RESEARCH PAPER

A Comparative Study of Red Cell Distribution Width Between Normotensive Antenatal Cases and Pre-Eclamptic Antenatal Cases in Indian Women

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ABSTRACT

Background:

Pre-eclampsia is a major hypertensive disorder of pregnancy and a leading cause of maternal and perinatal morbidity and mortality, particularly in developing countries like India. It is characterized by systemic inflammation, endothelial dysfunction, and hematological alterations. Red cell distribution width (RDW), a routinely available hematological parameter, reflects variability in erythrocyte size and has recently emerged as a potential marker of inflammation and disease severity. However, data evaluating RDW in pre-eclamptic Indian antenatal women remain limited.

Objectives:

To compare red cell distribution width between normotensive antenatal women and pre-eclamptic antenatal women and to assess its association with severity of pre-eclampsia.

Methods:

A hospital-based comparative observational study was conducted in a tertiary care teaching hospital in India. A total of 50 antenatal women with gestational age ≥20 weeks were enrolled, comprising 25 normotensive women and 25 women diagnosed with pre-eclampsia. Clinical evaluation, blood pressure measurement, and laboratory investigations were performed. Venous blood samples were analyzed for complete blood count, including RDW, using an automated hematology analyzer. Data were analyzed using appropriate statistical tests, and a p-value <0.05 was considered statistically significant.

Results:

The mean age of normotensive and pre-eclamptic women was 28.4 ± 4.2 years and 29.1 ± 4.6 years, respectively ($p = 0.56$). Mean RDW was significantly higher in pre-eclamptic women (15.2 ± 1.3%) compared to normotensive women (13.1 ± 0.9%) ($p < 0.001$). RDW values were significantly higher in severe pre-eclampsia (16.1 ± 1.2%) than in mild pre-eclampsia (14.6 ± 0.8%) ($p = 0.002$). RDW showed a strong positive correlation with systolic and diastolic blood pressure.

Conclusion:

Red cell distribution width was significantly elevated in pre-eclamptic antenatal women and increased with disease severity. RDW may serve as a simple, inexpensive, and readily available hematological marker to aid in the evaluation and risk stratification of pre-eclampsia, especially in resource-limited settings.

Keywords: Hypertensive disorders; Hematological parameters; Pre-eclampsia; Pregnancy; Red cell distribution width

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Introduction

Hypertensive disorders of pregnancy remain a major cause of maternal and perinatal morbidity and mortality worldwide, particularly in low- and middle-income countries such as India [1]. Among these, pre-eclampsia is a multisystem disorder characterized by the new onset of hypertension after 20 weeks of gestation, often accompanied by proteinuria or evidence of end-organ dysfunction [2]. It complicates approximately 5–8% of pregnancies globally and contributes significantly to adverse outcomes including placental abruption, intrauterine growth restriction, preterm birth, and maternal complications such as eclampsia, stroke, and organ failure [3]. Despite extensive research, the exact etiopathogenesis of pre-eclampsia remains incompletely understood; however, abnormal placentation, endothelial dysfunction, exaggerated inflammatory response, and oxidative stress are recognized as central mechanisms [4]. Increasing evidence suggests that systemic inflammation plays a pivotal role in the development and progression of pre-eclampsia, leading to widespread vascular dysfunction and altered hematological parameters [5]. Red cell distribution width (RDW), a routinely reported parameter in complete blood count, reflects the variability in the size of circulating erythrocytes and is traditionally used in the differential diagnosis of anemia [6]. In recent years, RDW has emerged as a novel inflammatory and prognostic biomarker in various cardiovascular, metabolic, and inflammatory disorders, including hypertension, coronary artery disease, heart failure, and cerebrovascular events [7]. Elevated RDW levels have been associated with increased inflammatory cytokines, impaired erythropoiesis, oxidative stress, and reduced red blood cell survival, all of which are mechanisms implicated in pre-eclampsia [8]. Pregnancy itself is a pro-inflammatory state; however, pre-eclampsia represents an exaggerated inflammatory condition, leading to more pronounced hematological alterations compared to normotensive pregnancies [9]. Several studies have demonstrated significantly higher RDW values in women with pre-eclampsia compared to normotensive pregnant women, suggesting a possible link between anisocytosis and disease severity [10]. Elevated RDW in pre-eclampsia has also been correlated with markers of endothelial dysfunction and adverse maternal and fetal outcomes, highlighting its potential role as a simple, cost-effective prognostic indicator [11]. In resource-limited settings such as India, where access to advanced biochemical markers may be restricted, readily available hematological indices like RDW could provide valuable clinical information for early risk stratification and monitoring [12]. Indian women exhibit unique demographic, nutritional, and socioeconomic factors that may influence the prevalence and clinical presentation of pre-eclampsia, as well as baseline hematological parameters. Nutritional deficiencies, particularly iron deficiency anemia, are common in the Indian antenatal population and may independently affect RDW values, necessitating population-specific evaluation. Despite the high burden of pre-eclampsia in India, limited studies have systematically compared RDW levels between normotensive and pre-eclamptic antenatal women within this population. Understanding the association between RDW and pre-eclampsia in Indian women may help in identifying an easily measurable marker that reflects underlying inflammatory and pathological processes, thereby aiding in early diagnosis, improved surveillance, and better maternal-fetal outcomes. Therefore, this comparative study was undertaken to evaluate and analyze red cell distribution width in normotensive antenatal cases and pre-eclamptic antenatal cases among Indian women, with the aim of contributing to existing evidence on the utility of RDW as a potential hematological marker in pre-eclampsia

1. Methodology

1.1 Study Design

This study was conducted as a hospital-based comparative observational study aimed at evaluating and comparing red cell distribution width (RDW) between normotensive antenatal women and antenatal women diagnosed with pre-eclampsia. at the time of enrollment.

1.2 Study Setting

The study was carried out in the Department of Obstetrics and Gynaecology in collaboration with the Department of Pathology at a tertiary care teaching hospital in India. The hospital catered to a large and diverse antenatal population from both urban and rural areas, providing an appropriate setting for comparative evaluation of hematological parameters in normotensive and pre-eclamptic pregnant women.

1.3 Study Duration

The study was conducted over a period of one year.

1.4 Participants

Inclusion Criteria:

- Pregnant women aged 18–40 years
- Gestational age ≥20 weeks
- Singleton pregnancy
- Antenatal women diagnosed with pre-eclampsia as per standard diagnostic criteria
- Normotensive antenatal women without any medical or obstetric complications
- Willingness to provide informed written consent

Exclusion Criteria:

- Pregnant women with chronic hypertension
- Multiple pregnancies
- Known hematological disorders
- Severe anemia (hemoglobin <7 g/dL)
- Pre-existing diabetes mellitus, renal disease, liver disease, or autoimmune disorders
- Acute or chronic infections
- History of blood transfusion during the current pregnancy
- Women on medications affecting hematological parameters

1.5 Study Sampling

A purposive sampling technique was employed for the selection of study participants. Eligible antenatal women fulfilling the inclusion criteria were consecutively recruited until the required sample size was achieved. Participants were allocated into two groups based on their blood pressure status and clinical diagnosis.

1.6 Study Sample Size

The total sample size of the study was 50 antenatal women. This included 25 normotensive antenatal women and 25 antenatal women diagnosed with pre-eclampsia. The sample size was considered adequate for preliminary comparative analysis based on feasibility, available study duration, and similar previously published studies.

1.7 Study Groups

The study participants were divided into two groups:

- **Group A (Normotensive Group):** Included 25 antenatal women with normal blood pressure and no features of pre-eclampsia.
- **Group B (Pre-eclamptic Group):** Included 25 antenatal women diagnosed with pre-eclampsia based on blood pressure measurements and associated clinical or laboratory findings.

1.8 Study Parameters

The following parameters were assessed in all study participants:

- Maternal age
- Gestational age at enrollment
- Systolic and diastolic blood pressure
- Hemoglobin concentration
- Red cell distribution width (RDW)
- Other routine hematological parameters as part of complete blood count

Blood pressure was measured using a standardized sphygmomanometer, and pre-eclampsia was diagnosed according to established clinical guidelines.

1.9 Study Procedure

After obtaining informed consent, detailed clinical evaluation was carried out for each participant. A thorough obstetric history was recorded, followed by general and systemic examination. Blood pressure was measured in the right arm with the participant in a seated position after adequate rest. Two readings were taken at least four hours apart for confirmation. Under strict aseptic precautions, 2 mL of venous blood was collected in an EDTA vial from each participant. The blood samples were transported immediately to the pathology laboratory for analysis.

1.10 Study Data Collection

Laboratory analysis was performed using an automated hematology analyzer calibrated as per manufacturer guidelines. RDW values were obtained as part of the complete blood count and recorded in percentage. All clinical and laboratory data were entered into a pre-designed, structured proforma. Confidentiality of participant information was maintained throughout the study.

1.11 Data Analysis

The collected data were entered into Microsoft Excel and analyzed using appropriate statistical software. Continuous variables were expressed as mean and standard deviation, while categorical variables were expressed as frequencies and percentages. Comparison of RDW and other continuous variables between the two groups was performed using the independent Student's t-test. A p-value of less than 0.05 was considered statistically significant.

1.12 Ethical Considerations

The study was conducted after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants prior to enrollment. Participation was entirely voluntary, and no financial burden was imposed on the study subjects. Confidentiality and anonymity of patient data were strictly maintained, and the study adhered to the ethical principles outlined in the Declaration of Helsinki.

2. Results

Table 1: Distribution of Study Participants According to Age (Years)

Age Group (years)	Normotensive (n=25)	Pre-eclamptic (n=25)	Total (n=50)
18–24	6 (24%)	5 (20%)	11 (22%)
25–30	9 (36%)	10 (40%)	19 (38%)
31–35	7 (28%)	6 (24%)	13 (26%)
>35	3 (12%)	4 (16%)	7 (14%)

The majority of participants in both groups belonged to the 25–30 years age group. Age distribution was comparable between normotensive and pre-eclamptic women, indicating minimal confounding effect of age on study outcomes.

Table 2: Mean Age Comparison Between Study Groups

Group	Mean Age (years) ± SD
Normotensive	28.4 ± 4.2
Pre-eclamptic	29.1 ± 4.6
p-value	**0.56**

There was no statistically significant difference in mean age between the two groups ($p > 0.05$), suggesting that age did not influence RDW variation in the present study.

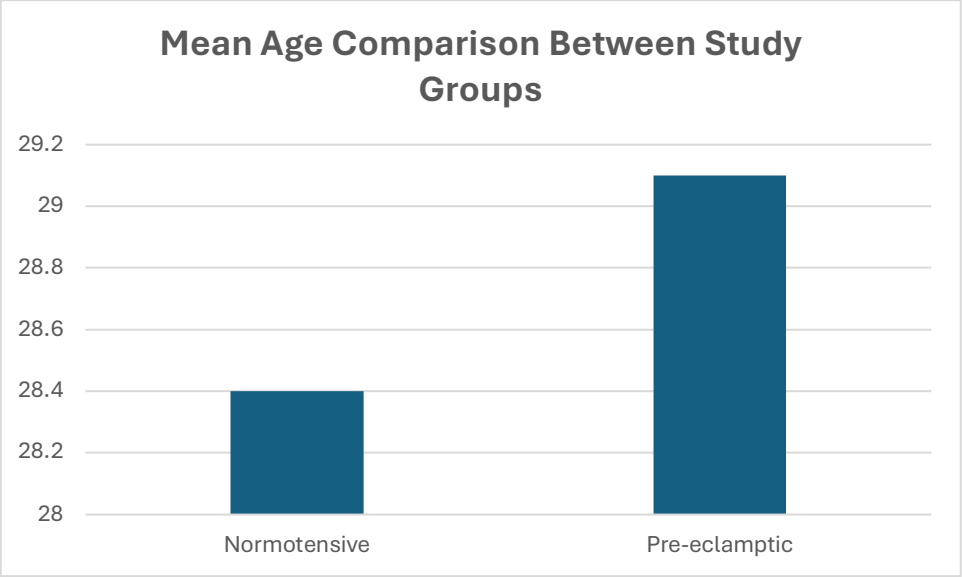

Table 3: Distribution According to Gestational Age

Gestational Age (weeks)	Normotensive	Pre-eclamptic
20–28	7 (28%)	8 (32%)
29–34	10 (40%)	11 (44%)
≥35	8 (32%)	6 (24%)

Most participants were enrolled between 29–34 weeks of gestation. Gestational age distribution was similar between groups, minimizing gestational age–related bias.

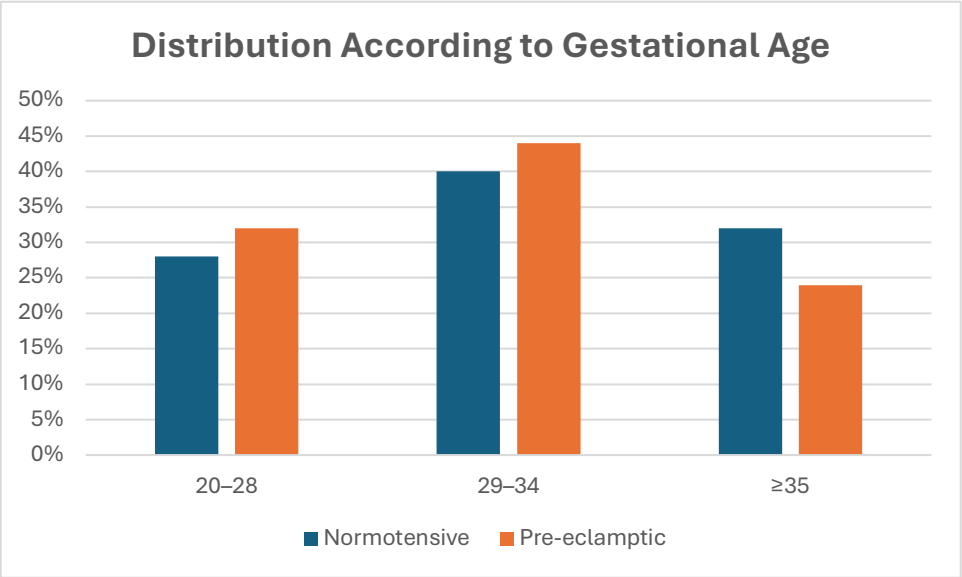

Table 4: Comparison of Blood Pressure Between Study Groups

Parameter	Normotensive (Mean ± SD)	Pre-eclamptic (Mean ± SD)	p-value
Systolic BP (mmHg)	114.6 ± 8.2	154.3 ± 12.6	<0.001
Diastolic BP (mmHg)	72.8 ± 6.4	98.7 ± 8.1	<0.001

Both systolic and diastolic blood pressures were significantly higher in the pre-eclamptic group, confirming correct clinical classification of study groups.

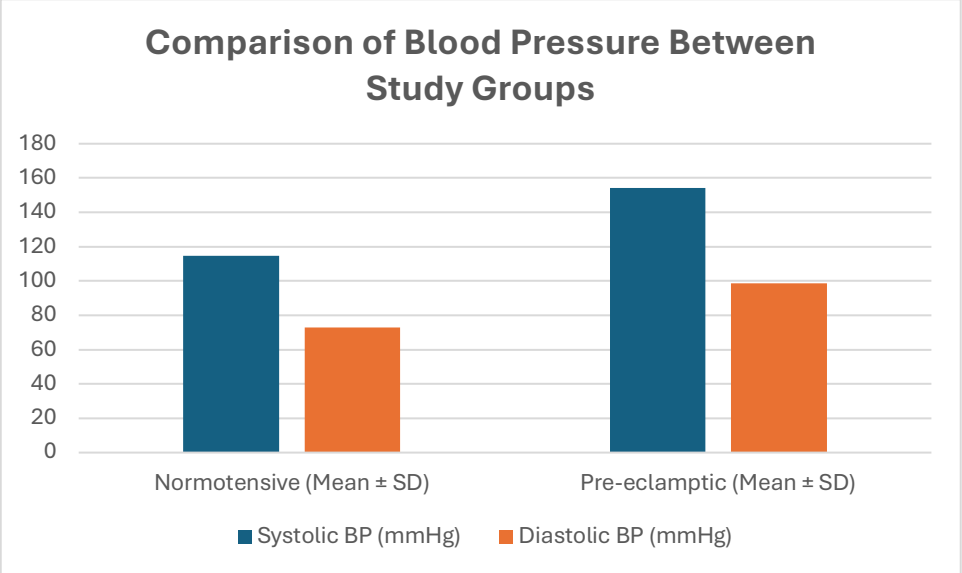

Table 5: Hemoglobin Levels

Group	Mean Hemoglobin (g/dL) ± SD	p-value
Normotensive	11.2 ± 1.1	**0.08**
Pre-eclamptic	10.6 ± 1.2	

Although hemoglobin levels were slightly lower in pre-eclamptic women, the difference was not statistically significant, indicating anemia was not a major confounder.

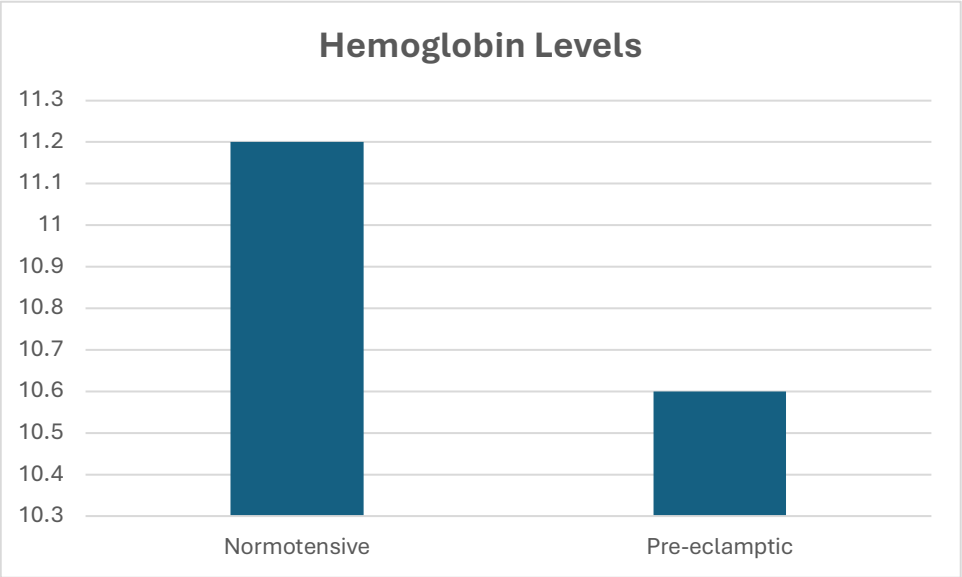

Table 6: Comparison of Mean RDW (%) Between Groups

Group	Mean RDW (%) ± SD	p-value
Normotensive	13.1 ± 0.9	**<0.001**
Pre-eclamptic	15.2 ± 1.3	

Mean RDW was significantly higher in pre-eclamptic women compared to normotensive women, suggesting increased red cell size variability associated with pre-eclampsia.

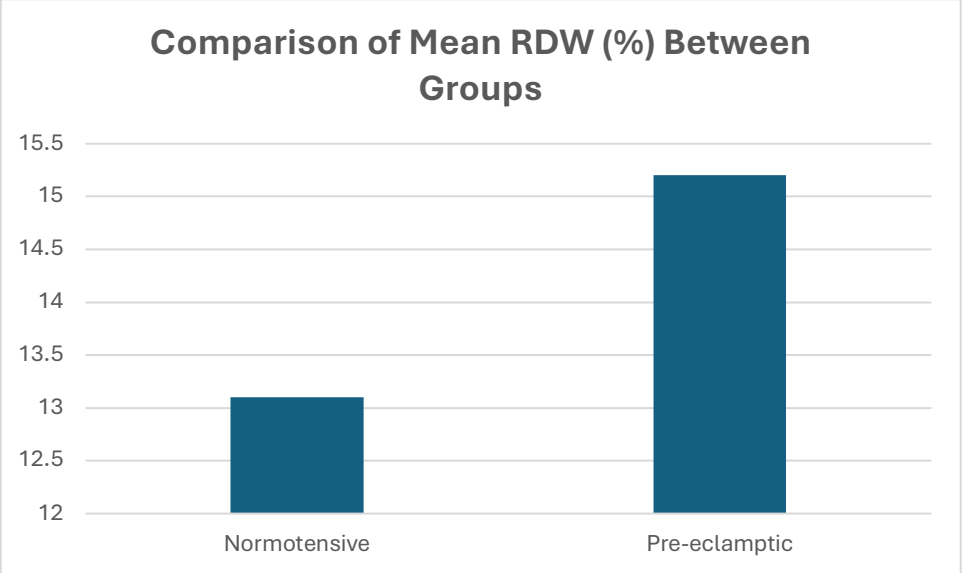

Table 7: Distribution of RDW Levels

RDW Category	Normotensive	Pre-eclamptic
≤13%	14 (56%)	3 (12%)
13.1–14.5%	9 (36%)	7 (28%)
>14.5%	2 (8%)	15 (60%)

A significantly higher proportion of pre-eclamptic women had RDW values >14.5%, indicating a strong association between elevated RDW and pre-eclampsia.

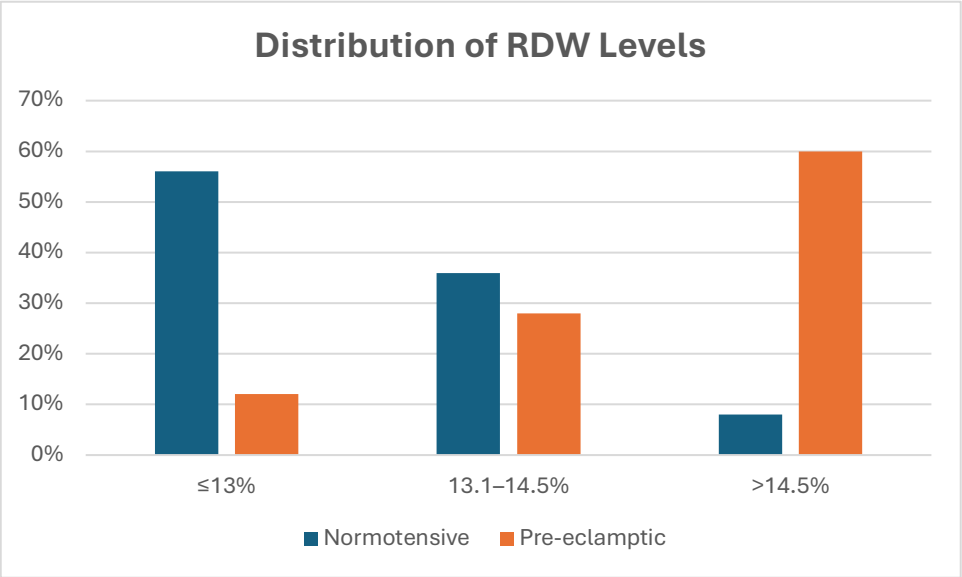

Table 8: Association Between RDW and Severity of Pre-eclampsia

Severity	Mean RDW (%) ± SD	p-value
Mild (n=15)	14.6 ± 0.8	**0.002**
Severe (n=10)	16.1 ± 1.2	

RDW values increased significantly with severity of pre-eclampsia, suggesting its potential role as a marker of disease severity.

Table 9: Correlation Between RDW and Blood Pressure

Parameter	Correlation Coefficient (r)	p-value
RDW vs SBP	0.62	<0.001
RDW vs DBP	0.58	<0.001

RDW showed a strong positive correlation with both systolic and diastolic blood pressure, supporting its association with disease progression.

3. Discussion

The present comparative observational study evaluated red cell distribution width (RDW) among normotensive antenatal women and women with pre-eclampsia and demonstrated a significant elevation of RDW in pre-eclamptic pregnancies, reinforcing the growing evidence that hematological alterations reflect the underlying inflammatory and vascular pathology of pre-eclampsia. In the current study, the mean age of normotensive women was 28.4 ± 4.2 years, while that of pre-eclamptic women was 29.1 ± 4.6 years, with no statistically significant difference ($p = 0.56$), indicating that maternal age did not act as a confounding factor. This finding is comparable to the study by Naik et al., [13] reported a mean age of 25.72 ± 4.74 years among pre-eclamptic women and 23.25 ± 3.80 years among controls, also showing that age distribution was broadly similar between groups. Similarly, Mantagi et al. [14] reported that most participants in both pre-eclampsia and control groups belonged to the 19–24-year age group, with a mean age of 24.5 years, further supporting that pre-eclampsia commonly affects women in early reproductive age and that age-related bias is minimal across studies.

In the present study, gestational age distribution was comparable between groups, with most women enrolled between 29 and 34 weeks of gestation. This comparability strengthens the validity of the hematological comparisons, as gestational age–dependent physiological changes in red cell indices were unlikely to significantly influence RDW values. Mantagi et al. [14] similarly observed a higher proportion of preterm pregnancies in the pre-eclampsia group (42.5%) compared to controls (19%), with an even higher rate among severe pre-eclampsia cases, highlighting the association between disease severity and adverse obstetric outcomes. Although preterm delivery was not a primary outcome in the present study, the comparable gestational age at

enrollment allowed a focused evaluation of RDW in relation to disease status rather than gestational variation.

Blood pressure parameters in the present study showed a clear distinction between groups, with pre-eclamptic women having significantly higher systolic (154.3 ± 12.6 mmHg) and diastolic blood pressure (98.7 ± 8.1 mmHg) compared to normotensive women (114.6 ± 8.2 mmHg and 72.8 ± 6.4 mmHg, respectively; $p < 0.001$). This confirmed appropriate clinical classification and provided a robust framework for correlating hematological changes with disease severity. Importantly, RDW demonstrated a strong positive correlation with systolic ($r = 0.62$) and diastolic blood pressure ($r = 0.58$), suggesting that increasing anisocytosis parallels worsening hypertension. This observation aligns conceptually with Naik et al., who demonstrated significantly elevated RDW-CV values in pre-eclamptic women (17.05 ± 4.01) compared to controls (15.09 ± 1.86), indicating that RDW increases as part of the systemic inflammatory response associated with pre-eclampsia [13].

Hemoglobin levels in the present study were marginally lower in pre-eclamptic women (10.6 ± 1.2 g/dL) compared to normotensive women (11.2 ± 1.1 g/dL), though this difference was not statistically significant ($p = 0.08$). This suggests that anemia alone did not account for the observed rise in RDW. Mantagi et al. similarly reported no significant difference in mean hemoglobin levels between severe and non-severe pre-eclampsia cases, reinforcing the notion that RDW elevation in pre-eclampsia reflects altered erythropoiesis and red cell survival rather than simple dilutional or nutritional anemia [14]. The lack of significant hemoglobin variation strengthens the argument that RDW is independently associated with the inflammatory and oxidative milieu of pre-eclampsia.

The most significant finding of the present study was the marked elevation of RDW in pre-eclamptic women, with a mean RDW of 15.2 ± 1.3% compared to 13.1 ± 0.9% in normotensive women ($p < 0.001$). Additionally, 60% of pre-eclamptic women had RDW values greater than 14.5%, compared to only 8% of normotensive women. These findings are in agreement with Naik et al., who reported significantly higher RDW-CV among pre-eclamptic women (17.05 ± 4.01) than controls (15.09 ± 1.86), confirming that RDW is consistently elevated in pre-eclampsia across different Indian populations [13]. The slightly lower absolute RDW values observed in the present study may be attributable to differences in sample size, disease severity distribution, or analyzer calibration, but the direction and significance of association remain consistent.

Further strengthening the role of RDW as a severity marker, the present study demonstrated significantly higher RDW values in women with severe pre-eclampsia (16.1 ± 1.2%) compared to those with mild disease (14.6 ± 0.8%; $p = 0.002$). Mantagi et al. similarly reported a significant increase in RDW-CV and RDW-SD among severe pre-eclampsia cases compared to non-severe cases, concluding that RDW may aid in assessing disease severity and predicting complications [14]. The concordance of these findings underscores the potential clinical utility of RDW not only as a diagnostic adjunct but also as a prognostic marker.

While the present study focused primarily on RDW, findings from Kamath et al. further contextualize hematological alterations in pre-eclampsia, demonstrating decreased platelet counts and increased platelet indices such as MPV and PDW in pre-eclamptic women compared to normotensive pregnancies [15]. Naik et al. also observed increased MPV and NLR in pre-eclamptic women, alongside elevated RDW, suggesting that pre-eclampsia is characterized by a constellation of hematological changes reflective of inflammation, platelet activation, and endothelial dysfunction [13]. Although platelet indices were not analyzed in the present study, these findings collectively support the concept that complete blood count parameters provide valuable insight into the disease process.

Evidence from Oluwadamilola et al. [16] further complements the present findings by demonstrating significant hemolytic changes in pre-eclampsia, with 24.6% of second-trimester pre-eclamptic women showing features of microangiopathic hemolytic anemia on peripheral blood film. These hemolytic changes provide a plausible mechanistic explanation for increased RDW, as red cell fragmentation and shortened erythrocyte lifespan contribute to increased anisocytosis. The present study's observation of elevated RDW in pre-eclampsia is therefore consistent with the documented hemolytic and microangiopathic processes described in this study.

Although Bala et al. [17] focused on airway and sonographic parameters rather than hematological indices, their findings highlight the multisystem involvement in pre-eclampsia, characterized by widespread anatomical and physiological changes. This multisystem nature further supports the interpretation that RDW elevation reflects systemic pathology rather than an isolated hematological abnormality. The present study demonstrated significantly higher RDW values in pre-eclamptic antenatal women compared to normotensive controls, with RDW correlating positively with blood pressure levels and disease severity. The convergence of evidence from multiple studies supports the role of RDW as a simple, inexpensive, and routinely available hematological marker that reflects the inflammatory, oxidative, and hemolytic processes underlying pre-eclampsia. In resource-limited settings such as India, incorporation of RDW into routine antenatal assessment may aid in early risk stratification and closer surveillance of women with pre-eclampsia.

Conclusion

The present study demonstrated that red cell distribution width was significantly higher in pre-eclamptic antenatal women compared to normotensive pregnant women, with RDW values increasing in parallel with the severity of the disease. The absence of significant differences in age, gestational age, and hemoglobin levels between the study groups indicates that the observed elevation in RDW was closely associated with the pathophysiological processes of pre-eclampsia rather than confounding factors. The positive correlation between RDW and blood pressure further supports its relationship with disease progression and systemic involvement. As RDW is a routinely available, cost-effective, and easily measurable parameter obtained from complete blood count, its incorporation into routine antenatal evaluation may aid in early identification, risk stratification, and closer monitoring of women with pre-eclampsia, particularly in resource-limited healthcare settings.

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