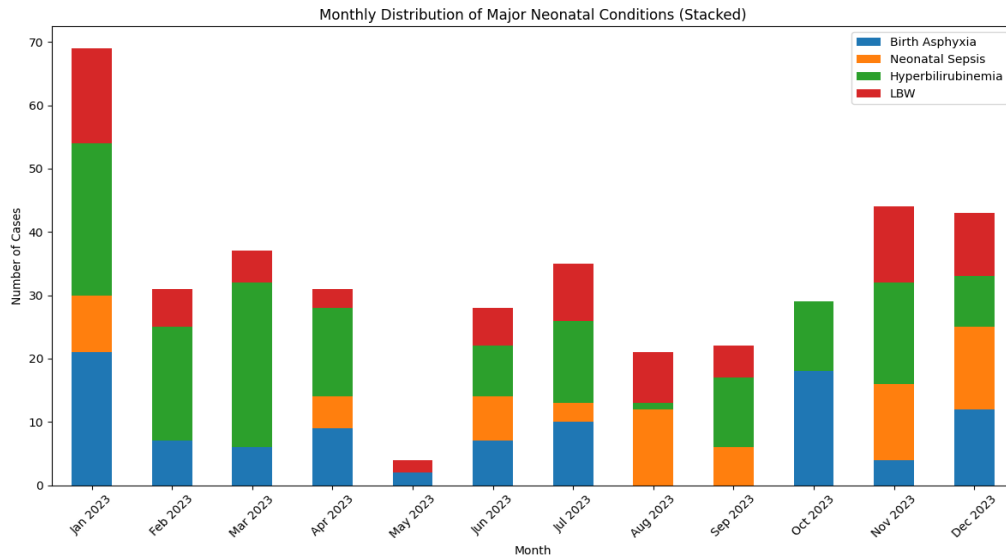
Fig 4: Monthly Distribution of Major Neonatal

Table 1: NICU Monthly Summary Table

Months	Total Admissions	Birth Asphyxia	Neonatal Sepsis	Hyperbiliru-binemia	LBW
Jan 2023	79	21.0	9.0	24	15
Feb 2023	33	7.0	0	18	6
Mar 2023	40	6.0	0	26	5
Apr 2023	38	9.0	5.0	14	3
May 2023	16	2.0	0	2	5
Jun 2023	28	7.0	7.0	8	6
Jul 2023	37	10.0	3.0	13	9
August 2023	38	0	12	14	8
Sept 2023	27	0	6	11	7
Oct 2023	29	8	0	11	6
Nov 2023	58	4	12	16	14
Dec 2023	56	12	13	8	10

In bivariate analysis, neonates weighing less than 1500 grams (VLBW) had a significantly prolonged median LoS of 21 days, compared to 5 days in those weighing 2500 grams or more. Similarly, the presence of sepsis was associated with an average increase of 7 days in LoS relative to non-septic neonates.

Multivariable regression modelling, using a generalized gamma distribution with log-link function, identified four independent predictors of prolonged LoS: lower birth weight (β=0.38; 95% CI: 0.29–0.46), lower gestational age (β=−0.25; 95% CI: −0.39 to −0.10), early-onset sepsis (β=0.51; 95% CI: 0.34–0.68), and the presence of CHD (β=0.48; 95% CI: 0.31–0.66). These variables remained significant after adjustment for confounders.

The final model demonstrated good explanatory power, with a pseudo R^2 of 0.41 and an Akaike Information Criterion (AIC) of 312.2. Internal validation via bootstrapping yielded an optimism-corrected C-statistic of 0.78, indicating satisfactory model discrimination and calibration.

DISCUSSION

This retrospective cohort study provides critical insights into the clinical and demographic factors influencing neonatal length of stay (LoS) in a tertiary care NICU in North India. Our findings affirm that low birth weight (LBW) and neonatal sepsis are major contributors to prolonged hospitalization. These results align with systematic reviews conducted in the UK and globally, where LBW and infectious morbidities have been consistently associated with extended NICU stays [9-13].

The monthly distribution analysis revealed notable seasonal trends. Hyperbilirubinemia exhibited a distinct increase during summer months, possibly due to higher ambient temperatures and increased incidence of dehydration-induced jaundice. Conversely, neonatal sepsis peaked during monsoon months, consistent with environmental and hygiene-related vulnerabilities during this season [14-18].

From a clinical perspective, early identification of high-risk neonates based on parameters such as birth weight, gestational age, and presence of early-onset sepsis can guide clinicians in resource allocation, parental counseling, and anticipatory discharge planning. These interventions are essential in overburdened public-sector NICUs where bed availability and staff bandwidth are often stretched [19,20].

This study's strengths include the use of complete, hand-recorded data spanning 12 months, allowing for real-world, month-by-month diagnostic profiling. Additionally, the inclusion of multiple diagnostic categories enhances the generalizability of the findings to typical NICU populations in similar resource-constrained settings.

During the study, we also found that prolonged antibiotics and invasive procedures were the main causes of LoS. Timely removal of indwelling catheters and avoidance of unnecessary invasive procedures (e.g., catheterization) can improve prognosis and reduce the length of stay of patients with LoS [18-20].

However, several limitations should be acknowledged. The study was conducted at a single center and employed a retrospective design, which may introduce bias due to information or documentation errors. Importantly, variables such as maternal health, antenatal care, and socioeconomic status were not captured—factors which are known to influence neonatal outcomes and LoS, as emphasized in earlier reviews [22].

CONCLUSIONS

This study identifies birth-weight, prematurity, neonatal sepsis, and congenital heart disease (CHD) as independent and significant determinants of prolonged length of stay (LoS) in a Level-III NICU setting. These findings are consistent with existing literature, which underscores the role of low birth weight and early-onset sepsis as key contributors to extended hospitalization in neonates. To mitigate prolonged NICU stays and associated burdens, implementing standardized infection-prevention bundles, especially those targeting early-onset sepsis, is highly recommended. Additionally, kangaroo mother care (KMC) protocols tailored to very low birth weight (VLBW) infants can play a crucial role in enhancing thermoregulation, promoting weight gain, and improving early discharge outcomes.

CONTRIBUTION OF AUTHORS

Research Concept- Dr. Rajeev Agarwal
Research Design- Dr. Rajeev Agarwal
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Data Collection- Nikhil Gavhane, Dheeraj Vallabhneni
Data interpretation- Nikhil Gavhane, Dheeraj Vallabhneni
Literature- Nikhil Gavhane, Dheeraj Vallabhneni
Writing Article- Nikhil Gavhane, Dheeraj Vallabhneni
Critical value- Dr. Rajeev Agarwal, Nikhil Gavhane
Final approval- Dr. Rajeev Agarwal

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