



Red Blood Cell Distribution Width (RDW) as a Predictor of 28-Day Mortality in Sepsis in ICU: A Comparison to SOFA Score in a Tertiary Care Hospital of Bangladesh



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Abstract

Background: Sepsis remains a primary cause of ICU admissions globally and carries high mortality rates, particularly in low- and middle-income countries (LMICs). Calculating multi-systemic scoring metrics, such as the Sequential Organ Failure Assessment (SOFA) score, can be complex and expensive in resource-limited triage settings. Red Blood Cell Distribution Width (RDW) is an automated component of routine blood counts that increases under systemic inflammation. **Objective:** This study evaluated the association between admission RDW and SOFA score and compared their predictive accuracy for 28-day mortality in sepsis patients in the ICU. **Methodology:** This prospective observational study followed 101 adult sepsis patients (defined by Sepsis-3 criteria with blood culture confirmation) in the general ICU of Dhaka Medical College Hospital, Bangladesh, of whom 98 completed the study. Baseline RDW levels and SOFA scores were determined within the initial 24 hours of admission or diagnosis of sepsis. Patients were tracked for 28-day mortality outcomes. Spearman's correlation assessed parameter associations, and Receiver Operating Characteristic (ROC) curve analysis evaluated prognostic accuracy. **Results:** The mean age of the patients with sepsis was 47.7 ± 16.4 years and the majority, 54 (55.1%) were male. A significant, moderate positive correlation was observed between admission RDW and SOFA scores ($r_s = 0.648$) ($p < 0.001$). The crude 28-day ICU mortality rate was 45.9% ($n=45$). Non-survivors exhibited significantly higher median RDW (16.4% vs. 14.7%, $p < 0.001$) and median SOFA scores (10.0 vs. 6.0, $p < 0.001$) than survivors. ROC curve analysis demonstrated an Area under the Curve (AUC) of 0.961 for the SOFA score and 0.860 for RDW ($p < 0.001$). Using the maximum Youden Index, the optimal predictive cutoff value for RDW was 15.55% (77.8% sensitivity, 84.9% specificity) and 8.5 for the SOFA score (82.2% sensitivity, 96.2% specificity). **Conclusion:** Admission RDW strongly correlates with SOFA scores and could be used to serve as an independent prognostic marker for mortality prediction in sepsis patients. While the multi-systemic SOFA score retains higher diagnostic accuracy, an RDW threshold exceeding 15.55% offers a rapid, reliable, and inexpensive triage alternative or prognostic stratification in resource-constrained clinical settings. [Bangladesh Journal of Infectious Diseases, June 2026;13(1):367-374]

Keywords: Sepsis; Red Blood Cell Distribution Width; SOFA score; Mortality; Intensive Care Unit

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Introduction

The most common cause of admission to an intensive care unit (ICU) is sepsis, which is associated with high morbidity and mortality¹. Sepsis is life-threatening organ damage which results from an aberrant host response to infection². Despite significant advancements in healthcare, sepsis remains a major global health burden, particularly in low- and middle-income countries (LMIC), where access to early diagnosis and critical care is limited. Globally, it is estimated that sepsis accounts for 48.9 million cases and up to 11 million deaths in the year 2017³. The sepsis process follows a biphasic reaction in the host; initial immune hyper-responsiveness is followed by a hypo-responsive state due to the immune exhaustion. The majority of sepsis deaths occur during this second stage, often from secondary infection⁴. However, the coagulopathy, vascular endothelial leakage, cardiovascular strain, and massive release of pro-inflammatory cytokines characteristic of early sepsis comprise the major mechanism of organ damage^{2,5}.

While standardized protocols are improving sepsis outcomes, early detection remains crucial to further improve outcomes^{2,6}. Scoring methods such as the Sequential Organ Failure Assessment (SOFA) and APACHE II scales are useful instruments and commonly employed for risk assessment and severity evaluation. However, their applicability in emergency care is frequently constrained by their elaborate and time-consuming nature. In the ICU, the SOFA score has statistically high predictive validity for mortality⁷. SOFA is based on six different scores, one for each of the respiratory, cardiovascular, hepatic, coagulation, renal, and neurological systems⁸. In addition, PaO₂, platelet count, creatinine, and bilirubin level are needed for full computation. Some of the factors used in scoring can be difficult to assess depending on the care being provided, and calculating the SOFA score is cumbersome^{9,10}.

Therefore, to facilitate prompt diagnosis and prognosis, the use of reliable, rapid, and affordable biomarkers is being increasingly explored¹¹. Traditional inflammatory biomarkers such as C-reactive protein (CRP) and Procalcitonin (PCT) have been frequently used in the evaluation of sepsis severity and early diagnosis; nevertheless, they are expensive and have insufficient predictive value for individual patients¹². Recent research work suggested that the Red Blood Cell Distribution width (RDW) has been shown to predict the mortality and morbidity of sepsis¹³. RDW varies in

sepsis under the influence of pro-inflammatory cytokines released during the inflammatory process¹⁴. These cytokines cause inefficient erythropoiesis, resulting in structural and volumetric changes of erythrocytes and increased RDW. Furthermore, reactive erythropoiesis stimulated under oxidative stress leads to the release of large immature red blood cells with poor oxygen-binding capacity. RDW may also reflect the patient's degree of physiologic reserve, which represents the cellular response to acute stress. Thus, elevated RDW likely reflects the presence of pro-inflammatory cytokines and oxidative stress in septic shock^{15,16}.

While the prognostic value of RDW in sepsis has been studied, there is little data regarding the association of RDW and disease severity according to SOFA score. RDW is routinely and inexpensively assessed in emergency settings as part of the complete blood cell count. Identifying an inexpensive, routine, and quick-to-report potential biomarker that correlates with the degree of severity would be advantageous in resource-limited settings. Therefore, this study was undertaken to evaluate the association between admission RDW and SOFA score in sepsis and to demonstrate their comparative accuracy in predicting 28-day mortality among sepsis patients in the ICU.

Methodology

Study Design and Settings: This was a prospective observational study, conducted in the Intensive Care Unit (ICU) of the Department of Anaesthesia, Pain, Palliative & Intensive Care Medicine, Dhaka Medical College Hospital (DMCH), Dhaka. DMCH serves as the apex tertiary care facility in Bangladesh, functioning as the primary national referral hub for a population of approximately 160 million people. The facility manages a high volume of critically ill patients with diverse clinical presentations referred from all regions of the country, potentially providing a representative cohort of the nation's sepsis cases¹⁷. The patients were enrolled in the study from March 2020 to February 2021 and were followed up for 28 days or till discharge or death (whichever came first) prospectively. DMCH operates a 12-bed general ICU; however, our timeline includes the period of the ongoing COVID-19 epidemic, and DMCH operated a specialized ICU during that time. Patients from the COVID-19 ICU were not part of the study.

Study Population and Sample Size: The study population included adult patients (age ≥ 18 years)

of both sexes who were admitted to the general ICU of DMCH with sepsis or developed sepsis during their ICU stay. Patients were diagnosed with sepsis according to the Sepsis-3 criteria, defined as an acute change in total SOFA score ≥ 2 points consequent to infection¹⁸. Further, for this study, infection was confirmed by a positive blood culture. Patients with trauma and acute stroke, pregnant women, patients with end-stage renal disease (ESRD), decompensated chronic liver disease (CLD), known thyroid and hematological disease, patients who received a drug that may alter RBC morphology (e.g., chemotherapy) within 6 months and patients who received blood transfusion within the previous 1 week, and patients for whom informed consent could not be ensured, were excluded. All the patients admitted to the general ICU of DMCH during the enrollment period were considered for inclusion according to the selection criteria described. During this period, 485 patients were treated at the study site, and among them 199 (41.1%) were diagnosed as sepsis. Among them a total of 101 patients met the selection criteria and were initially enrolled in the study. Three patients were lost to follow-up; therefore, 98 patients were included in the final analysis. A post-hoc statistical power analysis was conducted based on the final achieved sample size, splitting the cohort into 28-day survivors ($n = 53$) and non-survivors ($n = 45$). Utilizing the observed difference in baseline RDW between the two clinical outcome arms (median 14.7% vs. 16.4%, respectively) with a significance level of ($\alpha = 0.05$), the study achieved a post-hoc statistical power ($1 - \beta$) of greater than 95%. This confirms that despite the strict exclusion-driven reduction, the final clinical sample size remains mathematically robust to safely evaluate independent prognostic indicators for mortality.

Study Procedure: Following approval from the Dhaka Medical College Ethical Review Board, patients diagnosed with sepsis and confirmed by positive blood cultures in the study settings were approached, and informed written consent was obtained from the attendants of all eligible patients, resulting in consent from 101 patients. Relevant demographic profiles, clinical histories and systematic physical examinations were recorded in a pre-tested data collection sheet. In accordance with institutional ICU protocols, baseline testing, including complete blood count (CBC), liver function tests, renal function tests, blood sugar, arterial blood gas (ABG) analysis, coagulation profiles, and chest X-rays was performed to identify

the primary infection source and organ dysfunctions. RDW evaluation was performed on the day of admission as part of the automated CBC profile utilizing a SYSMEX XE 5000 automated analyzer (Germany) in the DMCH Hematology Department within 24 hours of ICU admission. Baseline SOFA scores were simultaneously calculated and recorded within the initial 24 hours. All patients received standardized care per the Surviving Sepsis Protocol 2016 and underwent daily clinical follow-ups to monitor 28-day mortality outcomes.

Statistical Analysis: Data analysis was performed using IBM SPSS software version 26.0 (IBM Corp., Armonk, NY, US). Group comparisons between survivors and non-survivors were conducted via the Chi-square test or Fisher's exact test for categorical parameters, and the Mann-Whitney U test for continuous parameters. The association between baseline RDW and SOFA scores was established using Spearman's rank correlation coefficient (rs). Receiver operating characteristic (ROC) curves were constructed to visualize predictive capacities, and the Area under the Curve (AUC) was calculated with 95% confidence intervals (CI) to compare the diagnostic performance of RDW and SOFA scores in predicting 28-day mortality. Optimal cutoff thresholds were determined using the maximum Youden Index value, from which diagnostic indices including sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were compiled. Statistical significance for all evaluations was established at ($p < 0.05$).

Ethical Considerations: The research protocol was reviewed and authorized by the Ethical Review Committee (ERC) of Dhaka Medical College prior to the study initiation. All participants' legal guardians were fully briefed on the study's objectives, methods, and clinical significance in a clear, accessible manner before obtaining voluntary, informed written consent. Collected patient details will be strictly reserved for academic research purposes under rigorous data confidentiality measures. Legal representatives retained the complete right to withdraw the patient from the study protocol at any stage without clinical prejudice. The Helsinki Declaration's guiding principles were followed in the conduct of this investigation.

Results

In this study, the RDW parameter was taken as the coefficient of variation of RBC volume, which quantified the heterogeneity of RBC volume

(anisocytosis) as the ratio of the standard deviation of RBC volume to the mean corpuscular volume. That was $RDW (\%) = (1 \text{ SD of RBC Volume} / MCV) \times 100$. While the general objective of this study was the evaluation of the association between RDW and SOFA score, the specific objectives included calculating the sensitivity, specificity, and AUC of RDW and SOFA score for predicting 28-day mortality.

Baseline Demographics and Clinical Characteristics: The final analysis included 98 patients with confirmed sepsis after accounting for 3 dropouts from the initial enrollment cohort of 101 individuals. The socio-demographic distribution of the study population demonstrated a mean age of 47.7 ± 16.4 years, with a greater proportion of the patients aged older than 40 years ($n=58$, 59.2%). A predominance of urban residence and male gender was observed, comprising 54 (55.1%) and 55 (56.1%) patients, respectively. In terms of primary septic etiologies, pneumonia was identified as the leading source, diagnosed in 61 (62.2%) patients, followed by Urinary tract infections in 13 (13.3%) and acute exacerbations of COPD in 9 (9.2%) patients (Table 1).

Table 1: Socio-Demographic of the Sepsis Patients (n=98)

Parameter	Frequency	Percent
Age Distribution		
• ≤ 40 years	40	40.8
• >40 years	58	59.2
Gender		
• Male	54	55.1
• Female	44	44.9
Residential Status		
• Urban	55	56.1
• Rural	43	43.9
Primary Sepsis Diagnoses		
• Pneumonia	61	62.2
• Urinary Tract Infection	13	13.2
• Acute Exacerbation of COPD	9	9.2
• Meningoencephalitis	5	5.1
• Acute Pancreatitis	4	4.1
• Acute Exacerbation of BA	3	3.1%
• Soft Tissue Infection	3	3.1%

Baseline laboratory profiles on admission yielded a mean haemoglobin level of 12.5 ± 1.4 g/dL, a mean white blood cell count of $17.524 \pm 4.758 \times 10^9/L$, and a mean platelet count of $181.916 \pm 72.682 \times 10^9/L$ (Table 2).

Table 2: Baseline Laboratory Profiles of The Sepsis Patients

Baseline Laboratory Parameters	Mean $\pm$ SD	Range (Min–Max)
Hemoglobin (g/dl)	12.5 ± 1.4	10.2 to 16.9
Mean Corpuscular Volume (MCV) (fl)	83.9 ± 5.4	76.0 to 95.0
White Blood Cells ($\times 10^9/L$)	17.5 ± 4.76	8.7 to 32.0
Platelet Count ($\times 10^9/L$)	181.9 ± 72.68	51.5 to 515.0
Serum Bilirubin (mg/dl)	1.1 ± 0.6	0.20 to 12.0
Serum Creatinine (mg/dl)	1.5 ± 0.9	0.50 to 6.30

COPD= Chronic Obstructive Pulmonary Disease, BA = Bronchial Asthma

Distribution and Correlation of RDW and SOFA Scores: On admission, the median baseline Red Blood Cell Distribution Width (RDW) was 15.2% (IQR: 14.5% to 16.4%). The cohort was stratified into three RDW intervals: less than 15.0% ($n=39$, 39.8%), 15.0% to 16.0% ($n=44$, 44.9%), and more than 16.0% ($n=15$, 15.3%). The mean baseline SOFA score was 7.7 ± 2.9 . A direct cross-tabulation of baseline indices revealed a significant shift: among patients presenting with low organ dysfunction (SOFA score less than 5), 18 (78.3%) exhibited an RDW less than 15.0%, with zero instances of RDW exceeding 16.0%. Conversely, within the SOFA score tier more than 10, 13 (61.9%) shifted into the 15.0% to 16.0% RDW band and 8 (38.1%) exceeded 16.0%. Higher SOFA score bands significantly matched increased RDW presentation ($p < 0.001$) (Table 2), reinforced by the significant Spearman correlations ($r_s = 0.648$, $p < 0.001$) (Figure I).

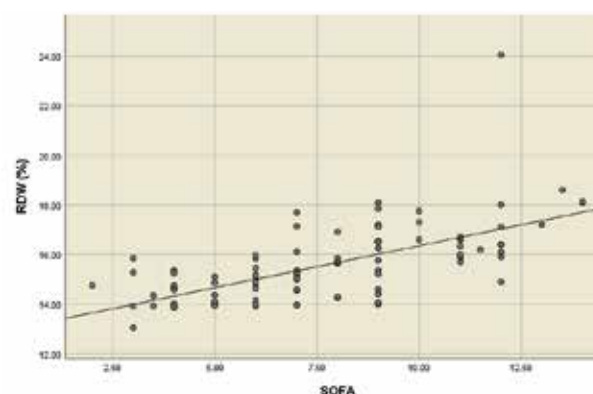


Figure I: Scatter plot illustrating the positive correlation between admission RDW (%) and SOFA score

Table 3: Distribution of Patient Biomarkers (RDW) Across SOFA Score Categories on Admission (n=98)

SOFA Score Category	RDW			Total	P value
	<15.0%	15.0%-16.0%	>16.0%		
SOFA ≤ 5	18(78.3%)	5(21.7%)	0(0.0%)	23(100%)	0.001
SOFA 6 – 10	21(38.9%)	26(48.1%)	7(13.0%)	54(100%)	
SOFA > 10	0(0.0%)	13(61.9%)	8(38.1%)	21(100%)	
Total	39	44	15	98	
Cohort Summary Metrics:					
SOFA Score (Mean ±SD)	—	—	—	7.7 ± 2.9	
SOFA Score [Median (IQR)]	—	—	—	7.0 (4.0 –10.0)	
RDW (%) [Median (IQR)]	—	—	—	15.2% (14.5% –16.4%)	

p-value determined by Fisher's exact test

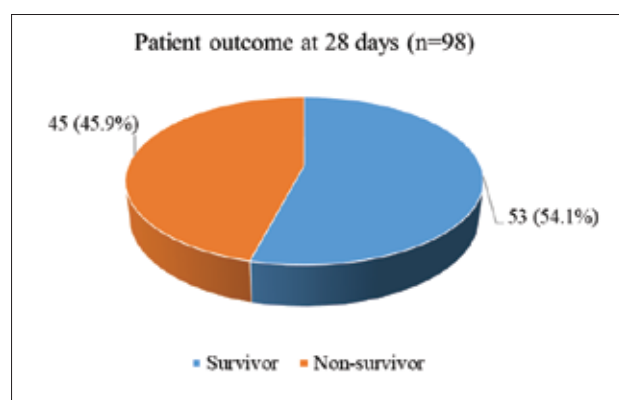
Table 4: Comparison of Admission Parameters and Outcome Associations [Median (IQR)]

Variables	Survivor (n=53)	Non-survivor (n= 45)	P value
RDW (%)	14.7 (13.9-15.2)	16.4 (15.7-17.2)	0.001
SOFA	6.0 (4.0-7.0)	10.0 (9.0-12.0)	0.001

p-value determined by Mann-Whitney U test

Prognostic Accuracy and Mortality Outcomes:

At the clinical endpoint, we recorded a 28-day crude mortality rate of 45.9% (n=45, non-survivors) within the ICU, while 53 (54.1%) patients survived (Figure II).

**Figure II: Summary of Patient Clinical Outcomes at the 28-day Prospective Endpoint**

Baseline parameters differed significantly between outcome groups; non-survivors presented with a significantly higher median RDW of 16.4% compared to 14.7% among survivors ($p < 0.001$). Similarly, the median SOFA score among non-survivors was 10.0 versus 6.0 in the survivor group ($p < 0.001$) (Table 3).

Receiver Operating Characteristic (ROC) curve analysis evaluated the individual prognostic performance of both indicators (Figure III).

The area under the curve (AUC) for baseline SOFA score was 0.961 (95% CI: 0.929–0.994, $p < 0.001$),

while the baseline RDW generated an AUC of 0.860 (95% CI: 0.784–0.936, $p < 0.001$). Utilizing the Youden Index, the optimal predictive cut-off for RDW was established at 15.55% ($J = 62.7$), which yielded a sensitivity of 77.8% and a specificity of 84.9%. The optimal cut-off for the SOFA score was determined to be 8.5 ($J = 78.4$), achieving a sensitivity of 82.2% and a specificity of 96.2%. Chi-square evaluation confirmed that an admission RDW more than 15.6%, true positives ($n=35$ out of 45 non-survivors) and an admission SOFA score >8.5 true positives ($n=37$) were strongly associated with mortality outcomes ($p < 0.001$) (Table 4).

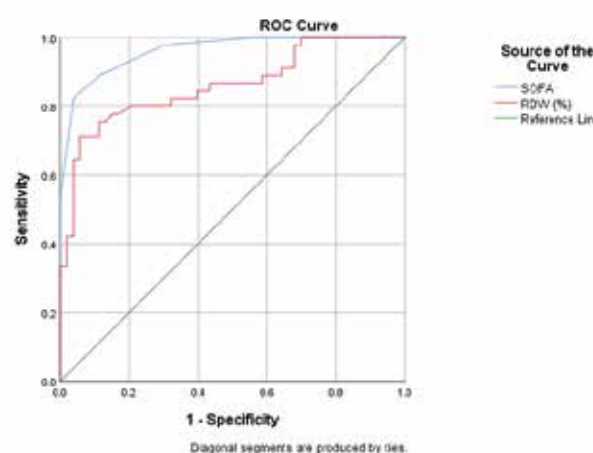
**Figure III: Comparative ROC Curves of Admission RDW (%) and SOFA scores for Predicting 28-day Mortality**

Table 4: Summary Diagnostic Test Validity Indices for Mortality Prediction (n=98)

Test Parameter	Optimal Cut-off	Youden Index (J)	AUC (95% CI)	Sensitivity	Specificity	PPV	NPV
Admission RDW	15.55%	62.7	0.860 (0.784–0.936)	77.8%	84.9%	81.4%	81.8%
Admission SOFA	8.5	78.4	0.961 (0.929–0.994)	82.2%	96.2%	94.9%	86.4%

Discussion

The primary objective of this work was to evaluate the clinical association between admission Red Blood Cell Distribution Width (RDW) and the Sequential Organ Failure Assessment (SOFA) score in sepsis patients within a primary tertiary care setting in Bangladesh. Our empirical findings demonstrate a statistically significant, moderate positive correlation ($r_s = 0.648$, $p < 0.001$) between these two parameters on ICU admission. The baseline demographics of our cohort revealed a mean age of (47.7 ± 16.4) years, with a distinct male predominance (55.1%). This male-predominant distribution is highly consistent with reviews affirming that sepsis is continuously more common in men¹⁹ and also localized evaluations by Saha et al⁹ and Ahmed et al²⁰. However, the age of our patients is lower than previous findings in sepsis patients of Bangladesh. This discrepancy is potentially due to the difference in defining sepsis, as both those articles used sepsis -2, whereas in our study we used the sepsis-3 definitions²¹.

Infectious etiologies revealed pneumonia as the leading cause of sepsis, accounting for 62.2% of all admissions, followed by urinary tract infection (UTI) (13.2%). This closely matches previous data that found pneumonia as the principal cause of sepsis admissions within Bangladeshi tertiary care facilities; as Ahmed et al²⁰ documented, the respiratory tract was the most common primary site of infection at 69.5%, and UTI came next at 11.4%. At the global scale, it reflects a meta-analysis-reported thematic consensus regarding pneumonia and UTI being the commonest sources of infection resulting to sepsis²². The 28-day crude mortality rate recorded in our general ICU cohort was 45.9%. This finding aligns closely with historical local observations by Karim²³, who reported an ICU sepsis mortality rate of 41.9% in Bangladesh. When contrasted globally, our mortality rate is comparable to the figure reported globally as about 42% of sepsis patients in ICU reportedly perish²⁴. However, in high-income nations such as South Korea²⁵ at 22.7% or Germany²⁶ at 23.5%, the rate is alarmingly high. This discrepancy underscores the persistent survival gaps potentially

driven by resource challenges and access barriers in lower-middle-income countries (LMICs).

Cross-tabulation analysis revealed that non-surviving septic patients exhibited significantly higher baseline RDW levels (median: 16.4%) compared to survivors (median: 14.7%). This biological shift aligns with a reported key feature of sepsis-driven systemic inflammation, describing how pro-inflammatory cytokines (such as TNF- α , IL-6, and IL-1 β) cause inefficient erythropoiesis by suppressing erythroid maturation, altering erythrocyte membrane structures, and reducing the active circulatory lifespan of mature cells^{14,27}. Additionally, the massive oxidative stress characteristic of sepsis prompts reactive erythropoiesis, triggering the premature release of large, immature red blood cells into systemic circulation, thereby raising the absolute RDW value^{15,16}. The diagnostic threshold evaluations calculated through the maximum Youden Index established an optimal predictive RDW cut-off value of 15.5% (sensitivity: 77.8%, specificity: 84.9%). This threshold maps closely to existing international evidence that septic patients with an RDW >15.5% carried a 70.0% higher risk of death within the first 30 days, and an RDW $\geq 16\%$ as a strong independent marker of fatal outcomes²⁸⁻²⁹. The AUC (0.860) of our RDW profile exceeds that of the reported AUC (0.73) in the work of Kim et al¹⁵.

For SOFA scoring, the optimal admission cut-off to predict mortality was 8.5 (Sensitivity: 82.2%, Specificity: 96.2%). This rests slightly higher than the cut-off of 7.50 identified by Saha et al⁹ in an alternate Bangladeshi ICU cohort, a variation likely originating from subtle differences in age distributions and the specific sepsis definition. Crucially, our ROC analysis confirmed that while the SOFA score provides premium accuracy (AUC = 0.961), the RDW calculation (AUC = 0.860) offers a potentially highly comparable, accessible alternative, given that full SOFA calculations require manual clinical scores combined with diverse laboratory tests (such as arterial blood gas, bilirubin, and creatinine measurements) and its execution is frequently described as complicated as well as expensive in

low-resource emergency settings like in Bangladesh¹⁰. Conversely, RDW is an entirely automated, standard parameter provided at no additional cost within a routine Complete Blood Count (CBC). This makes it an ideal, high-utility tool for early prognostic stratification and aggressive initial triage in resource-constrained care settings.

The study was conducted in a premium referral center of a densely populated country like Bangladesh, and the prospective nature, with the inclusion of all the available sepsis patients during the study time period, is the strongest part of this research work. The limitations include: a single-center study; factors affecting RDW, like vitamin B12, folic acid, and iron, were not included as variables; absence of dynamic monitoring for both SOFA and RWD; and exclusion of transfusion data. Furthermore, there is potential for selection bias regarding the general distribution resulting from the exclusion of patients from specialized COVID-19 ICU.

Conclusion

In conclusion, this study demonstrates a significant, moderate positive correlation between admission Red Blood Cell Distribution Width (RDW) and the Sequential Organ Failure Assessment (SOFA) score among sepsis patients admitted to a premier tertiary care ICU in Bangladesh. Both parameters function as strong, independent prognostic markers for 28-day mortality. While the multi-systemic SOFA score retains superior diagnostic accuracy, RDW values exceeding a cut-off threshold of 15.55% provide a reliable, rapid, and low-cost tool for identifying high-risk septic patients on admission. Integrating RDW assessments into routine emergency triage protocols represents a practical, economically viable strategy to enhance prognostic accuracy and could be used to guide early, aggressive therapeutic interventions in resource-limited healthcare settings.

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Conflict of interest:

The authors declare no competing interests.

Financial Disclosure

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Manuscript drafting and revising it critically: Bhuiyan MMA, Ansary AMAA, Mondal MK
All authors read and approved the final manuscript.

Data Availability

Participant-level data will be available on request from the corresponding author.

Ethics Approval and Consent to Participate

The study was given ethical clearance by Dhaka Medical College's (DMC) Ethical Review Committee (Memo No.: ERC-DMC/ECC/2020/69(R)). Informed written consent was obtained from each participant. The authors certify that the procedures followed the rules outlined in the Helsinki Declaration of the World Medical Association.

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