Modern Journal of Health and Applied Sciences *(MJHAS)*

E-ISSN 3078-2791; P-ISSN 3078-2783

Journal homepage: https://mucjournals.muc.edu.ps/index.php/MJHAS

Evaluating Neonatal CPR Diagnostic Accuracy

Safa Abdalla [1], Manal Taha [2], and Hassan Abdelnour [3,4]*

[1] Pediatric department, Sultanate of Oman, Sultan Gabos hospital, Dhofar, Oman.
[2] Pediatric Department, Elsewedy Pediatric Charity Hospital, Khartoum, Sudan. Faculty of Medicine, Al Mughtaribeen University, Khartoum, Sudan.
[3] Department of Rehabilitation Sciences. College of Medical Sciences, Northern Border University, Arar, KSA.
[4] Physiotherapy Department, School of Health Sciences, Ahfad University for Women (AUW), Omdurman, Sudan.

ARTICLE INFO

Received:05th April 2026
Received in revised form: 19th June 2026
Accepted: 22th June 2026
Published: 15th September 2026

***Corresponding Author:**
Safa Abdalla
E-mail :
Safoya762@gmail.com

Citation : Abdalla, S., Taha, M., & Abdelnour, H. (2026). Evaluating neonatal CPR diagnostic accuracy. *Modern Journal of Health and Applied Sciences*, 3(2), 31-41.

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ABSTRACT

Improving clinical outcomes in pediatric care requires the integration of age-appropriate diagnostic and therapeutic interventions. This study aims to evaluate the diagnostic accuracy of CPR among neonates at El-Sewedy Hospital, providing localised evidence to improve the speed and precision of sepsis management in Khartoum. This observational, hospital-based, retrospective cross-sectional study was conducted at the Neonatal Intensive Care Unit of El-Sewedy Pediatric Charity Hospital in Khartoum, Sudan, from January 2022 to January 2023. A convenience sample of 182 neonates (age 28 days and less) with confirmed sepsis was selected, and data regarding demographics, clinical risk factors, and laboratory findings were extracted using a structured form. Data were analysed using SPSS 25.0 with descriptive statistics and bivariate analysis (Chi-square and t-tests), with significance set at a p-value of 0.05 and less. The study secured ethical approval from the Sudan Medical Specialization Board, ensuring data anonymity and confidentiality.The study cohort was predominantly male (57.7%) and preterm (58.2%). The study results showed a 12.1% mortality rate. A significant majority exhibited low birth weight, with very low birth weight (VLBW) being the most common (36.3%). Maternal comorbidities were present in 44% of cases, with urinary tract infections (12.6%) and diabetes (7.6%) being the most frequent. The primary clinical presentations included respiratory distress (69.8%), dysthermia (62.6%), pyrexia (25.2%), and feeding intolerance (20.3%). Other significant findings included hyperbilirubinemia and glycemic instability (both 52.2%). In Khartoum, preterm and low-birth-weight infants face the highest risk of sepsis. Using C-Reactive Protein (CRP) within the Symptoms-Based Score (SBS) React framework provides a fast and reliable diagnostic link to clinical symptoms.

Keywords: Neonatal sepsis, C-reactive protein, Diagnostic accuracy, Blood culture, Neonatal intensive care unit, Biomarkers.

DOI: https://doi.org/10.70411/MJHAS.3.2.2026378

1. Introduction

Neonatal sepsis continues to be a formidable clinical challenge, acting as a primary driver of neonatal morbidity and mortality in Neonatal Intensive Care Units (NICUs) globally. It is defined as a systemic inflammatory response syndrome occurring within the first 28 days of life, triggered by suspected or proven infection (Folgori & Bielicki, 2019). Despite advancements in neonatal care, recent global estimates indicate that sepsis remains responsible for a significant proportion of the 2.3 million neonatal deaths occurring annually, with a disproportionate burden falling on low- and middle-income countries (Satti et al., 2025; *World Health Organization*, 2024). In regions such as sub-Saharan Africa, including Sudan, the prevalence is exacerbated by high rates of home births and limited access to immediate specialized care (Seale et al., 2013, 2014).

The clinical diagnosis of neonatal sepsis is notoriously complex because the initial signs, such as temperature instability, poor feeding, and lethargy, are subtle and highly non-specific, frequently overlapping with other neonatal conditions like respiratory distress or prematurity-related complications (Coetzee et al., 2017; Kariniotaki et al., 2024). Because the disease progresses with devastating speed, clinicians are often compelled to initiate empirical antibiotic therapy before laboratory confirmation. However, this "safety-first" approach has led to the excessive use of broad-spectrum antibiotics, which is a major driver of the emerging global crisis of multidrug-resistant organisms (Rallis et al., 2023).

Blood culture remains the microbiological reference standard for confirming neonatal sepsis. However, its usefulness for early clinical decision-making is limited by the time required to obtain definitive results, typically 36–48 hours, and by imperfect sensitivity. Diagnostic yield can be reduced when inadequate blood volumes are collected, particularly in neonates with low-level or intermittent bacteraemia; maternal intrapartum antimicrobial exposure may also complicate organism recovery (Celik et al., 2022; Iroh Tam & Bendel, 2017). Consequently, many neonates receive empirical treatment for suspected or “culture-negative” sepsis despite sterile blood cultures. This diagnostic uncertainty creates a need for rapid, accurate, affordable, and clinically validated biomarkers to support early treatment decisions and antimicrobial stewardship (Klingenberg et al., 2018; Sturrock et al., 2023).

Among these markers, C-Reactive Protein (CRP) remains the most widely utilised acute-phase reactant in the NICU setting. CRP is synthesised by the liver in response to inflammatory cytokines like IL-6 during infection (Emokpae et al., 2025). While CRP is highly valued for its accessibility and low cost—crucial factors in resource-constrained hospitals its interpretation requires precision. CRP levels may rise due to non-infectious stressors, necessitating a clear understanding of their diagnostic accuracy, specifically their sensitivity and specificity, within specific clinical contexts (Beltempo et al., 2018; Gilfillan & Bhandari, 2019). A positive or elevated CRP means that the body is fighting infection or inflammation. The SBSReact (or SBSReaction) framework is a specialised clinical protocol designed for the rapid diagnosis and management of neonatal sepsis (blood infections in newborns), particularly in resource-limited healthcare settings.

At El-Sewedy Pediatric Charity Hospital in Khartoum, Sudan, the neonatal intensive care unit serves neonates who may be at high risk of severe infection and adverse outcomes. In this setting, timely identification of neonatal sepsis is essential because delays in diagnosis and treatment can be life-threatening, whereas unnecessary empirical antibiotic exposure may contribute to antimicrobial resistance (Braima et al., 2021; Murless-Collins et al., 2023). Establishing a locally validated CRP threshold against blood-culture results could support more timely clinical decision-making, improve diagnostic precision, and strengthen antimicrobial stewardship (Murless-Collins et al., 2023; Sarafidis, 2023). This study therefore aims to evaluate the diagnostic accuracy of serum CRP for neonatal sepsis among neonates admitted to the NICU at El-Sewedy Pediatric Charity Hospital, using blood culture as the microbiological reference standard.

2. Methodology

This research utilizes a retrospective observational cross-sectional, hospital-based design to investigate the clinical profile of neonatal sepsis at the Neonatal Intensive Care Unit (NICU) of El-Sewedy Pediatric Charity Hospital in Khartoum, Sudan. Established in 2006, this specialized facility serves as a critical regional hub for neonatal care. The NICU features four specialised areas with a capacity of 15 neonates and is equipped with advanced life-support technology, including 12 mechanical ventilators, 20 CPAP machines, 40 incubators, and 20 phototherapy units. Diagnostic capabilities are supported by on-site arterial blood gas (ABG) and electrolyte analysis, portable X-ray, and ultrasound services. Additionally, the unit facilitates advanced interventions such as umbilical venous catheters (UVCs) and peripherally inserted central catheters (PICCs).

The study population comprised neonates aged 28 days or less who were admitted between January 2022 and January 2023. Inclusion required a confirmed diagnosis of neonatal sepsis based on clinical presentation and dual laboratory confirmation via C-reactive protein (CRP) testing and blood culture results. Only patients with complete, high-quality medical records were enrolled, while those failing to meet these diagnostic or administrative benchmarks were excluded.

Given the known population of 334 septic neonates during the study period, the sample size was determined using the formula $n=N/(1+N(e)^2)$. With a 0.05 margin of error, a sample of 182 participants was established via convenience sampling. Data were systematically extracted from medical records using a structured, close-ended form designed to capture demographic, clinical characteristics, and longitudinal laboratory data.

Statistical analysis was performed using SPSS version 25.0. Descriptive statistics summarised baseline characteristics, using frequencies and percentages for categorical variables and means with standard deviations for continuous variables. To identify significant associations, the Chi-square test or Fisher's exact test was applied to categorical data, while independent t-tests or Mann-Whitney U tests were used for continuous data. Statistical significance was set at $p < 0.05$.

Ethical integrity was maintained according to the Declaration of Helsinki, with formal approval from the hospital's Research Ethics Committee and the Ministry of Health. A waiver of informed consent was granted for this retrospective study, though strict confidentiality was maintained through data anonymisation and password-protected electronic records.

3. Results

Table 1. Demographical data of the study group (n = 182).

		Frequency	Percent
Gender	Male	105	57.7
	Female	77	42.3
Number	Single	143	78.6
	Twin	32	17.6
	Triple	2	1.1
	Quadruplet	5	2.7
Gestational age	Preterm	106	58.2
	Term	76	41.8
Birth Weight	Macrosomia	4	2.2
	Normal	36	19.8
	Low birth weight	47	25.8
	Very low birth weight	66	36.3
	Extremely low birth weight	29	15.9

Table 1, delineates the demographic and clinical characteristics of the study cohort. The sample exhibited a male predominance (57.7% vs. 42.3%), with singleton gestations constituting the majority of births (78.6%), followed by twin pregnancies (17.6%). In terms of clinical parameters, preterm deliveries (58.2%) were more prevalent than term births (41.8%). Neonatal birth weight distribution indicated significant vulnerability; very low birth weight (VLBW) was the most frequent classification (36.3%), followed by low birth weight (LBW; 25.8%) and extremely low birth weight (ELBW; 15.9%). Conversely, normal birth weight and macrosomia represented only 19.8% and 2.2% of the population, respectively.

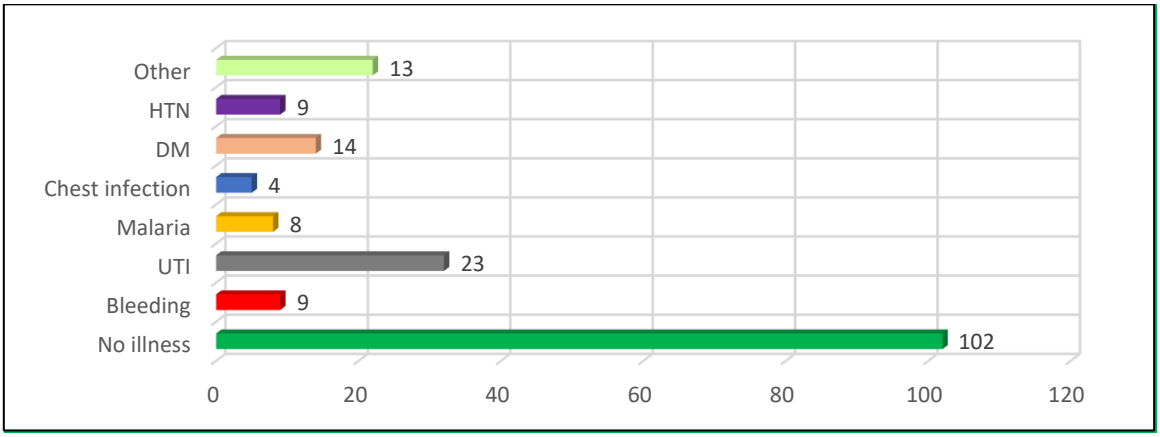

Figure 1. The distribution of the study population according to the mothers' comorbidities (n = 182).

Figure 1 illustrates the distribution of maternal comorbidities within the study population. More than half of the mothers (n=102, 56%) had no medical illness. Among those with documented pathologies, urinary tract infection (UTI) was the most prevalent (n = 23, 12.6%), followed by diabetes mellitus (n = 14, 7.6%), hypertension (n = 9,4.9%), and antepartum hemorrhage (n = 9, 4.9%). Other recorded conditions included malaria (n = 8, 4.3%) and respiratory tract infections (n = 4, 2.1%).

Table 2 details the frequency of clinical manifestations and signs of neonatal sepsis. The most common presenting symptoms were pyrexia (n = 46, 25.2%), feeding intolerance (n =37, 20.3%), and lethargy (n = 28, 15.38%). Regarding clinical signs, respiratory distress specifically tachypnea was the most frequent finding (n = 127, 69.78%), followed by dysthermia (n=114, 62.64%). Other significant observations included hyperbillirubinemia (n = 95, 52.20%), glycemic instability (n=95, 52.20%), irritability (n=92, 50.55%), and compromised peripheral perfusion (n=88, 48.35%).

Table 2. The clinical features of the study population (n=182).

		Frequency	Percent
Symptoms	Fever	46	25.2%
	Refuse of feeding	37	20.3%
	Lethargy	28	15.38%
	Vomiting	17	9.3%
	Weak cry	10	5.4%
	Others	44	24.2%
Clinical signs	Thermal instability	114	62.64%
	Irritability	92	50.55%
	Tachycardia	75	41.21%
	Oliguria	19	10.44%

	Poor feeding	82	45.05%
	Tachypnea	127	69.78%
	Poor skin perfusion	88	48.35%
	Convulsion	22	12.09%
	Jaundice	95	52.20%
	Abnormal glucose level	95	52.20%
	Abdominal distension	71	39.01%

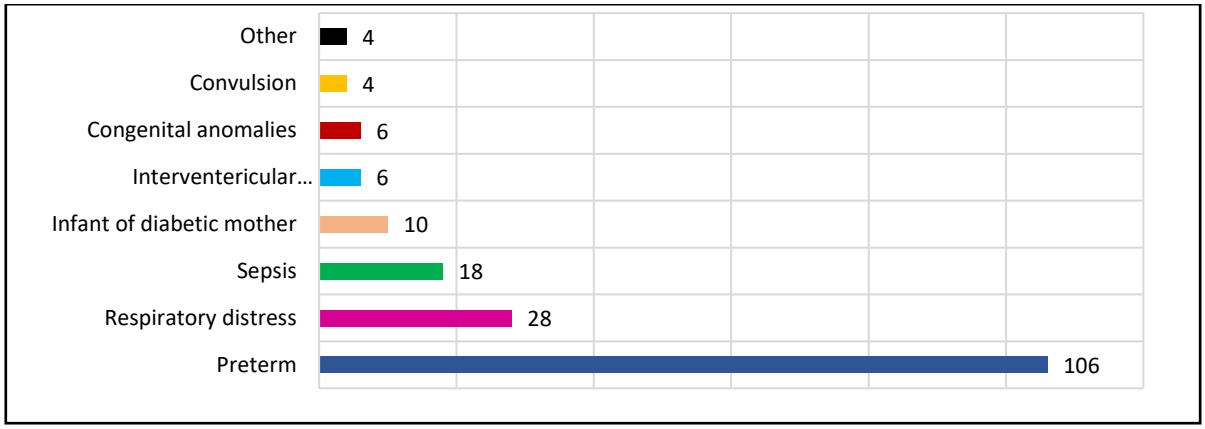

Figure 2. The frequencies of indications for admission for the Neonatal ICU (n=182).

Figure 2 outlines the primary indications for admission among the study subjects. The most frequent cause was preterm birth, accounting for 106 patients (58.2%). This was followed by respiratory distress (n = 28, 15.3%) and neonatal sepsis (n = 18, 9.9%). Less frequent indications included infants of diabetic mothers (IDM) (n = 10, 5.4%), intraventricular hemorrhage (IVH) (n = 6, 3.2%), and congenital anomalies (n = 6, 3.2%), while seizures and other miscellaneous conditions each accounted for 2.1% of admissions.

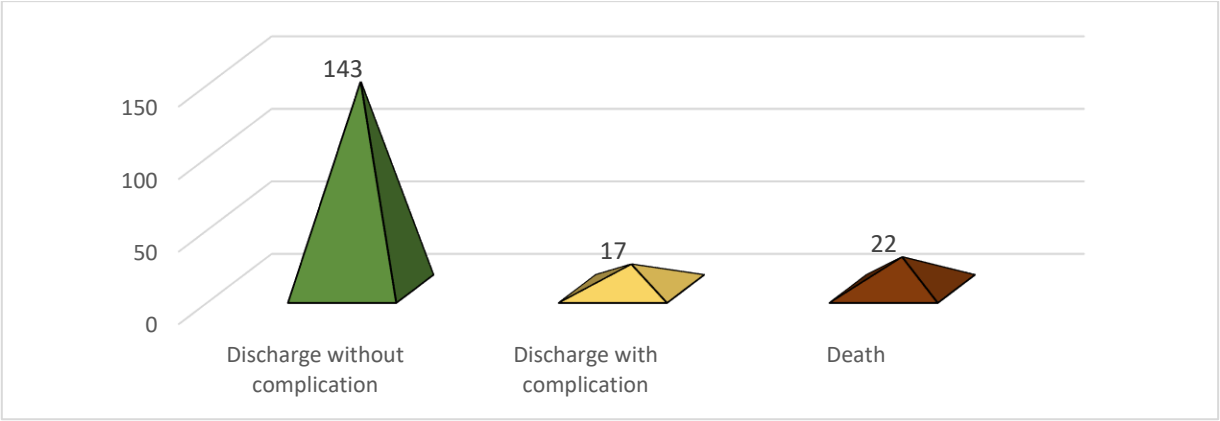

Figure 3. The distribution of the study group according to the outcomes of NICU admission (n = 182).

Figure 3 delineates the clinical outcomes of patients admitted to the Neonatal Intensive Care Unit (NICU). The majority of the cohort (n = 143, 78.6%) was successfully discharged in stable condition. Conversely, morbidity was observed in 17 patients (9.3%), who developed complications, while the mortality rate accounted for 12.1% of the cases (n = 22).

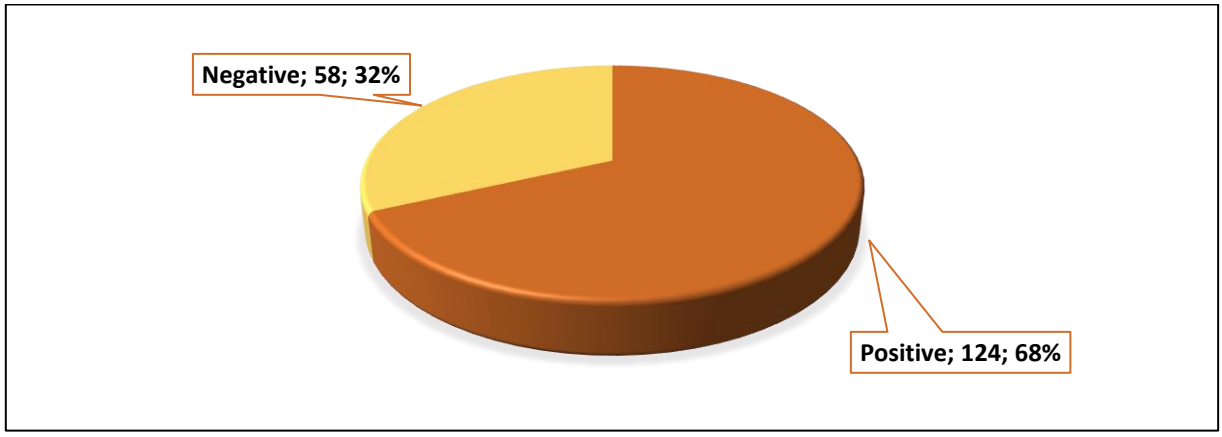

Figure 4. The distribution of the study population according to the results of the Blood culture (n = 182).

Figure 4, illustrates the results of microbiological blood cultures**.** Culture-proven sepsis was identified in 124 cases (68.1%), while 58 cases (31.9%) yielded negative results, indicating no bacterial growth.

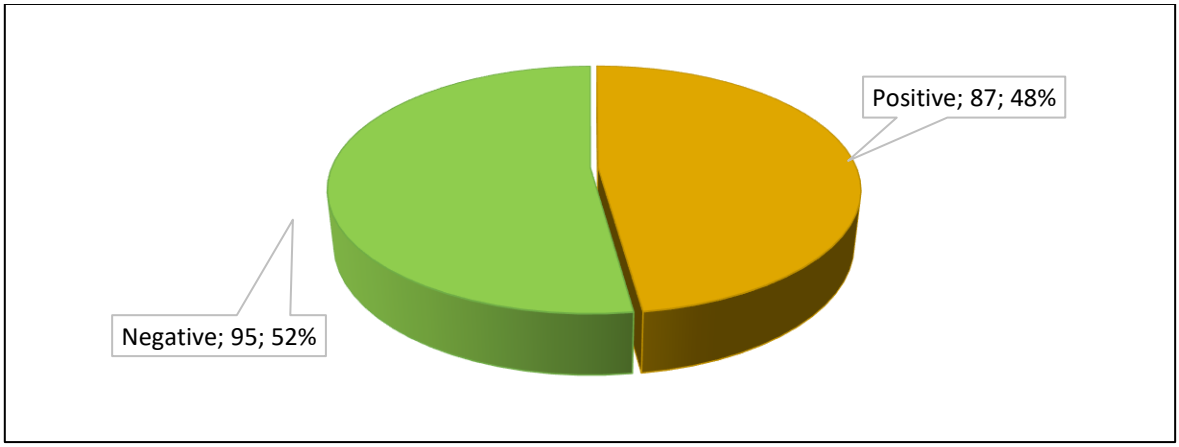

Figure 5. The distribution of the study population according to the results of the CRP (n = 182).

Figure 5, illustrates the distribution of C-reactive protein (CRP) results within the study population, with CRP positivity observed in 48% of cases (n = 87) and negative results in 52% (n = 95).

Table 3, evaluates the statistical correlation between CRP reactivity and various demographic and clinical variables. No statistically significant associations were identified between CRP results and neonatal gender ($p = 0.08$) or mode of delivery ($p = 0.098$). However, a highly significant correlation was observed between CRP positivity and both preterm birth ($p < 0.0001$) and premature rupture of membranes (PROM) ($p = 0.008$).

Table 3. The correlation between the results of CRP with the gender of neonate, Mode of delivery, gestational age and PROM.

		CRP		Total	P-value
		Positive	Negative		
Gender	Male	56	49	105	0.08
	Female	31	46	77	
	NVD	37	52	89	0.098

Mode of delivery	E C/S	8	12	20	
	EM C/S	42	31	73	
Gestational age	Term	9	67	76	< 0.0001*
	Preterm	78	28	106	
PROM	< 18 hours	19	38	*57*	0.008*
	>18 hours	68	57	*125*	

**Significant correlation*

4. Discussion

The findings provide a descriptive overview of the demographic and diagnostic profile of neonates evaluated for sepsis at El-Sewedy Pediatric Charity Hospital. Male neonates constituted 57.7% of the study cohort, indicating a modest male predominance. This observation is consistent with previous literature reporting greater susceptibility of male neonates to adverse outcomes and several forms of neonatal infection, including sepsis (Kelly et al., 2023; Özmeral Odabaşı, 2020). Biological explanations for this pattern remain multifactorial. The X chromosome contains numerous genes involved in innate immune signaling, and the XX genotype may provide females with immunological advantages through X-linked gene expression and cellular mosaicism. In addition, sex hormones may influence neonatal immune-cell function and inflammatory responses (McGovern et al., 2024). Therefore, the male predominance observed in the present cohort may reflect recognized sex-related differences in neonatal immune vulnerability; however, it should be interpreted alongside other determinants of sepsis risk, including prematurity, birth weight, delivery-related exposures, and local patterns of care.

A critical observation in this cohort was the high prevalence of preterm births and the alarming proportion of neonates classified as very low birth weight (VLBW) (36.3%), low birth weight (LBW) (25.8%), and extremely low birth weight (ELBW) (15.9%), together representing 78% of the sample. These physical vulnerabilities are primary drivers of sepsis, as preterm infants possess an immature skin barrier and a deficiency in IgG antibodies (Lekić et al., 2019). In resource-constrained environments like Khartoum, the management of these high-risk neonates is further complicated by the necessity of invasive procedures, such as umbilical venous catheters (UVCs) (Rees et al., 2023). While life-saving, these interventions serve as potential portals for nosocomial pathogens, especially where environmental colonisation is a constant threat (Popescu et al., 2020). The synergy between prematurity and invasive care creates a "perfect storm" for late-onset sepsis in overcrowded NICUs (Tumuhamye et al., 2020).

The diagnostic utility of C-Reactive Protein (CRP) remains a focal point of clinical debate (Beltempo et al., 2018). In this study, CRP served as a pivotal rapid biomarker. While the "gold standard" blood culture is essential, its application in Sudan is hampered by long incubation periods and high false-negative rates (Rees et al., 2023). These false-negative results are often due to low-volume blood sampling or maternal intrapartum antibiotic use, which suppresses bacterial growth in vitro (Sarkar et al., 2014). CRP synthesis by the liver in response to IL-6 provides a measurable indicator of systemic inflammation (Emokpae et al., 2025). Our findings suggest that within the SBSReact framework, CRP serves as an effective diagnostic adjunct (Liberati et al., 2025). When serial CRP levels remain low, clinicians can consider the early cessation of empirical antibiotics, thereby supporting antimicrobial stewardship (Gkentzi & Dimitriou, 2019). This is crucial in reducing the selection pressure for multidrug-resistant organisms, which represent a growing crisis in sub-Saharan Africa.

Furthermore, CRP interpretation must be contextualized within the neonatal transition period (Eichberger et al., 2022). CRP levels can naturally fluctuate during the first 48 hours due to non-infectious stressors like fetal distress or meconium aspiration (Hofer et al., 2012). Therefore, integrating CRP findings within a specialized framework is vital to avoid overdiagnosis (Cosovanu et al., 2026). The high rate of multiple gestations in this study (over 21%) also suggests that obstetric

factors play a significant role in the local sepsis burden (Seale et al., 2013). This highlights the need for integrated maternal-neonatal health strategies, as proposed by international guidelines (*World Health Organization,* 2024).

Socio-economic instability in Sudan during the study period (2022-2023) directly impacted medical supply chains and laboratory efficiency (Ahmed et al., 2025; Mohammed et al., 2023). In such a landscape, the SBSReact framework provides a structured pathway to maximize biochemical data utility (Wong et al., 2018). By utilizing CRP as a high-sensitivity screening tool, NICUs can better allocate limited resources to neonates with the highest likelihood of confirmed sepsis (De Rose et al., 2024). This strategy not only improves individual patient outcomes but also enhances overall hospital efficiency by reducing unnecessary hospitalizations among neonates with non-infectious inflammatory responses (Chevalier et al., 2025). Ultimately, the results underscore that a high index of suspicion combined with rapid biomarkers is essential for survival in high-burden settings (Fleischmann-Struzek et al., 2018).

5. Conclusion

This study concludes that neonatal sepsis disproportionately affects preterm and low-birth-weight neonates in Khartoum. C-reactive protein (CRP), when integrated into the SBSReact framework, serves as a vital rapid diagnostic tool that correlates effectively with clinical presentation. While blood cultures remain the gold standard, the prompt use of CRP facilitates timely intervention and supports antimicrobial stewardship in resource-limited settings.

6. Limitations

This retrospective, single-center study, limited by potential selection bias from convenience sampling, may not reflect broader, multi-institutional clinical patterns. Future research should prioritise prospective, multi-center trials incorporating additional, advanced inflammatory biomarkers to enhance diagnostic precision.

Conflict of Interest

The authors declare no conflicts of interest, financial or personal, that could have influenced the work presented in this study.

Data Availability

This research did not receive any specific funding from public, commercial, or non-profit organisations.

Acknowledgments

The authors express their gratitude to the NICU of El-Sewedy Pediatric Charity Hospital in Khartoum, Sudan, for providing the necessary facilities and support to carry out this study.

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