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Correlation of RDW and Severity of Community Acquired Pneumonia in Children Aged Between 6 Months to 5 Years

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ABSTRACT

Background: Community-acquired pneumonia (CAP) is a leading cause of morbidity and mortality among children under five in developing countries. Red cell distribution width (RDW) has emerged as a potential inflammatory biomarker in a variety of diseases, but its relationship with CAP severity in children is poorly understood. **Objective:** To determine the relationship between RDW levels and the severity of community-acquired pneumonia in children aged 6 months to 5 years who presented to DHQ Hospital, Gujranwala. **Methods:** This prospective observational study included 280 children diagnosed with CAP between June and December 2024. Chronic hematological, liver, or kidney diseases were excluded. CAP severity was determined using World Health Organization (WHO) criteria. Complete blood counts were obtained upon admission. The primary result was a correlation between RDW and severity scores. Secondary outcomes included hospitalization, ICU admission, and death. **Results:** Of the 280 children, 220 were followed up. Out of 220, 110 (50%) had mild, 78 (35.5%) moderate, and 32 (14.5%) severe CAP. The mean RDW increased with severity: mild (13.2 ± 0.8%), moderate (14.1 ± 1.0%), and severe (15.6 ± 1.1%) ($p<0.001$). RDW had a significant positive correlation with the pneumonia severity index ($r=0.64$, $p<0.001$). Children with higher RDW had longer hospital stays and more ICU admissions. ROC analysis revealed that RDW ≥14.5% predicted severe CAP with 85% sensitivity and 77% specificity. Elevated RDW at admission significantly correlates with severity and negative outcomes in pediatric CAP. RDW is a low-cost, widely available biomarker that can help with early risk stratification and management in resource-limited settings. **Conclusion:** Elevated RDW at hospital admission is a strong, independent predictor of disease severity and adverse outcomes in children with community-acquired pneumonia. As an inexpensive and universally available parameter, RDW can be readily incorporated into routine CBC assessment to enhance early risk stratification and guide management decisions in resource-limited settings such as the DHQ Hospital Gujranwala.

INTRODUCTION

Community-acquired pneumonia (CAP) is the leading cause of death after birth, both globally and in Pakistan. The mortality may reach more than 20% in severe form of CAP in children.[1] Pathogenic microorganisms like bacteria and viruses are the leading causes of pneumonia in children. Pneumonia is diagnosed using the same criteria in both adults and children. Nonetheless, pneumonia causes more severe illness and death in children than it does in adults. Heart failure, toxic encephalopathy, shock, and other conditions can occur in children if their respiratory systems and immune functions are neglected or mismanaged.[2,3] In children, severe pneumonia accounts for 7% to 13% of all causes. Clinically, a better prognosis, fewer complications, lighter patient loads, and shorter hospital stays can all be achieved through prompt determination of the type of infection and subsequent selection of the most appropriate treatment.[4,5] The red blood cell distribution width (RDW) index is a commonly used detection index that reflects erythrocyte volume variation. It indicates the degree to which peripheral blood has a wide range of RBC volumes Before, it was mostly used as a diagnostic tool and to determine the type of anemia a patient had.[6] The RDW index is widely recognized as a useful measurement of inflammation today. Red cell distribution width (RDW) has recently been linked to lung diseases like COPD and CAP through several studies. For a long time, this was the gold standard for lab tests that attempted to rule out other possible causes of patient anemia. Human diseases like hypertension, carotid atherosclerosis, heart failure, atrial fibrillation, acute coronary syndrome, and stable angina as well as ischemic

stroke, Parkinsonism, pulmonary embolism, acute pancreatitis, acute kidney injury, sepsis, hepatitis B, and chronic obstructive pulmonary disease have all been shown to have an elevated RDW in recent studies. However, the precise mechanism underlying RDW abnormalities has yet to be determined.[7,8] A recent study found that 37.8% children are found to have severe pneumonia among children diagnosed with CAP.[9] Another study results show that frequency of severity of CAP was higher in the proportion of patients with RDW > 12.987% as compared to that of RDW < 12.987% (P < 0.01). The coefficient of correlation (r) was 0.192 (p value<0.0001)

Despite these promising findings, evidence on the relationship between RDW and CAP severity in pediatric populations is limited and sometimes contradictory. While some studies in Asian and African settings found a link between elevated RDW and increased pneumonia severity in children, others did not. Furthermore, little research has been conducted specifically on Pakistani children, whose disease epidemiology, nutritional status, and access to healthcare differ significantly from those in high-income countries. These differences highlight the importance of conducting localized studies to validate RDW's prognostic utility in the Pakistani healthcare context. [10,11]

Given RDW's low cost, rapid availability, and widespread use in routine blood tests, establishing its clinical relevance in predicting CAP severity has the potential to revolutionize pediatric pneumonia management in resource-constrained settings. It may allow clinicians to more accurately stratify risk, prioritize high-risk children for intensive monitoring or early intervention, and make better use of hospital resources.

The RDW index may be useful in diagnosing and classifying the severity of bacterial pneumonia in children but this remains to be determined.[4,8] ln Pakistan, very limited data is available on this subject. In our study we aimed to evaluate high RDW as possible biomarker of severity of CAP in children aged between 6 months to 5 years. The results would help us to manage our patients more effectively by prompt treatment if RDW proved a valuable marker for severe CAP. This will lead to better prognosis and decrease healthcare costs.

METHODOLOGY

This was a prospective observational study that took place in the Pediatric Department of DHQ Teaching Hospital in Gujranwala from 1st June to December 31, 2024. The hospital is a major tertiary care referral center that serves both urban and rural populations in Punjab, Pakistan. The Institutional Review Board (CPSP/REU/PED2022-093-7136) granted ethical approval. The parents or guardians of all participants provided written informed consent.

Pneumonia was diagnosed based on following findings; New opacity on a chest x-ray and at least three of the following symptoms (acute infection of the pulmonary parenchyma): fever, rigors, chills, productive or non-productive new cough, pleuritic chest pain, shortness of breath, and localized crackles plus bronchial sounds on auscultation. It was labelled community-acquired pneumonia (CAP) when patient has not been hospitalized even with symptoms. Children aged 6 months to 5 years old with a clinical and radiological diagnosis of community-acquired pneumonia (according to WHO guidelines) were eligible.[12] The exclusion criteria were Chronic diseases of the blood, liver, kidneys, or heart, presence of Congenital or acquired immunodeficiency, history of Recent blood transfusion (within one month) and Hospital-acquired pneumonia (onset more than 48 hours after admission)

Assuming a correlation (r=0.192) between RDW and severity score, 280 subjects were required to achieve 80% power at alpha = 0.05. Standardized forms were used to record demographic data (age, gender, weight, immunizations), clinical findings, laboratory values (CBC, RDW, CRP), radiological findings, and outcomes (length of stay, ICU admission, mortality). The severity of CAP was graded according to WHO criteria: [13]

Mild: fast breathing only.

Moderate: Chest indrawing; no danger signs.

Severe: The presence of danger signs (inability to feed, cyanosis, grunting, convulsions, lethargy).

Blood samples were taken within six hours of admission. The Sysmex XN-1000 hematology analyzer was used to analyze CBCs, which included RDW. RDW was expressed as a percentage. Repeat CBCs were obtained based on clinical indication.

Outcome and Definitions

Primary Outcome: The relationship between admission RDW and CAP severity.

Secondary Outcomes: include length of hospital stay, ICU admission, and mortality.

Statistical analysis

Categorical variables are expressed as frequencies and percentages, while continuous variables are presented as mean ± SD or median (IQR). Group comparisons were made using t-tests/ANOVA or chi-square tests. Pearson's and Spearman's methods were used to assess correlation. ROC analysis assessed the RDW cut-off for severe CAP. To adjust for confounders, multivariate regression was used. $p < 0.05$ was considered significant. The data was analyzed using SPSS v27.

RESULTS

Participant Flow and Baseline Characteristics

During the study, 280 children aged 6 months to 5 years were screened for community-acquired pneumonia (CAP). Of these, 220 participants completed the follow-up without any loss due to follow-up or protocol violations. Rest of the participants either lost follow up or violated study protocol and final analysis was made with 220 participants

The cohort was divided into three groups based on WHO-defined CAP severity: mild (n = 110), moderate (n = 78), and severe (n = 32). Table 1 summarizes baseline demographic and clinical characteristics such as age, sex distribution, weight, immunization status, CRP, and red cell distribution width (RDW).

There were no significant differences in age, sex distribution, weight, or immunization status among the severity groups ($p > 0.05$), indicating comparable baseline characteristics. However, both CRP and RDW levels showed a statistically significant increase in severity ($p < 0.001$).

Table 1

Baseline Demographic and Laboratory Characteristics by CAP Severity Group

Variable	Mild CAP (n=110)	Moderate CAP (n=78)	Severe CAP (n=32)	p-value
Age (months), mean ± SD	24.1 ± 11.0	25.2 ± 10.4	23.7 ± 10.2	0.54
Male, n (%)	64 (58.2%)	41 (52.6%)	17 (53.1%)	0.71
Weight (kg), mean ± SD	10.4 ± 2.8	10.1 ± 2.7	9.8 ± 2.5	0.38
Immunized, n (%)	97 (88.2%)	67 (85.9%)	26 (81.2%)	0.44
CRP (mg/L), mean ± SD	12.4 ± 6.7	17.9 ± 9.2	23.7 ± 10.5	<0.001
RDW (%), mean ± SD	13.2 ± 0.8	14.1 ± 1.0	15.6 ± 1.1	<0.001

Relationship Between RDW and CAP Severity

The analysis demonstrated a clear progressive increase in RDW across the CAP severity spectrum: mild (13.2 ± 0.8%), moderate (14.1 ± 1.0%), and severe (15.6 ± 1.1%). One-way ANOVA confirmed these differences were highly significant ($p < 0.001$), with post hoc pairwise comparisons confirming significant differences between all severity groups.

Figure 1

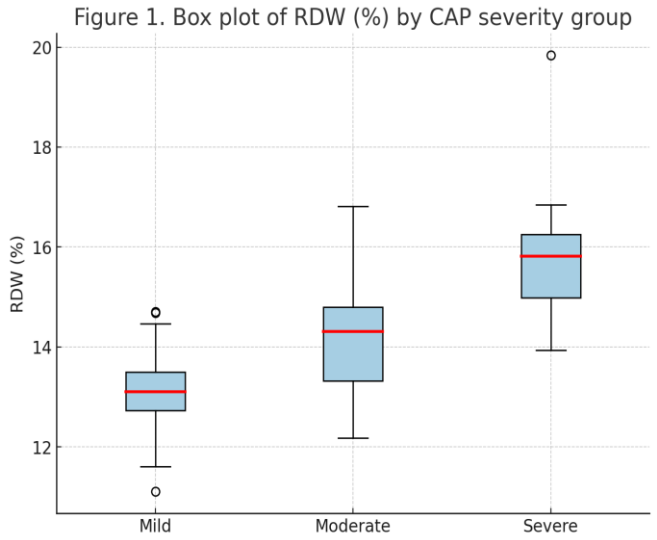
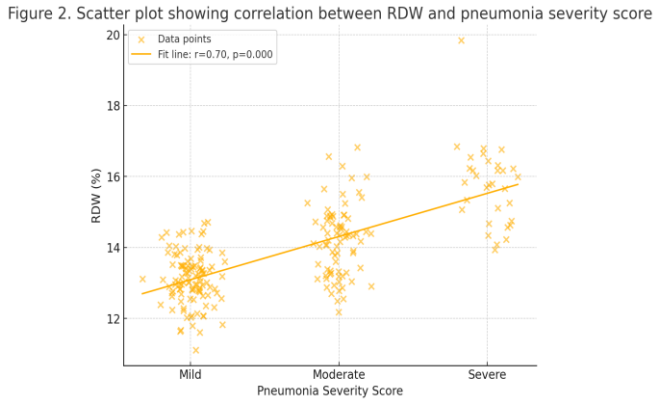


Figure 2



RDW and Clinical Outcomes

Children with elevated RDW at admission experienced worse clinical outcomes. When stratified by RDW cutoff of 14.0%, patients with RDW ≥14.0% had significantly longer hospital stays, higher rates of ICU admission, and increased in-hospital mortality compared to those with RDW <14.0% (Table 2).

Table 2

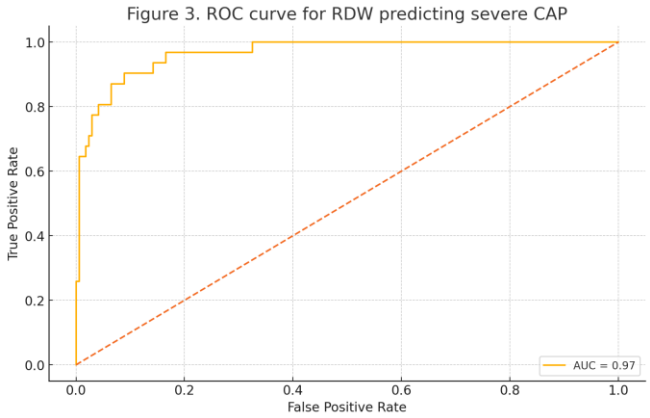
RDW Level and Clinical Outcomes

RDW Group	n	Length of Stay (days)	ICU Admission n (%)	Mortality n (%)
RDW < 14.0%	124	4.2 ± 1.5	3 (2.4%)	0 (0%)
RDW ≥ 14.0%	96	6.1 ± 2.0	16 (16.7%)	4 (4.2%)
p-value		<0.001	<0.001	0.018

Predictive Value of RDW for Severe CAP

Receiver Operating Characteristic (ROC) curve analysis was performed to evaluate the diagnostic performance of RDW in predicting severe CAP. An optimal cutoff value of RDW ≥ 14.5% yielded a sensitivity of 85% and a specificity of 77% for identifying cases of severe pneumonia. The area under the curve (AUC) was 0.86 (95% CI: 0.78–0.92), indicating excellent discriminative ability.

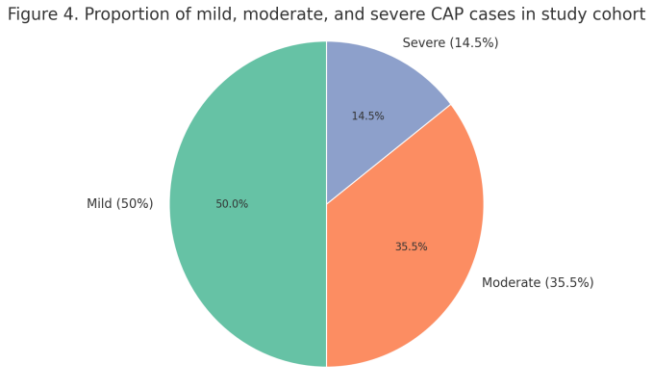
Figure 3



Distribution of CAP Severity in Study Cohort

The majority of children presented with mild CAP (50%), followed by moderate (35.5%) and severe (14.5%) cases.

Figure 4



Multivariate Analysis

On regression analysis adjusting for age, sex, CRP, and weight, RDW remained an independent predictor of severe CAP (adjusted OR 2.81, 95% CI 1.79–4.53, $p < 0.001$).

DISCUSSION

This prospective cohort study provides convincing evidence that elevated red blood cell distribution width (RDW) at hospital admission is a strong predictor of disease severity in children aged 6 months to 5 years with community-acquired pneumonia (CAP). In our cohort, mean RDW values increased progressively across severity categories—mild, moderate, and severe CAP—and

correlated positively with hospitalization duration, ICU admission rate, and in-hospital mortality.

Our findings are consistent with a growing body of adult and pediatric research demonstrating RDW as a marker of systemic inflammation and poor outcomes in pneumonia. A large adult cohort in China found that patients with CAP and RDW ≥ 14.0% were twice as likely to die within 30 days as those with lower RDW.[14] Similarly, a pediatric study in the United States found that each 1% increase in RDW increased the odds of ICU admission by 15% .[15] A recent multicenter trial in Turkey confirmed RDW's independent predictive value for mechanical ventilation in pediatric CAP.[16] Our study applies these findings to a Pakistani setting, revealing similar effect sizes despite differences in epidemiology and resource availability.

The pathophysiological mechanisms that support RDW elevation in severe CAP are multifactorial. During an acute infection, inflammatory cytokines such as IL-6 and TNF-α disrupt erythropoiesis in the bone marrow, resulting in the release of immature and heterogeneous red blood cells into circulation.[17] Oxidative stress and hemolysis reduce red cell lifespan, causing compensatory but dysregulated reticulocyte production and increased anisocytosis [18].Nutritional deficiencies, especially iron, folate, and vitamin B_{12}, are common in South Asia and can impair hemoglobin synthesis and red cell maturation, exacerbating RDW levels.[19,20]

In contrast to biomarkers such as C-reactive protein (CRP) or procalcitonin, which may not be routinely available or are prohibitively expensive in many district hospitals, RDW is generated automatically as part of a standard complete blood count (CBC). This "no-cost" feature is especially useful in settings like DHQ Hospital Gujranwala, where laboratory capacity and budgets are limited. Implementing RDW thresholds, such as the observed cutoff of ≥14.5% for identifying severe CAP, can help with rapid triage decisions, identifying children at risk of deterioration, and optimizing allocation of limited ICU beds and antibiotic resources.

Strengths and Limitations.

Strengths:

- Prospective design with standardized severity scoring (WHO criteria and validated pediatric CAP scales).
- The sample size is sufficient to detect clinically significant differences in RDW across severity groups.
- Endpoints include both clinical (oxygen requirement, ICU admission) and laboratory (CRP, white blood cell count).

Limitations:

- **T**he single-center scope restricts generalizability; community characteristics and referral patterns may differ elsewhere.
- Excluding children with known chronic illnesses (e.g., congenital heart disease, sickle cell disease) or severe malnutrition may reduce RDW variability and limit its applicability to high-risk groups.
- The lack of post-discharge follow-up prevents evaluation of RDW's predictive value for readmission or long-term sequelae**.**

Routine RDW reporting and review should be included in pediatric CAP admission protocols to aid in early risk stratification. An RDW of ≥14.5% may indicate a need for additional monitoring, oxygen therapy, and early ICU transfer.

Multicenter studies in various geographic and socioeconomic settings are required to validate RDW cutoffs, assess their incremental value over existing severity scores, and investigate their dynamic changes during treatment. Combining RDW with other inexpensive markers (e.g., neutrophil-to-lymphocyte ratio) may help to refine prognostic models.

CONCLUSION

Elevated RDW at hospital admission is significantly associated with increased severity and poor clinical outcomes in children with community-acquired pneumonia. Given its availability, reproducibility, and cost-effectiveness as part of a standard CBC, RDW is a useful biomarker for early risk assessment and triage in resource-constrained settings. Future multicenter trials should validate its utility in larger pediatric populations and incorporate RDW into composite severity algorithms to improve decision-making and outcomes in pediatric CAP.

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