INSIGHTS-JOURNAL OF
HEALTH AND REHABILITATION

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

TRENDS IN NEONATAL SEPSIS: INCIDENCE, CAUSATIVE ORGANISMS, AND ANTIBIOTICS SUSCEPTIBILITY IN NEONATOLOGY DEPARTMENT OF SERVICES HOSPITAL, LAHORE

Original Research

Muhammad Wasim Salim[1]*, Sikandar Hayat[1], Shagufta Niazi[1], Zunera Riaz[1], Muhammad Awais Zafar[1], Rehman Sher[1]
[1]Services Hospital Lahore, Pakistan.
Corresponding Author: Muhammad Wasim Salim, Services Hospital Lahore, Pakistan, muhammadwaxim0@gmail.com
Acknowledgement: The authors express gratitude to the Neonatology Department, Services Hospital Lahore, for their support and access to medical records.

Conflict of Interest: None
Grant Support & Financial Support: None

ABSTRACT

Background: Neonatal sepsis remains a critical contributor to neonatal morbidity and mortality in low-resource countries, particularly Pakistan. Despite advances in perinatal care, early diagnosis and appropriate antimicrobial management remain challenging due to changing microbial patterns and resistance. Understanding local prevalence, causative organisms, and resistance trends is essential for guiding empirical therapy and improving neonatal outcomes in hospital-based settings.

Objective: To assess the prevalence, bacterial etiology, and antibiotic susceptibility patterns of culture-confirmed neonatal sepsis in a tertiary care hospital in Lahore, Pakistan.

Methods: A retrospective cohort study was conducted over a 12-month period (January to December 2024) at the Neonatology Department of Services Hospital, Lahore. The study included 307 neonates aged ≤28 days who presented with clinical signs of sepsis and had positive culture results from sterile sites. Data were extracted from hospital records, including maternal, perinatal, and laboratory parameters. Statistical analysis was performed using SPSS version 27.0, with Pearson correlation, chi-square tests, and binary logistic regression applied to identify associations and predictors.

Results: Out of 307 neonates, 200 (65.1%) were male, and 159 (51.8%) were born preterm. Cesarean section deliveries accounted for 188 (61.2%) cases, and 230 (74.9%) mothers had received antenatal antibiotics. A total of 185 (60.3%) neonates required resuscitation. The most commonly isolated pathogen was Pseudomonas species in 142 (46.25%) cases, followed by Klebsiella (26.38%) and Burkholderia (11.07%). Significant correlations were observed for abnormal CTG ($r = -0.737$), positive swab cultures ($r = 0.666$), and need for resuscitation ($r = 0.713$). Logistic regression identified antenatal antibiotic exposure, preterm status, congenital anomalies, and birth-related complications as significant predictors of sepsis ($p < 0.001$).

Conclusion: Pseudomonas emerged as the leading cause of neonatal sepsis in this tertiary care setting. High rates among preterm infants, those with deformities, and neonates requiring resuscitation underscore the need for early identification, targeted screening, and locally guided antibiotic policies to improve survival outcomes.

Keywords: Antibiotic resistance, Neonatal infection, Neonatal resuscitation, Pakistan, Prematurity, Pseudomonas, Sepsis predictors.

INTRODUCTION

Neonatal sepsis remains a formidable threat to infant survival, particularly within the first 90 days of life. Clinically, it is classified into early-onset sepsis (EOS), occurring within the first seven days—often as early as 24 to 48 hours after birth—and late-onset sepsis (LOS), which manifests from day seven up to three months of age (1). The distinction between these two categories is not only temporal but also etiological. EOS typically results from vertical transmission of pathogens from mother to infant during or before delivery, whereas LOS is frequently associated with hospital-acquired or community-acquired infections postnatally (2). Despite notable progress in neonatal care, sepsis continues to account for substantial neonatal morbidity and mortality worldwide. An estimated 1.3 to 3.9 million cases are reported globally each year, contributing to approximately 203,000 neonatal deaths annually (3). It stands as the third leading cause of neonatal mortality, responsible for around 8% of neonatal deaths. Interventions such as intrapartum antibiotic prophylaxis and universal screening for Group B Streptococcus (GBS) have significantly contributed to the decline in EOS rates, which dropped from 1.37 to 0.23 cases per 1,000 live births between 1990 and 2015 (3). Conversely, the incidence of LOS has remained relatively stable, continuing to pose a critical challenge, especially in resource-limited settings. Premature and low-birth-weight neonates are particularly vulnerable, with mortality in this subgroup reported at 17.6% (3). In countries like Pakistan, neonatal sepsis constitutes a major public health concern, driven by systemic healthcare challenges and limited access to quality perinatal services. Research from various regions in Pakistan has reported suspected sepsis rates as high as 29.5% among hospitalized neonates in tertiary care centers. Culture-proven cases predominantly involve Gram-negative bacteria, with mortality rates ranging between 16% and 26%. Infectious diseases remain a persistent public health issue in Pakistan, with previous studies on viral hepatitis highlighting the broader burden of communicable illnesses in the country (4).

Klebsiella species and Escherichia coli are the most common causative agents of EOS, accounting for approximately 53% and 10% of cases respectively, while LOS is often caused by a broader range of pathogens including Pseudomonas and Group A Streptococcus (5). Alarmingly, the rising resistance to first-line antimicrobials such as gentamicin and ampicillin has further complicated treatment strategies (6,7). Clinically, neonatal sepsis may present subtly, with symptoms including lethargy, temperature instability, apnea, respiratory distress, bradycardia, reduced feeding, and diminished spontaneous movement (8,9). Given the non-specificity of these signs and the urgency of intervention, empirical antibiotic therapy often precedes confirmatory diagnostics. However, the effectiveness of empirical regimens hinges on current, localized data concerning microbial profiles and antimicrobial resistance patterns. Understanding the shifting epidemiology and resistance trends in neonatal sepsis is therefore essential to formulating contextually appropriate treatment protocols and preventative strategies. Despite its substantial contribution to neonatal mortality, particularly in low- and middle-income countries, there is a paucity of recent region-specific data on the incidence and bacterial spectrum of neonatal sepsis in Pakistan. This study seeks to address this gap by investigating the current incidence, causative organisms, and antimicrobial susceptibility patterns of neonatal sepsis in Pakistan, with the objective of informing more effective clinical practices and contributing to broader global efforts aimed at reducing neonatal mortality.

METHODS

This retrospective cohort study was conducted over a 12-month period, from January to December 2024, in the Neonatology Department of Services Hospital, Lahore. A total of 307 neonates aged ≤28 days were included, all of whom had positive culture results from sterile body sites—such as blood, cerebrospinal fluid (CSF), urine, or other body fluids—accompanied by clinical signs indicative of neonatal sepsis. Data were extracted from hospital records following approval from the institutional ethical review board and patient confidentiality was maintained throughout the study. Eligibility criteria were clearly defined to enhance the specificity of the study population. Neonates were eligible if they were singletons, presented with signs of sepsis (e.g., fever, hypothermia, respiratory distress, poor feeding, or lethargy), had culture-confirmed infections, and complete medical records. Only neonates without prior antibiotic exposure were considered for inclusion to prevent confounding the antibiotic resistance patterns. Exclusion criteria comprised neonates with negative, inconclusive, or contaminated cultures, those who had received antibiotics prior to sampling, incomplete medical documentation, congenital anomalies, or those who expired within 24 hours of hospital admission, as early death may not allow sufficient time for proper diagnostic evaluation or antimicrobial assessment (10).

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

Blood cultures were obtained aseptically using a standardized single-bottle BACTEC system to ensure consistency and reduce contamination. All identified pathogens underwent antimicrobial susceptibility testing in accordance with Clinical and Laboratory Standards Institute (CLSI) guidelines, ensuring standardization and reliability of sensitivity profiling. Collected data encompassed demographic characteristics, perinatal history, mode and place of delivery, clinical features at presentation, microbial isolates, and associated resistance patterns. These variables were carefully coded and entered for statistical analysis using SPSS version 27.0. Descriptive statistics were applied for demographic and clinical variables. Categorical variables were analyzed using chi-square tests. Variables showing statistical significance at $p < 0.05$ were further assessed using binary logistic regression to identify independent predictors, and outcomes were expressed as odds ratios (ORs) with 95% confidence intervals (CIs). A p-value ≤ 0.05 was considered statistically significant for all inferential analyses.

RESULTS

A total of 307 neonates were admitted during the study period, with a mean gestational age of 33.74 ± 3.71 weeks and an average birth weight of 2.85 ± 0.53 kg. The maternal mean age was 28.93 ± 6.08 years. The average duration of premature rupture of membranes (PROM) was 11.79 ± 6.87 hours. Male neonates comprised 65.1% of the cohort, and 51.8% were delivered preterm. Most neonates (60.3%) required resuscitation at birth, and malformations, anomalies, and developmental deficits were reported in 39.7%, 27.7%, and 26.4% of the cases, respectively. Regarding obstetric profiles, 27.4% of the mothers were primigravida, while 26.7% had four previous pregnancies. Nulliparity was observed in 30% of cases, and abortion history was nearly equally split between none (50.5%) and one prior abortion (49.5%). Caesarean section was the most common mode of delivery (61.2%), with 52.4% of births occurring in hospitals and 71.7% of deliveries conducted by doctors. Antenatal antibiotic use was documented in 74.9% of mothers. Microbiological findings revealed that the most frequently isolated organism was **Pseudomonas species (46.25%)**, followed by **Klebsiella (26.38%)** and **Burkholderia (11.07%)**. Less common isolates included Acinetobacter, Salmonella typhi, Enterobacter, and Staphylococcus aureus, each comprising less than 2% of the total culture-positive samples. Some culture records showed polymicrobial growth or variant antibiotic sensitivity patterns, suggesting the presence of mixed infections or strain diversity.

Chi-square analysis demonstrated highly significant associations between sepsis and several clinical variables. Positive associations were found for abnormal CTG ($\chi^2(1)=166.9$, $p<.001$), positive swab culture ($\chi^2(1)=136.3$, $p<.001$), complete blood count abnormalities ($\chi^2(1)=307.0$, $p<.001$), CRD results ($\chi^2(1)=307.0$, $p<.001$), and positive urine ($\chi^2(1)=79.6$, $p<.001$), CSF ($\chi^2(1)=52.7$, $p<.001$), and blood cultures ($\chi^2(1)=307.0$, $p<.001$). Additionally, culture outcome and sensitivity pattern were strongly correlated ($\chi^2(1)=307.0$, $p<.001$). Sepsis was also significantly related to congenital conditions such as malformations ($\chi^2(1)=67.8$, $p<.001$), anomalies ($\chi^2(1)=39.4$, $p<.001$), and developmental deficits ($\chi^2(1)=36.8$, $p<.001$), along with gestational age ($\chi^2(1)=110.4$, $p<.001$) and need for neonatal resuscitation ($\chi^2(1)=155.9$, $p<.001$). Prenatal antibiotic use was also a significant factor ($\chi^2(1)=307.0$, $p<.001$). Pearson correlation analysis reinforced these associations. Strong negative correlations were observed for abnormal CTG ($r = -0.737$, $p<.01$), gestational age at term ($r = -0.600$, $p<.01$), CBC results ($r = -1.000$, $p<.01$), and culture outcome ($r = -1.000$, $p<.01$). Conversely, positive correlations were seen for swab positivity ($r = 0.666$, $p<.01$), resuscitation needed ($r = 0.713$, $p<.01$), malformations ($r = 0.470$, $p<.01$), anomalies ($r = 0.358$, $p<.01$), and developmental deficits ($r = 0.346$, $p<.01$). Notably, antibiotic use, blood culture, sensitivity pattern, and CRD findings all had perfect positive correlation ($r = 1.000$, $p<.01$), indicating a consistent association with sepsis occurrence. Binary logistic regression revealed that prenatal antibiotic use (Wald $\chi^2=307.000$, $p<.001$), gestational age at term (Wald $\chi^2=110.417$, $p<.001$), resuscitation requirement (Wald $\chi^2=155.852$, $p<.001$), malformations (Wald $\chi^2=67.778$, $p<.001$), anomalies (Wald $\chi^2=39.352$, $p<.001$), and developmental deficits (Wald $\chi^2=36.836$, $p<.001$) perfectly predicted sepsis outcomes, suggesting their critical role as predictors. Other variables, including mode of delivery ($p=0.561$), place of delivery ($p=0.694$), maternal history of infection ($p=0.081$), PROM duration ($p=0.490$), and birth weight ($p=0.387$), were not found to be significant predictors.

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

Table 1: Demographic, Clinical, and Microbiological Characteristics of Neonates with Culture-Proven Sepsis

Variable	Total (n)	Percentage (%)	Mean ± SD
Maternal Age (years)	307	100.0	28.93 ± 6.08
Gestational Age (weeks)	307	100.0	33.74 ± 3.71
Duration of PROM (hrs.)	307	100.0	11.79 ± 6.87
Birth Weight (kg)	307	100.0	2.85 ± 0.53
Gender			
Male	200	65.1	
Female	107	34.9	
Gravida	307	100.0	–
1	84	27.4	–
2	76	24.8	–
3	65	21.2	–
4	82	26.7	–
Para	307	100.0	–
0	92	30.0	–
1	78	25.4	–
2	73	23.8	–
3	64	20.8	–
Abortion	307	100.0	–
0	155	50.5	–
1	152	49.5	–
Previous History	307	100.0	–
No significant history	157	51.1	–
History of infection	150	48.9	–
Mode of Delivery	307	100.0	–
C-section	188	61.2	–
SVD	119	38.8	–
Place of Delivery	307	100.0	–
Home	55	17.9	–
Hospital	161	52.4	–
Private clinic	91	29.6	–
Delivered by	307	100.0	–
Doctor	220	71.7	–
Non-doctor	87	28.3	–
Antenatal Antibiotics	307	100.0	–
Yes	230	74.9	–
No	77	25.1	–
GA Term	307	100.0	–
Preterm	159	51.8	–
Term	148	48.2	–
Resuscitation Needed	307	100.0	–
Yes	185	60.3	–
No	122	39.7	–
Malformations	307	100.0	–
Yes	122	39.7	–
No	185	60.3	–
Anomalies	307	100.0	–

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

Variable	Total (n)	Percentage (%)	Mean ± SD
Yes	85	27.7	–
No	222	72.3	–
Deficits	307	100.0	–
Yes	81	26.4	–
No	226	73.6	–
Bacterial Organisms on culture			
nlf ox+ve pseudomonas	142	46.25%	
lf bio/s klebsiella	81	26.38%	
nlf ox+ve burkholderia	34	11.07%	
nlf ox+veburkholderia	10	3.26%	
nlf ox+ve acinetobacter	5	1.63%	
nlf ox+veacinetobacter	4	1.30%	
nlf ox-ve burkholderia	3	0.98%	
nlf ox-ve acinetobacter	3	0.98%	
nlf bio/s acinetobacter	2	0.65%	
nlf bio/s salmonella typhi	2	0.65%	
nlf ox-ve pseudomonas	2	0.65%	
nlf bio/s klebsiella	2	0.65%	
lf os-veklebsiella	1	0.33%	
nlf ox+ve enterobacter	1	0.33%	
lf bio/s E.coli	1	0.33%	
nlf ox-veburkholderia	1	0.33%	
smear dna +ve scaph aureus	1	0.33%	
nlf bio/s ox+ve pseudomonas	1	0.33%	
nlf ox-ve klebsiella	1	0.33%	
lf(-ve) bio/s klebsiella	1	0.33%	
lf (-ve) bio/s klebsiella	1	0.33%	
acne to bacter +ve	1	0.33%	
staph aureus +ve	1	0.33%	
lf bio/s klebsiella (s)pb (r) cip ctxmem ipm...	1	0.33%	
cons (s) va l2d da (r)fox p	1	0.33%	
nlf ox Providencia	1	0.33%	
nlf bio/s enterobacter	1	0.33%	
nlf ox/s pseudomonas	1	0.33%	
smear dns/ncq	1	0.33%	

Table 2: Chi-Square Analysis of Associations Between Clinical Variables and Neonatal Sepsis

Variable	χ^2 / t (df)	*p*-value
Sepsis*CTG	$\chi^2(1)=166.9$	<0.001
Sepsis*Swab	$\chi^2(1)=136.3$	<0.001
Sepsis*CBC Result	$\chi^2(1)=307.0$	<0.001
Sepsis*CRD	$\chi^2(1)=307.0$	<0.001
Sepsis*Urine	$\chi^2(1)=79.6$	<0.001
Sepsis*CSF	$\chi^2(1)=52.7$	<0.001
Sepsis*Blood culture	$\chi^2(1)=307.0$	<0.001
Sepsis*Culture outcome	$\chi^2(1)=307.0$	<0.001
Sepsis*Sensitivity pattern	$\chi^2(1)=307.0$	<0.001

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

Variable	χ^2 / t (df)	*p*-value
Sepsis*Previous History	$\chi^2(1)=3.04$	0.081
Sepsis*Mode of Delivery	$\chi^2(1)=0.34$	0.561
Sepsis*Place of Delivery	$\chi^2(2)=0.19$	0.912
Sepsis*Handled by(non-doctor, doctor)	$\chi^2(1)=0.06$	0.810
Sepsis*Antibiotics Use	$\chi^2(1)=307.0$	<0.001
Sepsis*GA Term	$\chi^2(1)=110.4$	<0.001
Sepsis*Resuscitation Needed	$\chi^2(1)=155.9$	<0.001
Sepsis*Malformation	$\chi^2(1)=67.8$	<0.001
Sepsis*Anomalies	$\chi^2(1)=39.4$	<0.001
Sepsis*Deficits	$\chi^2(1)=36.8$	<0.001

Table 3: Pearson Correlation Analysis Between Clinical Variables and Neonatal Sepsis

Variable	Pearson Correlation (r)	Significance (p-value)
CTG	-0.737	< 0.01
Swab	0.666	< 0.01
Use of Antibiotics	1.000	< 0.01
GA Term	-0.600	< 0.01
Resuscitation needed	0.713	< 0.01
Malformation	0.470	< 0.01
Anomalies	0.358	< 0.01
Deficits	0.346	< 0.01
CBC Result	-1.000	< 0.01
CRD	1.000	< 0.01
Urine	0.509	< 0.01
Sensitivity pattern	1.000	< 0.01
Culture outcome	-1.000	< 0.01
Blood culture	1.000	< 0.01
CSF	0.414	< 0.01
Previous History	0.100	0.082

Table 4: Binary Logistic Regression Analysis of Predictors for Neonatal Sepsis

Predictor Variable	B	SE	Wald χ^2	p-value	Exp(B) (OR)	95% CI for OR (LL – UL)
GA (Gestational Age)	-	-	0.353	0.553	-	-
Duration of PROM	-	-	0.476	0.490	-	-
Birth Weight	-	-	0.750	0.387	-	-
Previous History	-	-	3.042	0.081	-	-
Mode of Delivery	-	-	0.339	0.561	-	-
Place of Delivery	-	-	0.155	0.694	-	-
Handled by	-	-	0.058	0.810	-	-
Use of Antibiotics	-	-	307.000	0.000*	∞	Perfect separation
GA Term	-	-	110.417	0.000*	∞	Perfect separation
Resuscitation Needed	-	-	155.852	0.000*	∞	Perfect separation
Malformation	-	-	67.778	0.000*	∞	Perfect separation
Anomalies	-	-	39.352	0.000*	∞	Perfect separation
Deficits	-	-	36.836	0.000*	∞	Perfect separation

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

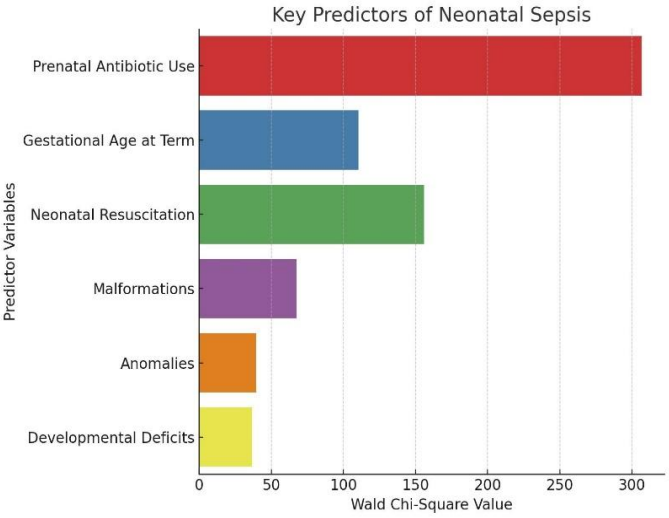

Figure 1 Key Predictors of Neonatal Sepsis

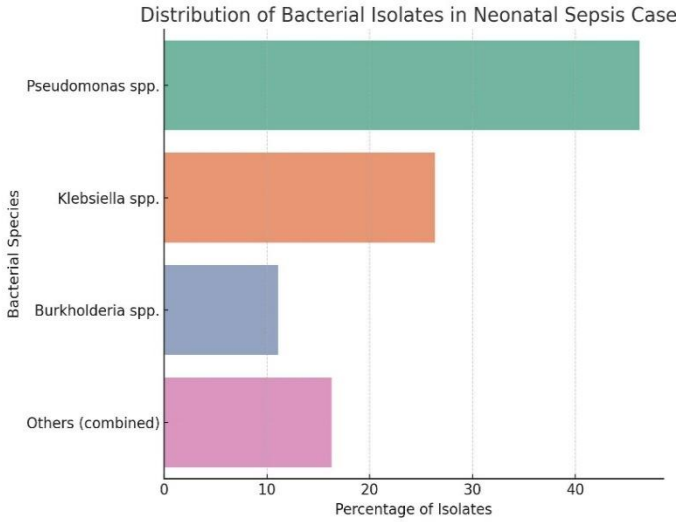

Figure 2 Distribution of Bacterial Isolates in Neonatal Sepsis Case

DISCUSSION

The mean maternal age observed in the present study was 28.93 ± 6.08 years, consistent with findings from a similar study conducted in Ethiopia, which reported a mean maternal age of 29 ± 4.7 years (8). A male predominance was noted among neonates, aligning with previous research that documented male infants comprising 57.64% of neonatal sepsis cases. The average duration of premature rupture of membranes (PROM) in neonates with sepsis was 11.79 ± 6.87 hours, which corresponds with studies highlighting a significantly higher risk of neonatal sepsis when PROM exceeds 15 hours (11). PROM facilitates ascending microbial invasion from the vaginal tract to the amniotic cavity, increasing the fetus's susceptibility to infection. Risk amplifies with membrane rupture extending beyond 12 to 18 hours, as colonizing bacteria gain access to the intrauterine environment. Primigravida mothers accounted for the highest proportion (27.4%) of sepsis cases in neonates, supporting earlier findings where neonates born to primigravida women were shown to have a 1.89 to 2.9 times greater risk of developing sepsis (12,13). This may be attributed to inexperienced labor management, prolonged delivery duration, and possibly suboptimal utilization of antenatal care. Furthermore, immunologic adaptations during subsequent pregnancies may offer protective advantages that are absent in first-time pregnancies. A significant association was found between neonatal sepsis and caesarean section deliveries. The observed trend mirrors prior findings where sepsis occurred in 13.8% of neonates born via caesarean, compared to 3.1% for vaginal deliveries (14,15). This may be explained by factors such as longer hospital stays, potential for surgical site contamination, lack of protective colonization from maternal vaginal flora, and the fact that complicated pregnancies more frequently necessitate surgical deliveries, inherently increasing infection risk. Additionally, the study identified a higher incidence of neonatal sepsis in hospital-delivered infants, with the lowest rates seen in home births. This parallels findings from research in Ethiopia where infants delivered in healthcare settings experienced greater infection rates (16,17). Increased exposure to nosocomial pathogens and invasive procedures in hospital environments, particularly in resource-limited settings, contributes to the elevated risk.

Neonates born to mothers who received antenatal antibiotics also exhibited a higher incidence of sepsis. This observation is consistent with studies reporting increased neonatal infections and complications following prolonged prenatal antibiotic exposure (18). Potential mechanisms include alterations in maternal and neonatal microbiota, emergence of resistant organisms, or underlying maternal infections indicating high-risk pregnancies (19). In this dataset, antenatal antibiotic exposure emerged as a statistically significant predictor of sepsis. Similarly, preterm delivery was significantly associated with neonatal sepsis, in line with research identifying higher infection rates among preterm infants—5.9% compared to 2.5% in term births (20). Preterm neonates are inherently vulnerable due to immature immune defenses, fragile integumentary barriers, and frequent dependence on invasive life-support interventions (21). A higher prevalence of sepsis was also observed among neonates with congenital malformations and developmental deficits, both of which were strongly predictive of sepsis. These findings support literature documenting sepsis as a cause of neonatal mortality in up to 11% of infants with birth defects (22). Malformations not only compromise immunity and organ function but also often require prolonged

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

hospital stays or surgical interventions, increasing pathogen exposure. Sepsis remains a major contributor to mortality among neonates with structural or developmental anomalies (23). Laboratory and culture-confirmed findings were significantly associated with sepsis in this cohort. This is corroborated by other studies highlighting elevated white blood cell counts, abnormal CRP levels, and positive cultures (urine and blood) as reliable diagnostic indicators in neonatal sepsis (20). Laboratory markers remain essential in supporting clinical suspicion, determining etiology, and guiding targeted antimicrobial therapy. Positive cultures provide pathogen-specific insights, improving treatment outcomes and infection control measures.

The retrospective cohort design of this study enabled extensive data extraction over a 12-month period, including a substantial sample size of 307 neonates, thereby offering a comprehensive view of neonatal sepsis trends within a tertiary care hospital in Pakistan. The use of culture-confirmed diagnoses and multivariate statistical techniques, such as Pearson correlation and logistic regression, strengthened the internal validity and identification of predictive factors. However, several limitations merit consideration. As a single-center study, generalizability to other regional or national contexts remains limited. The reliance on retrospective data introduces risks of missing information and documentation bias. Exclusion of neonates with negative or inconclusive cultures may have underestimated the overall burden of neonatal sepsis, particularly in resource-limited settings where culture sensitivity is variable. Additionally, inconsistencies in reporting polymicrobial infections and resistance profiles due to laboratory limitations may have restricted the characterization of certain microbial trends. Future studies should adopt multicentric designs with larger sample sizes and include both culture-positive and clinically suspected sepsis cases to capture the full spectrum of disease burden. Standardized protocols for microbial culture and antibiotic sensitivity testing would improve inter-study comparability and surveillance accuracy. Longitudinal follow-up could also elucidate the long-term outcomes of neonatal sepsis survivors, an area still underexplored in low- and middle-income countries.

CONCLUSION

This study provides vital insight into the bacterial spectrum, associated risk factors, and clinical predictors of neonatal sepsis in a tertiary care setting in Pakistan. The findings underscore the influence of maternal, perinatal, and neonatal variables—such as prematurity, congenital anomalies, and prolonged antibiotic exposure—on the occurrence of sepsis, while highlighting the predominance of Gram-negative organisms like Pseudomonas and Klebsiella. These observations have practical implications for refining empirical treatment strategies, reinforcing infection control practices, and guiding targeted interventions aimed at reducing neonatal morbidity and mortality. By identifying key predictors and resistance trends, the study supports the development of more effective, context-specific neonatal sepsis management protocols.

AUTHOR CONTRIBUTION

Author	Contribution
Muhammad Wasim Salim*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Sikandar Hayat	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Shagufta Niazi	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Zunera Riaz	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published

Author	Contribution
Muhammad Awais Zafar	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Rehman Sher	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

REFERENCES

1. Kariniotaki C, Thomou C, Gkentzi D, Panteris E, Dimitriou G, Hatzidaki E. Neonatal Sepsis: A Comprehensive Review. Antibiotics. 2024 Dec 25;14(1):6
2. De Rose DU, Ronchetti MP, Martini L, Rechichi J, Iannetta M, Dotta A, et al. Diagnosis and Management of Neonatal Bacterial Sepsis: Current Challenges and Future Perspectives. Trop Med Infect Dis. 2024 Aug 28;9(9):199.
3. Attia Hussein Mahmoud H, Parekh R, Dhandibhotla S, Sai T, Pradhan A, Alugula S, et al. Insight Into Neonatal Sepsis: An Overview. Cureus. 2023 Sep 19;
4. Muhammad SK, Shaikh BA, Gurbakshani KM, Jalbani AU. Frequency triple hepatitis (hepatitis B and C and D virus) in HBs Ag positive patients. Rawal Medical Journal. 1970 Jan 1;37(2):142-.
5. Abiy SA, Animut Y, Ambaw WM, Aragaw GM, Rade BK. Incidence of death and its predictors among neonates admitted with sepsis in referral hospitals, northwest Ethiopia, a prospective cohort study. Front Pediatr. 2023 Apr 13;11.
6. Zhuang L, Li ZK, Zhu YF, Ju R, Hua SD, Yu CZ, et al. Latency period of PROM at term and the risk of neonatal infectious diseases. Sci Rep. 2022 Jul 18;12(1):12275.
7. Salama B, Tharwat EM. A case control study of maternal and neonatal risk factors associated with neonatal sepsis. J Public Health Res. 2023 Jan 25;12(1).
8. Kay VR, Liang I, Twiss J, Morais M. Mode of delivery in chorioamnionitis: impact on neonatal and maternal outcomes. BMC Pregnancy Childbirth. 2024 Oct 23;24(1):693.
9. Bekele T, Merga H, Tesfaye T, Asefa H. Predictors of mortality among neonates hospitalized with neonatal sepsis: a case control study from southern Ethiopia. BMC Pediatr. 2022 Dec 3;22(1):1.
10. Kim H, Choe YJ, Cho H, Heo JS. Effect of Prenatal Antibiotic Exposure on Neonatal Outcomes of Preterm Infants. Pediatric Infection & Vaccine. 2021;28(3):149.
11. Gamberini C, Donders S, Al-Nasiry S, Kamenshchikova A, Ambrosino E. Antibiotic Use in Pregnancy: A Global Survey on Antibiotic Prescription Practices in Antenatal Care. Antibiotics. 2023 Apr 29;12(5):831.
12. Marsh MC, Lin HM, Black J, Allen K, Weiner B, Ramilo O, et al. Preterm and Term Infants Evaluated for Sepsis: Differences in Management and Clinical Outcomes. Hosp Pediatr. 2023 Jun 1;13(6):544–54.
13. Sampah MES, Hackam DJ. Dysregulated Mucosal Immunity and Associated Pathogeneses in Preterm Neonates. Front Immunol. 2020 May 15;11
14. Benjamin RH, Salemi JL, Canfield MA, Nembhard WN, Ganduglia Cazaban C, Tsao K, et al. Causes of neonatal and postneonatal death among infants with birth defects in Texas. Birth Defects Res. 2021 May 15;113(9):665–75.
15. A S, P M, J N S, M G, A A. Neonatal Sepsis - A Study of Predisposing Factors and Causative Organisms. Scholars Journal of Applied Medical Sciences. 2020 Oct 11;8(10):2256–9.
16. Gulersen M, Lenchner E, Eliner Y, Grunebaum A, Johnson L, Chervenak FA, et al. Risk factors and adverse outcomes associated with syphilis infection during pregnancy. Am J Obstet Gynecol MFM. 2023;5(6):100957.
17. Ekanem E, Ngene NC, Moodley J, Konje J. Prevention of surgical site infection and sepsis in pregnant obese women. Best Pract Res Clin Obstet Gynaecol. 2023;91:102406.
18. Flannery DD, Ramachandran V, Schrag SJ. Neonatal Early-Onset Sepsis: Epidemiology, Microbiology, and Controversies in Practice. Clin Perinatol. 2025;52(1):15-31.
19. Pascoal LB, Carellos EVM, Tarabai BHM, Vieira CC, Rezende LG, Salgado BSF, et al. Maternal and perinatal risk factors associated with congenital syphilis. Trop Med Int Health. 2023;28(6):442-53.

20. Stocker M, Rosa-Mangeret F, Agyeman PKA, McDougall J, Berger C, Giannoni E. Management of neonates at risk of early onset sepsis: a probability-based approach and recent literature appraisal : Update of the Swiss national guideline of the Swiss Society of Neonatology and the Pediatric Infectious Disease Group Switzerland. Eur J Pediatr. 2024;183(12):5517-29.
21. Wang X, Li Y, Shi T, Bont LJ, Chu HY, Zar HJ, et al. Global disease burden of and risk factors for acute lower respiratory infections caused by respiratory syncytial virus in preterm infants and young children in 2019: a systematic review and meta-analysis of aggregated and individual participant data. Lancet. 2024;403(10433):1241-53.
22. Cuna A, Morowitz MJ, Ahmed I, Umar S, Sampath V. Dynamics of the preterm gut microbiome in health and disease. Am J Physiol Gastrointest Liver Physiol. 2021;320(4):G411-g9.
23. Allotey J, Stallings E, Bonet M, Yap M, Chatterjee S, Kew T, et al. Clinical manifestations, risk factors, and maternal and perinatal outcomes of coronavirus disease 2019 in pregnancy: living systematic review and meta-analysis. Bmj. 2020;370:m3320.