Sudan Journal of Medical Sciences
Volume 20, Issue no. 2, DOI 10.18502/sjms.v20i2.18055
Production and Hosting by KnE Publishing

KNE Publishing

Check for updates

Research Article

Length of Stay and Associated Factors in the Neonatal Intensive Care Units in Central Saudi Arabia: A Retrospective Study

Abdullah Al-Nafeesah* and Ashwaq AlEed

Department of Pediatrics, College of Medicine, Qassim University, Saudi Arabia

Abstract

Background: Global improvements in neonatal survival have been associated with increased admissions of preterm infants to neonatal intensive care units (NICUs) and longer hospital stays. However, data on the length of stay (LOS) for infants in NICUs and related factors in Saudi Arabia are scarce. This study aimed to evaluate the LOS and its associated factors in the NICUs in Central Saudi Arabia.

Methods: In 2023, a retrospective study was conducted in the NICU of King Saud Hospital in Unaizah, Qassim region, Saudi Arabia. Neonatal and maternal information was gathered from medical records using questionnaires. Modified Poisson regression models were generated, providing relative risk and a 95.0% confidence interval.

Results: A total of 915 neonates (53.6% males vs 46.4% females) were included in this analysis. Of these, 293 (32.0%) were low birth weight (LBW), 270 (29.5%) were preterm, and 51 (5.6%) had hypothermia. The median interquartile range (IQR) for the neonates' white blood cell (WBC) count and red cell distribution width (RDW) was 13.8% (10.7–17.8%) and 16.7% (15.4–18.1%) × 10^3/mm^3, respectively. Their LOS ranged from 1 to 47 days, with a mean of 5.5 days, a median (IQR) of 3.0 (2–6) days, and a 90th percentile of 12 days. Multivariate Poisson analysis indicated that cesarean delivery (aRR = 1.38, 95% CI = 1.30–1.47), preterm delivery (adjusted relative risk [aRR] = 1.93, 95% CI = 1.79–2.07), LBW (aRR = 1.63, 95% CI = 1.51–1.74), and RDW (aRR = 1.02, 95% CI = 1.01–1.03) were positively associated with LOS, while neonatal jaundice (aRR = 0.74, 95% CI = 0.65–0.85) and WBC count (aRR = 0.99, 95% CI = 0.98 –0.99) were negatively associated.

Conclusion: The average LOS in this study was 5.5 days. The identified factors could help healthcare providers predict neonatal LOS, thereby enhancing neonatal care management.

Keywords: outcome assessment, LBW, preterm, WBC, hospital admission, newborn

Corresponding Author:
Abdullah Al-Nafeesah; email: a.alnafeesah@qu.edu.sa

Received: 21 January 2025
Accepted: 9 May 2025
Published: 30 June 2025

Production and Hosting by KnE Publishing

Editor-in-Chief:
Prof. Nazik Elmalaika Obaid Seid Ahmed Husain, MD, M.Sc, MHPE, PhD.

OPEN ACCESS

1. Introduction

Neonatal survival rates have improved significantly, increasing from 52% to 63% (P = 0.016) among newborns delivered at 25 weeks of gestation. This rise has resulted in longer lengths of stay (LOS) in hospitals, particularly for newborns admitted to neonatal intensive care units (NICUs) [1]. Additionally, the number of neonates needing long-term NICU care has risen, which increases their exposure to the healthcare environment, intravenous (IV) medications, and associated risks such as infection and medication side effects [2]. Approximately 15 million infants are estimated to be born prematurely each year, a figure that is anticipated to rise globally [3]. According to the World Health Organization (WHO), a birth is regarded as extremely preterm if the infant's gestational age is <28 weeks, very preterm if it is 28–<32 weeks, and moderate to late preterm if the gestational age is 32–<37 weeks [4].

Identifying predictors of neonatal LOS is essential for tailoring the type, quality, and duration of care provided and informing parental counseling [5]. Notably, survival rates for preterm and extremely preterm infants have increased from 76.0% to 78.3% [6, 7], leading to higher NICU admissions and longer LOS. The longer infants remain in the hospital, the greater their risk of complications due to prolonged exposure to potential hazards in the hospital environment [8, 9]. Predicting risk factors for extended LOS is crucial for clinicians to counsel parents and provide effective, appropriate care.

Currently, there is limited evidence on predicting LOS in NICUs and the factors contributing to prolonged stays. Birth weight is one of the most common factors, influencing up to 60.9% of cases [10, 11], followed by gestational age (43.5%) [10, 12]. Several other neonatal conditions, notably infection/sepsis, necrotizing enterocolitis (NEC), retinopathy of prematurity (ROP), and bronchopulmonary dysplasia (BPD), also play significant roles [13]. Some studies have suggested that congenital anomalies, neonatal treatment protocols, and specific laboratory indicators impact LOS for neonates [14, 15]. Additionally, maternal factors, including antenatal care and delivery mode, have been linked to variations in LOS [11, 14]. Furthermore, a few studies have found that organizational facilities and socio-economic factors can affect hospital neonatal LOS [16].

Existing research on the determinants of LOS for newborns in NICUs in Saudi Arabia is limited [17–19]. While these studies provide some insight into NICU LOS in the Saudi Arabian context, they have certain limitations. One study focused solely on preterm newborns [17], whereas others examined broader pediatric intensive care units [18, 19]. Additionally, no prior research has been carried out in the Qassim region. Understanding the factors influencing NICU LOS for surviving newborns is essential for optimizing resource allocation, enhancing care efficiency, and informing parental expectations. Identifying these factors in our context will facilitate targeted interventions to improve outcomes and potentially lower healthcare costs. Therefore, this study aims to identify the factors influencing LOS for newborns in the NICU who were discharged alive.

2. Methods

2.1. Study design and setting

After obtaining ethical approval, a retrospective hospital-based study was conducted in 2023 at the NICU of King Saud Hospital in Unaizah, Qassim

region, Saudi Arabia. The Qassim region is situated 350 km from Riyadh, the capital of Saudi Arabia, and has a population of 1,336,179. The NICU at King Saud Hospital offers care for at-risk or ill neonates free of charge. The unit is supervised by consultants, specialist neonatologists, pediatricians, and skilled nurses 24 hrs a day. In addition to newborn and neonatal services, the unit is equipped with the following facilities: incubators, supplemental oxygen administration, radiant warmers, phototherapy machines, umbilical transfusions, nasogastric tube insertion, IV infusion, urinary catheterization, lumbar punctures, laboratory investigations, and continuous positive airway pressure ventilation.

2.2. Data collection

Two trained medical officers reviewed medical files and collected data using a paper-based questionnaire. The questionnaire developed for this study was based on previously published similar studies [20–24] and included sections on the respondents' sociodemographic, maternal, and neonatal characteristics. The information collected included the birth weight and sex of the newborn, gestational age, hospital LOS in days, mode of delivery (vaginal or cesarean), Apgar score, diagnosis and cause of admission, and discharge status.

2.3. Inclusion and exclusion criteria

We reviewed the files of mothers with neonates aged 0–28 days who were admitted to the NICU at King Saud Hospital in Unaizah. The inclusion criteria required neonates to be discharged home alive, while the exclusion criteria included incomplete data, brief observation stays, death, or discharge against medical advice.

2.4. Sample size determination and sampling procedure

Based on previous guidelines [25], a sample size of 915 neonates was calculated, assuming a minimum significant correlation (r = 0.10) between LOS in days and other independent factors (e.g., sex, low birth weight [LBW], and preterm birth). This sample size was accurate and optimal for achieving a 95% confidence level with a 5% margin of error (precision) and 80% power.

2.5. Statistical analysis

Data were entered and analyzed using the Statistical Package for the Social Sciences (SPSS) Statistics for Windows, version 22.0 (IBM, Armonk, NY, USA). After checking the continuous variables (using the Shapiro-Wilk test), they were found to be non-normally distributed. Therefore, their medians (interquartile range [IQR]) were used to express them. Modified univariate Poisson regression was performed with LOS as the dependent variable and neonatal factors as independent variables. Furthermore, variables with a P-value < 0.200 in the univariate analysis were shifted to the constructed multivariate Poisson regression to model LOS and provide adjusted relative risk (aRR) with a 95.0% confidence interval (CI). A two-sided P-value < 0.05 was considered statistically significant.

3. Results

3.1. General characteristics

A total of 915 neonates admitted to the NICU and discharged were enrolled. Of these, 490 (53.6%) were male and 425 (46.4%) were female. Most neonates (851, 93.0%) were from singleton

pregnancies, with 59 (6.4%) being twins and two (0.5%) triplets. Additionally, 293 (32.0%) of the neonates had LBW, 270 (29.5%) were preterm, and 51 (5.6%) had hypothermia (Table **1**).

The median white blood cell (WBC) count and red cell distribution width (RDW) were 13.8% (10.7–17.8%) and 16.7% (15.4–18.1%) × 10^3/mm^3, respectively.

LOS ranged from 1 to 47 days (mean = 5.5 days), with a median (IQR) of 3.0 (2–6) days and a 90th percentile of 12 days. Of the 915 neonates, 373 (40.7%) were discharged within two days. The results of the univariate Poisson analysis indicated that being twins, having neonatal jaundice and congenital malformations, being delivered by cesarean section, undergoing preterm delivery, low birth weight, WBC, and RDW were associated with LOS. In contrast, the sex of the newborn and hypothermia were not (Table **2**).

After adjustment (multivariate Poisson analysis), newborns delivered by cesarean (aRR = 1.38, 95% CI = 1.30–1.47), those with preterm delivery (aRR = 1.93, 95% CI = 1.79–2.07), LBW (aRR = 1.63, 95% CI = 1.51–1.74), and RDW (aRR = 1.02, 95% CI = 1.01–1.03) were positively associated with LOS. Neonatal jaundice (aRR = 0.74, 95% CI = 0.65–0.85) and neonatal WBC (aRR = 0.99, 95% CI = 0.98–0.99) were inversely associated with LOS. Twins and congenital malformations were only associated with LOS in the univariate analysis as confounders (Table **3**).

Table 1: The primary diagnosis and reason for admission to the NICU at King Saud Hospital, Qassim, Saudi Arabia, in 2022 (*n* = 915).

Variables	Numbers	Proportions
Hypothermia	51	5.6
Twins	64	7.0
Neonatal jaundice	107	11.7
Congenital malformation	44	4.8
Cesarean delivery	395	43.2
Low birth weight	293	32.0
Preterm birth	270	29.5

Table 2: Unadjusted (univariate Poisson analysis) factors associated with LOS in the NICU at King Saud Hospital, Qassim, Saudi Arabia, 2022.

Variables		Relative risk	95% confidence interval	*P*-value
Sex	Male	Reference		0.787
	Female	1.01	0.95 –1.06	
Hypothermia	No	Reference		0.722
	Yes	1.02	0.90–1.15	
Twins	No	Reference		<0.001
	Yes	1.74	1.59–1.89	
Neonatal Jaundice	No	Reference		<0.001
	Yes	0.43	0.38–0.49	
Congenital malformation	No	Reference		<0.001
	Yes	0.65	0. 56–0.76	

Table 2: Continued.

Variables		Relative risk	95% confidence interval	*P*-value
Mode of delivery	Vaginal	Reference		<0.001
	Cesarean	1.75	1.66–1.86	
Low birth weight	Yes	2.53	2.40–2.68	<0.001
	No	Reference		
Preterm birth	Yes	2.75	2.60–2.91	<0.001
	No	Reference		
Neonate white blood cell		0.99	0.99–0.99	0.008
Neonate red cell distribution width		1.02	1.01–1.03	<0.001

Table 3: Adjusted factor (multivariate Poisson regression analysis) associated with LOS in the NICU at King Saud Hospital, Qassim, Saudi Arabia, 2022.

Variables		Adjusted relative risk	95% confidence interval	*P*-value
Twins	No	Reference		0.262
	Yes	0.94	0.86–1. 04	
Neonatal jaundice	No	Reference		<0.001
	Yes	0.74	0.65–0.85	
Congenital malformation	No	Reference		0.899
	Yes	0.99	0. 84–1.16	
Mode of delivery	Vaginal	Reference		<0.001
	Cesarean	1.38	1.30–1.47	
Low birth weight	Yes	1.63	1.51–1.74	<0.001
	No	Reference		
Preterm birth	Yes	1.93	1.79–2.07	<0.001
	No	Reference		
Neonate white blood cell		0.99	0.98 –0.99	0.001
Neonate red cell distribution width		1.02	1.01–1.03	0.005

4. Discussion

This study investigated LOS in an NICU and identified factors that positively influenced it, including cesarean delivery, LBW, preterm delivery, and RDW. Additionally, factors that negatively influenced LOS included neonatal jaundice and WBC count. The study found that the mean LOS was 5.5 days, while the median was 3.0 days. This duration is shorter than what is reported in other African countries. For instance, the median LOS in an Ethiopian study was seven days [26]. The median LOS was 11 days in a Southern African private NICU, and the mode of delivery was associated with LOS [27]. Moreover, a much longer LOS with a median of 39 days was reported in another study in South Africa among newborns with LBW, with reports indicating that gestational age, chronic lung disease, and healthcare-associated infections were factors linked to an extended hospital stay [28]. Likewise, a median LOS of 36 hrs was reported in Ghana, Malawi, and Eswatini [29].

The differences in means and medians of LOS in these studies, including ours, may be explained by the methods used, the inclusion and exclusion criteria, the outcomes (alive or dead), and other

factors such as birth weight and gestational age. Previous studies have reported that LOS varies by neonatal weight, with lower neonatal weight associated with more extended stays [17, 30].

Various attempts have been made to reduce LOS by involving the families of neonates and the community [31–33]. For example, in Sweden, a randomized controlled trial found that family-centered care, which allowed parents to stay with their children 24/7, reduced the total LOS by 5.3 days compared to standard care [31].

Our findings align with several studies from Saudi Arabia that have consistently associated LBW and prematurity with longer LOS [17, 27, 28, 34–36]. A study from Al Kharj in the Riyadh region reported that both extreme preterm birth and extreme LBW were linked to high mortality, reaching as much as 38.4% [37, 38]. Additionally, in Riyadh, both gestational age and birth weight at delivery were negatively correlated with LOS among preterm infants [17]. Moreover, birth weight and gestational age were associated with LOS in a systematic review of 23 studies [13] and in a model developed to predict LOS in Southern African private hospitals [27].

This study identified two laboratory indicators associated with LOS: increasing RDW was associated with longer LOS, while increasing WBC was associated with shorter LOS. In Sudan, Omer and Mohammed revealed that elevated RDW was significantly associated with neonatal sepsis [39]. Additionally, Mohammed *et al.* reported in Sudan that elevated RDW levels (≥17%) were the most sensitive hematological marker for predicting mortality in neonatal sepsis [40]. Ramby *et al.* found RDW to be a strong prognostic marker for child mortality and extended stays in the NICU [41].

In contrast to our study, other research yielded different WBC results. One study reported a positive correlation between WBC counts and prolonged LOS [42]. Another study reported no association between WBC and LOS [43]. The observed relationship between increasing WBC counts and shorter LOS in this study could be attributed to an enhanced immune response in neonates, potentially leading to earlier discharge from the NICU. These conflicting findings highlight the complex relationship between WBC counts, RDW, and neonatal infections, emphasizing the need to interpret these markers carefully in clinical practice.

This study also found a positive association between neonatal LOS and cesarean delivery. Similar findings were reported in other studies, suggesting that the mode of delivery can affect LOS [14, 27, 35]. However, some studies have shown no effect of delivery mode on NICU stay [44, 45]. These discrepancies may be explained by the clinical indications for cesarean delivery rather than the delivery mode and differences in mortality versus live discharge rates in the NICU. In Ethiopia, Chekole et al. reported that cesarean delivery and twin pregnancy were predictors of neonatal mortality in NICUs [46].

We found no significant differences in LOS based on gender, contrasting with studies from the United States and China showing that male infants had longer NICU stays than females [11, 47]. The absence of gender-related LOS differences in Saudi Arabia, unlike findings in the US and China, which indicate shorter female stays [11, 47], could stem from various factors. Biologically, potential hormonal or genetic predispositions affecting infant resilience might differ across populations. Healthcare access and practices, including resource allocation, medical insurance, and clinical protocols for male versus female infants, could vary internationally. Culturally, parental expectations,

caregiving roles, and the perceived vulnerability of male infants might influence healthcare-seeking behavior and the intensity of care provided, potentially impacting LOS. Further research exploring these multifaceted influences is warranted.

The initial association between congenital anomalies and LOS in our study, which subsequently diminished in multivariate analysis, warrants careful consideration. While some studies exclude this vulnerable population, our univariate finding, combined with the significant impact of LOS on infants with anomalies, aligns with research from Canada and India, especially concerning those requiring surgical intervention [10, 48]. The discrepancy in our multivariate analysis may be attributed to several factors. First, the relatively smaller sample size of infants with specific congenital anomalies within our study might have limited the statistical power to detect an independent effect when considering other factors. Second, the high mortality rates linked to certain severe congenital anomalies, as highlighted by others [48], might have led to shorter observed LOS in non-surviving infants, potentially obscuring a direct association between the anomaly itself and prolonged survival in the NICU. Therefore, while congenital anomalies may not have emerged as an independent predictor of LOS in our multivariate model, their significant impact on those who survive longer, especially those needing surgery, underscores the importance of including this group in future research with larger, more targeted samples to understand better the nuanced relationship between specific congenital anomalies, LOS, and patient outcomes in the Saudi Arabian context. Researchers should view these contrasting findings as a catalyst for conducting country- or region-specific evaluations of NICU LOS and its contributing factors.

This study showed that neonates with jaundice had a shorter LOS, which may be attributed to the type and severity of jaundice. Mild or physiologic jaundice typically involves shorter stays compared to severe jaundice, a major neonatal issue in low-resource settings [49].

The present study has several implications for neonatal care in Saudi Arabia, particularly in the country's central region. The identified predictors can aid healthcare providers in counseling parents about their neonates [5]. These predictive factors are crucial for optimizing resource allocation (staff, budget, facilities) and developing tailored, holistic programs to improve neonatal outcomes within the NICUs, ultimately refining future management strategies. Moreover, this study highlights key areas for further local investigation, specifically the observed discrepancies between Saudi Arabia and other nations regarding LOS related to gender and congenital anomalies. Given that prematurity and LBW are common predictors of neonatal morbidity and mortality in Saudi Arabia and elsewhere, preventive measures are needed to address these health issues. For instance, reducing unnecessary cesarean deliveries might reduce neonatal health problems [50]. Indeed, an increase in cesarean deliveries has been documented in central Saudi Arabia, with rates reaching 20%, and this increase has been associated with a rise in NICU admissions [51].

5. Limitations

This study represents the first large-scale investigation of LOS epidemiology in the Qassim region of Saudi Arabia. Notably, nearly all births (98.7%) are attended by healthcare workers [52], and all births are registered in Saudi Arabia [53].

This study provides valuable data for decision-makers aiming to tackle NICU-related challenges and enhance care quality. Despite these strengths, some limitations should be addressed in future studies. First, while the study was quantitative, further exploration of NICU issues, particularly with increased parental involvement, could benefit from a mixed-methods approach. Additionally, this study focused solely on neonates admitted to the NICU with live outcomes, and no data were collected on neonates admitted with fatal outcomes or those discharged against medical advice.

6. Conclusion

The average LOS in this study was 5.5 days. The identified factors could help healthcare providers predict neonatal LOS, thereby improving neonatal care management.

Declarations

Acknowledgments

The authors thank the hospital staff who participated in the study.

Ethical Considerations

This study was approved by the Research Board at the Regional Research Ethical Committee in Qassim Province (#607/44/16884) and was conducted following the Declaration of Helsinki. To ensure confidentiality and privacy, all personal identifiers were removed during data collection, and the data were used exclusively for research purposes.

Availability of Data and Material

The datasets used in the present study are available from the corresponding author upon reasonable request.

Competing Interests

None.

Funding

No funding was received for this work.

References

[1] Field, D. J., Dorling, J. S., Manktelow, B. N., & Draper, E. S. (2008). Survival of extremely premature babies in a geographically defined population: Prospective cohort study of 1994-9 compared with 2000-5. *BMJ (Clinical Research Ed.), 336*(7655), 1221–1223. https://doi.org/10.1136/bmj.39555.670718.BE PMID:18469017

[2] Baek, H., Cho, M., Kim, S., Hwang, H., Song, M., & Yoo, S. (2018). Analysis of length of hospital stay using electronic health records: A statistical and data mining approach. *PLoS One, 13*(4), e0195901. https://doi.org/10.1371/journal.pone.0195901 PMID:29652932

[3] Liu, L., Oza, S., Hogan, D., Chu, Y., Perin, J., Zhu, J., Lawn, J. E., Cousens, S., Mathers, C., & Black, R. E. (2016). Global, regional, and national causes of under-5 mortality in 2000-15: An updated systematic analysis with implications for the Sustainable Development Goals. *Lancet, 388*(10063), 3027–3035. https://doi.org/10.1016/S0140-6736(16)31593-8 PMID:27839855

[4] World Health Organization. (2018). Preterm birth. Fact sheet. https://www.who.int/news-room/fact-sheets/detail/preterm-birth

[5] Seaton, S. E., Barker, L., Jenkins, D., Draper, E. S., Abrams, K. R., & Manktelow, B. N. (2016). What factors predict length of stay in a neonatal unit: A systematic review. *BMJ Open, 6*(10), e010466. https://doi.org/10.1136/bmjopen-2015-010466 PMID:27797978

[6] Bell, E. F., Hintz, S. R., Hansen, N. I., Bann, C. M., Wyckoff, M. H., DeMauro, S. B., Walsh, M. C., Vohr, B. R., Stoll, B. J., Carlo, W. A., Van Meurs, K. P., Rysavy, M. A., Patel, R. M., Merhar, S. L., Sánchez, P. J., Laptook, A. R., Hibbs, A. M., Cotten, C. M., D'Angio, C. T.,... Das, A., & the Eunice Kennedy Shriver National Institute of Child Health and Human Development Neonatal Research Network. (2022). Mortality, in-hospital morbidity, care practices, and 2-year outcomes for extremely preterm infants in the US, 2013-2018. *Journal of the American Medical Association, 327*(3), 248–263. https://doi.org/10.1001/jama.2021.23580 PMID:35040888

[7] Li, J., Wang, Q. H., Wu, H. M., Wei, K. L., Yang, Y. J., Du, L. Z., & Yao, Y. J. (2012). [A survey of neonatal births in maternity departments in urban China in 2005]. *Zhongguo Dang Dai Er Ke Za Zhi = Chinese Journal of Contemporary Pediatrics, 14*(1), 7–10. PMID:22289743

[8] Harrison, W., & Goodman, D. (2015). Epidemiologic trends in neonatal intensive care, 2007-2012. *JAMA Pediatrics, 169*(9), 855–862. https://doi.org/10.1001/jamapediatrics.2015.1305PMID:26214387

[9] Kirkby, S., Greenspan, J. S., Kornhauser, M., & Schneiderman, R. (2007). Clinical outcomes and cost of the moderately preterm infant. *Advances in Neonatal Care, 7*(2), 80–87. https://doi.org/10.1097/01.ANC.0000267913.58726.f3 PMID:17605448

[10] Murki, S., Vardhelli, V., Deshabhotla, S., Sharma, D., Pawale, D., Kulkarni, D., Kumar, P., Kabra, N. S., Sundaram, M., Plakkal, N., Mehta, A., Tandur, B., Chawla, D., Sreeram, S., Saha, B., Suman Rao, P. N., & Kadam, S. (2020). Predictors of length of hospital stay among preterm infants admitted to neonatal intensive care unit: Data from a multicentre collaborative network from India (INNC: Indian National Neonatal Collaborative). *Journal of Paediatrics and Child Health, 56*(10), 1584–1589. https://doi.org/10.1111/jpc.15031

[11] Xie, F., Shu, Q., Chen, Z. Y., & Li, J. (2022). Length of stay and influencing factors of NICU in the Western Hunan, an underdeveloped area of China: A 9-year retrospective study. *The Journal of International Medical Research, 50*(6), 3000605221100753. https://doi.org/10.1177/03000605221100753

[12] Bender, G. J., Koestler, D., Ombao, H., McCourt, M., Alskinis, B., Rubin, L. P., & Padbury, J. F. (2013). Neonatal intensive care unit: Predictive models for length of stay. *Journal of Perinatology, 33*(2), 147–153. https://doi.org/10.1038/jp.2012.62

[13] Fu, M., Song, W., Yu, G., Yu, Y., & Yang, Q. (2023). Risk factors for length of NICU stay of newborns: A systematic review. *Frontiers in Pediatrics, 11*, 1121406. https://doi.org/10.3389/fped.2023.1121406

[14] Singh, H., Cho, S. J., Gupta, S., Kaur, R., Sunidhi, S., Saluja, S., Pandey, A. K., Bennett, M. V., Lee, H. C., Das, R., Palma, J., McAdams, R. M., Kaur, A., Yadav, G., & Sun, Y. (2021). Designing a bed-side system for predicting length of stay in a neonatal intensive care unit. *Scientific Reports, 11*(1), 3342. https://doi.org/10.1038/s41598-021-82957-z PMID:33558618

[15] Kheiry, F., Kargarian-Marvasti, S., Afrashteh, S., Mohammadbeigi, A., Daneshi, N., Naderi, S., & Saadat, S. H. (2020). Evaluation of goodness of fit of semiparametric and parametric models in analysis of factors associated with length of stay in neonatal intensive care unit. *Clinical and Experimental Pediatrics, 63*(9), 361–367. https://doi.org/10.3345/cep.2019.00437

[16] Zhang, M., Wang, Y. C., Feng, J. X., Yu, A. Z., Huang, J. W., Jiang, S. Y., Gu, X. Y., Sun, J. H., Cao, Y., Zhou, W. H., Lee, S. K., Wang, L. L., Yin, R., & the Chinese Neonatal Network. (2022). Variations in length of stay among survived very preterm infants admitted to Chinese neonatal intensive care units. *World Journal of Pediatrics, 18*, 126–134. https://doi.org/10.1007/s12519-021-00494-1

[17] AlJohani, E., Qaraqei, M., & Al-Matary, A. (2020). Estimating the neonatal length of stay for preterm babies in a Saudi tertiary hospital. *Journal of Clinical Neonatology, 9*(1), 13–17. https://doi.org/10.4103/jcn.JCN_115_19

[18] Alshaikh, R., AlKhalifah, A., Fayed, A., & AlYousef, S. (2022). Factors influencing the length of stay among patients admitted to a tertiary pediatric intensive care unit in Saudi Arabia. *Frontiers in Pediatrics, 10*, 1093160. https://doi.org/10.3389/fped.2022.1093160

[19] Temsah, M.-H., Abouammoh, N., Al-Eyadhy, A., AlRuthia, Y., Hassounah, M., Alsohime, F., Alhaboob, A., Almazyad, M., Alabdulhafid, M., Aljamaan, F., Alhasan, K., & Jamal, A. (2021). Predictors and direct cost estimation of long stays in pediatric intensive care units in Saudi Arabia: A mixed methods study. *Risk Management and Healthcare Policy, 14*, 2625–2636. https://doi.org/10.2147/RMHP.S311100

[20] Alrasheed, A. S., Alhussein, K., Alsayed, M., Alzahrani, W. M., Alotaibi, A. D., Alosaimi, F. M., Aldebasi, M. H., Alshuwayrikh, A. A., Alkhonezan, S. M., Alshehri, M. A. H., Alshaya, O. A., Aljethaily, A. A., Alasmari, A. I., AlMakhdob, M. A., Alfaris, A., & Jabari, M., (2020). The causes of death in the Neonatal Intensive Care Unit at Security Forces Hospital, Riyadh, Kingdom of Saudi Arabia (2012-2017). *International Journal of Medicine in Developing Countries, 3*(10), 861–866. https://doi.org/10.24911/IJMDC.51-1562410193

[21] Al-Mouqdad, M., Abdelrahim, A., Alodhaidan, N. A., Sumaily, H. H., Khalil, T. M., Asfour, Y., & Asfour, S. S. (2020). Antenatal care of mothers and morbidity and mortality disparities among preterm Saudi and non-Saudi infants less than or equal to 32 weeks' gestation. *Annals of Saudi Medicine, 40*(4), 290–297. https://doi.org/10.5144/0256-4947.2020.290

[22] Almudeer, A. H., Alibrahim, M. A., & Gosadi, I. M. (2020). Epidemiology and risk factors associated with early onset neonatal sepsis in the south of KSA. *Journal of Taibah University Medical Sciences, 15*(6), 509–514. https://doi.org/10.1016/j.jtumed.2020.08.009

[23] Fneish, A., Alhasoon, M., Al Essa, A., Mahlangu, R., Alshami, N., Alsaif, S., & Ali, K. (2022). Admission temperature and neonatal outcomes—Single-centre experience in Saudi Arabia. *International Journal of Pediatrics & Adolescent Medicine, 9*(4), 203–208. https://doi.org/10.1016/j.ijpam.2022.12.001

[24] Alharbi, A. S. (2022). Common bacterial isolates associated with neonatal sepsis and their antimicrobial profile: A retrospective study at King Abdulaziz University Hospital, Jeddah, Saudi Arabia. *Cureus, 14*(1), e21107. https://doi.org/10.7759/cureus.21107

[25] Bujang, M. A., & Baharum, N. (2016). Sample size guideline for correlation analysis. *WORLD (Oakland, Calif.), 3*(1), 37–46.

[26] Derese, T., Belay, Y., & Tariku, Z. (2020). The median survival recovery time and associated factors among admitted neonate in intensive care units of Dire Dawa Public Hospitals, East Ethiopia, 2019. *EC Emergency Medicine and Critical Care, 4*, 27–37. https://doi.org/10.21203/rs.3.rs-22899/v1

[27] Pepler, P. T., Uys, D. W., & Nel, D. G. (2012). Predicting mortality and length-of-stay for neonatal admissions to private hospital neonatal intensive care units: A Southern African retrospective study. *African Health Sciences, 12*(2), 166–173. https://doi.org/10.4314/ahs.v12i2.14

[28] Mahovo, R., & Velaphi, S. (2019). Duration of hospital stay and factors associated with prolonged hospital stay in very low birth weight infants surviving to hospital discharge. *Journal of Pediatrics, Perinatology and Child Health, 3*(4), 208–220. https://doi.org/10.26502/jppch.74050032

[29] Tsiga-Ahmed, F. I., Jalo, R. I., Ibrahim, U. M., Kwaku, A. A., Umar, A. A., Sanusi, S. M., & Amole, T. G. (2022). Length-of-stay after a health facility birth and associated factors: Analysis of data from three Sub-Saharan African countries. *Ghana Medical Journal, 56*(2), 100–109. https://doi.org/10.4314/gmj.v56i2.7

[30] Lee, H. C., Bennett, M. V., Schulman, J., Gould, J. B., & Profit, J. (2016). Estimating length of stay by patient type in the neonatal intensive care unit.

American Journal of Perinatology, 33(8), 751–757. https://doi.org/10.1055/s-0036-1572433

[31] Örtenstrand, A., Westrup, B., Broström, E. B., Sarman, I., Akerström, S., Brune, T., Lindberg, L., & Waldenström, U. (2010). The Stockholm Neonatal Family Centered Care Study: Effects on length of stay and infant morbidity. *Pediatrics, 125*(2), e278–e285. https://doi.org/10.1542/peds.2009-1511

[32] Langley, D., Hollis, S., Friede, T., MacGregor, D., & Gatrell, A. (2002). Impact of community neonatal services: A multicentre survey. *Archives of Disease in Childhood. Fetal and Neonatal Edition, 87*(3), F204–F208. https://doi.org/10.1136/fn.87.3.F204

[33] Petteys, A. R., & Adoumie, D. (2018). Mindfulness-based neurodevelopmental care: Impact on NICU parent stress and infant length of stay; A randomized controlled pilot study. *Advances in Neonatal Care, 18*(2), E12–E22. https://doi.org/10.1097/ANC.0000000000000474

[34] Hoque, M., Haaq, S., & Islam, R. (2011). Causes of neonatal admissions and deaths at a rural hospital in KwaZulu-Natal, South Africa. *The Southern African Journal of Epidemiology & Infection, 26*(1), 26–29. https://doi.org/10.1080/10158782.2011.11441416

[35] Shah, S., Zemichael, O., & Meng, H. D. (2012). Factors associated with mortality and length of stay in hospitalised neonates in Eritrea, Africa: A cross-sectional study. *BMJ Open, 2*(5), e000792. https://doi.org/10.1136/bmjopen-2011-000792

[36] Adebanji, A., Adeyemi, S., & Gyamfi, M. (2015). Empirical analysis of factors associated with neonatal length of stay in Sunyani, Ghana. *Journal of Public Health and Epidemiology, 7*(3), 59–64. https://doi.org/10.5897/JPHE2014.0679

[37] Alghadier, M., Alasraj, M., Elnaggar, R., Alazmi, M., Aldawsari, A., Alnadah, S., Alqahtani, F., & Zaghamir, D. (2024). A cross-sectional analysis of preterm birth incidence and survival in Al Kharj, Saudi Arabia. *Saudi Medical Journal, 45*(7), 710–718. https://doi.org/10.15537/smj.2024.45.7.20240194

[38] Altirkawi, K., Alyousef, N., Sobaih, B., Alhadid, A. J., Shaiba, L., Banoo, R., & Fariss, A. (2021). Mortality and major morbidities of very low birth weight infants at a teaching hospital in Saudi Arabia: A comparison of two periods. *Dubai Medical Journal, 4*(2), 100–106. https://doi.org/10.1159/000516289

[39] Omer, I. M., & Mohammed, B. A. A. (2021). A study of red cell distribution width and neonatal sepsis at Soba University Hospital, Khartoum, Sudan. *Sudanese Journal of Paediatrics, 21*(1), 42–47. https://doi.org/10.24911/SJP.106-1597237251

[40] Mohamed, O. A. A., Seedahmed, S. M., & Idris, A. A. A. (2024). Association of red cell distribution width (RDW) with positive blood culture of neonatal sepsis in Khartoum state, Sudan. *Discover Medicine, 1*(1), 6. https://doi.org/10.1007/s44337-024-00011-z

[41] Ramby, A. L., Goodman, D. M., Wald, E. L., & Weiss, S. L. (2015). Red blood cell distribution width as a pragmatic marker for outcome in pediatric critical illness. *PLoS One, 10*(6), e0129258. https://doi.org/10.1371/journal.pone.0129258

[42] Joachim, M. V., Abdo, M., Alkeesh, K., Oettinger-Barak, O., Abozaid, S., & El-Naaj, I. A. (2022). Factors associated with prolonged hospitalizations from odontogenic infections in children. *The Journal of Clinical Pediatric Dentistry, 46*(6), 40–44. https://doi.org/10.22514/jocpd.2022.024

[43] Williams, D. J., Hall, M., Auger, K. A., Tieder, J. S., Jerardi, K. E., Queen, M. A., Statile, A. M., Myers, A. L., & Shah, S. S. (2015). Association of white blood cell count and C-reactive protein with outcomes in children hospitalized for community-acquired pneumonia. *The Pediatric Infectious Disease Journal, 34*(7), 792–793. https://doi.org/10.1097/INF.0000000000000724

[44] Kurek Eken, M., Tüten, A., Özkaya, E., Karatekin, G., & Karateke, A. (2017). Major determinants of survival and length of stay in the neonatal intensive care unit of newborns from women with premature preterm rupture of membranes. *The Journal of Maternal-Fetal & Neonatal Medicine, 30*(16), 1972–1975. https://doi.org/10.1080/14767058.2016.1235696

[45] Kurek Eken, M., Tüten, A., Ozkaya, E., Dinçer, E., Şenol, T., Karatekin, G., & Karateke, A. (2016). Evaluation of the maternal and fetal risk factors associated with neonatal care unit hospitalization time. *The Journal of Maternal-Fetal & Neonatal Medicine, 29*(21), 3553–3557. https://doi.org/10.3109/14767058.2016.1138466

[46] Chekole, B., Terefe, T. F., Tenaw, S. G., Zewudie, B. T., GebreEyesus, F. A., Kassaw, A., Gelaw Walle, B., Aynalem Mewahegn, A., Tadesse, B., Mesfin, Y., Argaw, M., Abebe, H., Tesfa, S., & Tamene Zeleke, F. (2023). Survival status, length of stay, and predictors of mortality among neonates admitted in the neonatal intensive care unit of Gurage Zone public hospitals. *SAGE Open Nursing, 9*, 23779608231187480. https://doi.org/10.1177/23779608231187480

[47] Lee, H. C., Bennett, M. V., Schulman, J., & Gould, J. B. (2013). Accounting for variation in length of NICU stay for extremely low birth weight infants. *Journal of Perinatology, 33*(11), 872–876. https://doi.org/10.1038/jp.2013.92

[48] Berry, M. A., Shah, P. S., Brouillette, R. T., & Hellmann, J. (2008). Predictors of mortality and length of stay for neonates admitted to children's hospital neonatal intensive care units. *Journal of Perinatology, 28*(4), 297–302. https://doi.org/10.1038/sj.jp.7211904

[49] Dawodu, A. (1998). Neonatology in developing countries: Problems, practices and prospects. *Annals of Tropical Paediatrics, 18(*sup1): p. S73–S79. https://doi.org/10.1080/02724936.1998.11747984

[50] Zhang, Y., Zhou, J., Ma, Y., Liu, L., Xia, Q., Fan, D., & Ai, W. (2019). Mode of delivery and preterm birth in subsequent births: A systematic review and meta-analysis. *PLoS One, 14*(3), e0213784. https://doi.org/10.1371/journal.pone.0213784

[51] Al-Kadri, H. M., Al-Anazi, S. A., & Tamim, H. M. (2015). Increased cesarean section rate in Central Saudi Arabia: A change in practice or different maternal characteristics. *International Journal of Women's Health, 7*, 685–692. https://doi.org/10.2147/IJWH.S85215

[52] UNSD (2021). *General Authority for Statistics. Measuring progress towards the sustainable development goals*.

[53] World Health Organization. (2024). *Child and adolescent health*. https://www.emro.who.int/child-adolescent-health/adolescent-health/adolescent-health.html