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Evaluating The Diagnostic Value Of Red Cell Distribution Width (RDW) In Identifying Iron Deficiency Anemia: A Retrospective Analysis

*Dr. A. H. M. Saik Rahman[1], Dr. Munasib Noor[2],
Dr. Tanzila Tabib Chowdhury[3], Dr. Mrinal Saha[4], Dr. Nazmun Haque[5],
Dr. Muhammad Zahangir[6], Dr. Md. Hasan Tarek[7]

[1]*Assistant Professor, Department Of Transfusion Medicine, Ad-Din Barrister Rafique-Ul Huq Hospital, Dhaka, Bangladesh*

[2]*Medical Officer, Department Of Transfusion Medicine, Chittagong Medical College Hospital, Chittagong, Bangladesh*

[3]*Assistant Professor, Department Of Transfusion Medicine, Chittagong Medical College Hospital, Chittagong, Bangladesh*

[4]*Registrar, Department Of Critical Care Medicine, Chittagong Medical College Hospital, Chittagong, Bangladesh*

[5]*Registrar, Department Of Transfusion Medicine, M H Samorita Hospital & Medical College, Dhaka, Bangladesh*

[6]*Director And Head, Department Of Anesthesiology, Ad-Din Barrister Rafique-Ul Huq Hospital, Dhaka, Bangladesh*

[7]*Associate Professor, Department Of Anaesthesia Analgesia and Intensive Care Medicine, National Institute of Cardiovascular Disease (NICVD), Dhaka, Bangladesh*

Corresponding Author: *Dr. A. H. M. Saik Rahman, Assistant Professor, Department Of Transfusion Medicine, Ad-Din Barrister Rafique-Ul Huq Hospital, Dhaka, Bangladesh.*

Abstract

Background: *Iron Deficiency Anemia (IDA) is the most prevalent form of anemia globally, with a significant impact on public health, especially in low-resource settings like Bangladesh. Accurate and early diagnosis of IDA is essential for effective treatment. Red Cell Distribution Width (RDW) has emerged as a promising, accessible diagnostic tool for IDA, yet its utility remains underexplored in this context.*

Methods: *This retrospective cross-sectional study, conducted between July 2022 and July 2024 at Addin Barrister Rafique-ul Huq Hospital in Bangladesh, included 106 patients diagnosed with microcytic hypochromic anemia. Key hematological parameters, including hemoglobin, RBC count, MCV, and RDW, were analyzed. Correlation analyses were performed to assess the relationships between RDW and other parameters such as hemoglobin, MCV, RBC count, and Erythrocyte Sedimentation Rate (ESR).*

Results: *RDW was elevated (>14.5%) in 92.45% of the participants, with a mean RDW of 17.59±3.33%. Significant negative correlations were observed between RDW and hemoglobin ($r = -0.435$, $p < 0.001$) and between RDW and MCV ($r = -0.664$, $p < 0.001$). RDW showed positive correlations with RBC count ($r = 0.315$, $p = 0.001$) and ESR ($r = 0.225$, $p = 0.041$). The study confirmed RDW's strong diagnostic value in distinguishing IDA, particularly in resource-constrained settings.*

Conclusion: *RDW, combined with other hematological parameters, is a sensitive and reliable marker for diagnosing IDA. Its incorporation into routine diagnostic protocols could significantly enhance IDA detection and management in low-resource settings like Bangladesh.*

Keywords: *Iron Deficiency Anemia, Red Cell Distribution Width, Microcytic Anemia, Hematological Parameters, Bangladesh.*

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I. Introduction

Iron Deficiency Anemia (IDA) is recognized as the most prevalent form of anemia globally, affecting an estimated 1.62 billion people, with a significant impact on public health, especially in low- and middle-income countries. IDA is particularly widespread in South Asia, including Bangladesh, where nutritional deficiencies and socio-economic challenges exacerbate the condition. Women of reproductive age, pregnant women, and young children are the most vulnerable groups, with IDA contributing to substantial morbidity and mortality in these populations. The high prevalence of IDA in these groups is alarming, given its association with severe health consequences, including cognitive impairments, reduced physical capacity, and adverse pregnancy outcomes, such as preterm birth and low birth weight, which collectively diminish the quality of life and increase healthcare burdens globally and locally in Bangladesh (1–3). Diagnosing IDA accurately and early is crucial to mitigating its adverse effects. Traditionally, the diagnosis of IDA relies on serum ferritin, hemoglobin concentration, and transferrin saturation as standard diagnostic markers. However, these traditional markers have limitations, particularly in resource-limited settings like Bangladesh. Serum ferritin, while a sensitive marker, is an acute-phase reactant and can be elevated in the presence of inflammation, leading to false negatives in the diagnosis of IDA. Similarly, transferrin saturation and hemoglobin concentration, though indicative, may not always reflect iron deficiency accurately, especially in cases where anemia is masked by other concurrent conditions such as chronic inflammation or infection (4,5). The reliance on these tests is further challenged by their cost and the need for invasive procedures, which are not always accessible in resource-constrained settings, thereby underscoring the need for alternative, more accessible diagnostic tools (6,7). In this context, Red Cell Distribution Width (RDW), a hematological parameter that measures the variation in the size of red blood cells (anisocytosis), has emerged as a promising diagnostic marker for IDA. RDW is calculated as part of a routine complete blood count (CBC) and reflects the heterogeneity in red cell sizes, which is a hallmark of iron deficiency. Unlike serum ferritin and transferrin saturation, RDW is readily available in most healthcare settings as part of standard hematological tests, making it a more practical and cost-effective tool for large-scale screening and diagnosis, particularly in regions with limited resources (8). The utility of RDW in diagnosing IDA has been demonstrated in several studies, where it has shown significant sensitivity and specificity in distinguishing IDA from other forms of anemia, especially in populations with a high prevalence of microcytic hypochromic anemia (9,10). Several studies have validated the effectiveness of RDW in diagnosing IDA, particularly in pediatric populations and in resource-limited settings where access to comprehensive iron status markers is restricted. In a study conducted in Delhi, India, among children aged 1–3 years from a low socio-economic background, RDW demonstrated a sensitivity of 94% and a specificity of 95% at different cut-off levels, proving to be a highly effective tool for identifying iron deficiency in this vulnerable population. The study highlighted the potential of using RDW as a primary screening tool in resource-constrained settings, where it could significantly reduce the costs associated with IDA management by eliminating the need for expensive iron status markers (11). Similarly, another study in India showed that RDW had a higher sensitivity in diagnosing mild IDA compared to peripheral blood film changes, making it an effective tool for early diagnosis, which is critical for preventing the severe consequences of untreated IDA (12). The relevance of RDW extends beyond pediatric populations. Studies have shown that RDW can also effectively differentiate between IDA and other microcytic anemias, such as thalassemia traits, which is particularly important in regions like Bangladesh, where both conditions are prevalent. In such settings, RDW provides a valuable diagnostic tool that can help clinicians make more informed decisions without the need for invasive and costly tests (13). Furthermore, RDW's utility is not confined to specific age groups; its effectiveness has been observed across various demographic groups, including pregnant women, where early diagnosis of IDA is crucial for preventing adverse maternal and neonatal outcomes (14). In conclusion, while traditional diagnostic methods for IDA remain valuable, their limitations in certain contexts necessitate the adoption of alternative approaches. RDW, with its high sensitivity and specificity, cost-effectiveness, and accessibility, presents a viable solution for the early diagnosis of IDA, particularly in resource-limited settings. The integration of RDW into routine screening protocols could significantly improve the management of IDA in regions like Bangladesh, ultimately reducing the disease burden and improving public health outcomes.

II. Methods

This retrospective cross-sectional study was conducted at Addin Barrister Rafique-ul Huq Hospital, a tertiary care facility in Bangladesh, between July 2022 and July 2024. The study aimed to evaluate the diagnostic value of Red Cell Distribution Width (RDW) in identifying Iron Deficiency Anemia (IDA). A total of 106 patients with microcytic hypochromic anemia, as indicated by routine complete blood count (CBC) parameters, were included. Patients of all ages and both genders were considered, except those with other known hematological

disorders, recent blood transfusions, or prior iron supplementation therapy. Patient data, including demographic information and hematological parameters such as hemoglobin concentration, red blood cell (RBC) count, hematocrit (HCT/PCV), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), white blood cell (WBC) count, platelet count, and RDW, were retrospectively collected from hospital records. All hematological measurements were obtained using automated hematology analyzers available at the hospital's laboratory. RDW was the primary variable of interest, and serum ferritin levels and transferrin saturation were measured when available to confirm the diagnosis of IDA. Data analysis was performed using SPSS version 25.0. Descriptive statistics were used to summarize the demographic and hematological characteristics of the study population, with continuous variables expressed as mean ± standard deviation (SD) and categorical variables as frequencies and percentages. Correlation analysis, using Pearson coefficient, was conducted to explore the relationships between RDW and other key hematological parameters, such as hemoglobin, RBC count, and MCV. This study was conducted in accordance with the Declaration of Helsinki, with ethical approval granted by the Ethical Review Committee of Addin Barrister Rafique-ul Huq Hospital. Formal informed consent was waived due to the retrospective nature of the study and the use of de-identified patient data.

III. Results

Table 1: Age distribution of the participants (N=106)

Age	Frequency	Percentage
≤20	55	51.89%
21-30	28	26.42%
31-40	11	10.38%
41-50	4	3.77%
51-60	4	3.77%
61-70	2	1.89%
71-80	2	1.89%

The majority of the patients (51.89%) were aged 20 years or younger, followed by those in the 21-30 age group, which accounted for 26.42% of the sample. A smaller proportion of participants were aged 31-40 years (10.38%), while only 3.77% of the participants fell into the 41-50 and 51-60 age brackets. The older age groups, 61-70 and 71-80, represented the lowest proportions, each comprising 1.89% of the study population.

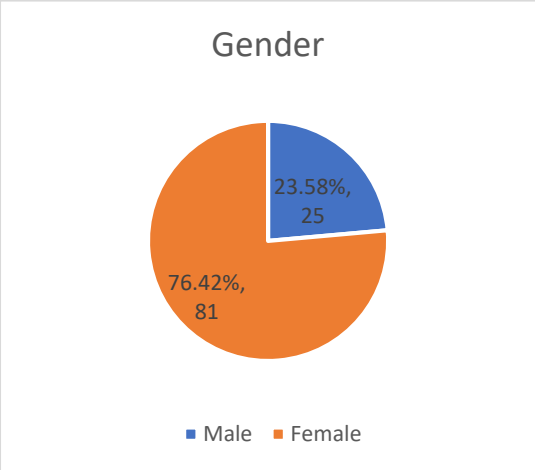

Figure 1: Gender distribution of the participants (N=106)

Regarding gender distribution, the study was predominantly female, with 76.42% of participants being women, while only 23.58% were men.

Table 2: Distribution of biochemical parameters among the participants (N=106)

Biochemical Parameters	Frequency	Percentage

ESR (mm/hr)		
Low ESR (≤20)	24	22.64%
Moderate ESR (21-40)	43	40.57%
Elevated ESR (41-60)	24	22.64%
High ESR (>60)	15	14.15%
Mean±SD	37.95±26.33 mm/hr	
RBC (million/cmm)		
Low RBC (≤3.9 million/cmm)	36	33.96%
Normal (4-5.2 million/cmm)	67	63.21%
High RBC (>5.2 million/cmm)	3	2.83%
Mean±SD	4.21±0.57 million/cmm	
Hematocrit/PCV (%)		
Low Hematocrit (≤36%)	104	98.11%
Normal (36.1-48%)	2	1.89%
Mean±SD	29.39±3.49%	
Red Cell Distribution Width (RDW) (%)		
Low RDW (≤12.5%)	1	0.94%
Normal (12.6-14.5%)	7	6.60%
High RDW (>14.5%)	98	92.45%
Mean±SD	17.59±3.33%	
Platelet Count (10^9/L)		
Low Platelets (≤150 *× 10^9/L)	14	13.21%
Normal (151-400 *× 10^9/L)	81	76.42%
High Platelets (>400 *× 10^9/L)	10	9.43%
Mean±SD	268.44±122.665	
MCV (fL)		
Low MCV (≤80 fL)	94	88.68%
Normal (80.1-100 fL)	11	10.38%
High MCV (>100 fL)	1	0.94%
Mean±SD	69.77±9.71 fL	
MCH (pg)		
Low MCH (≤27 pg)	101	95.28%
Normal (27.1-32 pg)	4	3.77%
High MCH (>32 pg)	1	0.94%
Mean±SD	21.80±6.44 pg	
Neutrophil		
Low Neutrophils (≤40%)	33	31.13%
Normal (41-75%)	53	50.00%
High Neutrophils (>75%)	20	18.87%
Mean±SD	54.28±21.09%	
MPV (fL)		
Normal (7.6-11 fL)	75	70.75%
High MPV (>11 fL)	31	29.25%
Mean±SD	10.31±1.11 fL	

The biochemical parameters among the participants (N=106) revealed several key findings. The mean erythrocyte sedimentation rate (ESR) was 37.95±26.33 mm/hr, with 40.57% of participants having moderate ESR levels (21-40 mm/hr). A notable portion of the population (33.96%) exhibited low RBC counts, with a mean RBC of 4.21±0.57 million/cmm. Almost all participants (98.11%) had low hematocrit values, with a mean hematocrit of 29.39±3.49%. Regarding RDW, 92.45% of the participants had elevated RDW levels (>14.5%), with a mean RDW of 17.59±3.33%, suggesting significant anisocytosis. The mean platelet count was 268.44±122.67 *10^9/L, and most participants (76.42%) had normal platelet levels. The majority of the population (88.68%) had low MCV values, with a mean MCV of 69.77±9.71 fL. Similarly, 95.28% of participants had low MCH levels (mean 21.80±6.44 pg). Neutrophil counts were normal in 50% of participants, with a mean neutrophil percentage of 54.28±21.09%. Lastly, 29.25% of the population had elevated mean platelet volumes (MPV), with a mean of 10.31±1.11 fL.

Table 3: Bivariate correlation between relevant biochemical parameters (N=106)

Correlations	**RDW (%)**	**Hemoglobin (g/dl)**	**RBC (million/cmm)**	**ESR (mm/hr)**	**HCT/PCV (%)**	**Platelet Count (cmm)**	**MCV (fL)**	**Neutrophils (%)**	**MCH (pg)**

RDW (%)	Pearson Correlation	1	-.435**	.315**	.225*	-0.027	0.097	-.664**	-.214*	-0.009
	Sig. (2-tailed)		**<0.001**	**0.001**	**0.041**	0.786	0.328	**<0.001**	**0.028**	0.925
Hemoglobin (g/dl)	Pearson Correlation	-.435**	1	.285**	-.397**	.825**	0.012	.420**	0.036	.349**
	Sig. (2-tailed)	**<0.001**		**0.003**	**<0.001**	**<0.001**	0.902	**<0.001**	0.711	**<0.001**
RBC (million/cmm)	Pearson Correlation	.315**	.285**	1	-0.169	.405**	0.153	-.559**	-.301**	-.362**
	Sig. (2-tailed)	**0.001**	**0.003**		0.127	**<0.001**	0.122	**<0.001**	**0.002**	**<0.001**
ESR (mm/hr)	Pearson Correlation	.225*	-.397**	-0.169	1	-.336**	0.039	-0.126	.294**	-0.197
	Sig. (2-tailed)	**0.041**	**<0.001**	0.127		**0.002**	0.733	0.257	**0.007**	0.074
HCT/PCV (%)	Pearson Correlation	-0.027	.825**	.405**	-.336**	1	-0.081	0.112	-0.102	.541**
	Sig. (2-tailed)	0.786	**<0.001**	**<0.001**	**0.002**		0.414	0.252	0.300	**<0.001**
Platelet Count (cmm)	Pearson Correlation	0.097	0.012	0.153	0.039	-0.081	1	-0.141	-0.038	-0.084
	Sig. (2-tailed)	0.328	0.902	0.122	0.733	0.414		0.156	0.707	0.400
MCV (fL)	Pearson Correlation	-.664**	.420**	-.559**	-0.126	0.112	-0.141	1	.361**	0.123
	Sig. (2-tailed)	**<0.001**	**<0.001**	**<0.001**	0.257	0.252	0.156		**<0.001**	0.208
Neutrophils (%)	Pearson Correlation	-.214*	0.036	-.301**	.294**	-0.102	-0.038	.361**	1	-0.031
	Sig. (2-tailed)	**0.028**	0.711	**0.002**	**0.007**	0.300	0.707	**<0.001**		0.749
MCH (pg)	Pearson Correlation	-0.009	.349**	-.362**	-0.197	.541**	-0.084	0.123	-0.031	1
	Sig. (2-tailed)	0.925	**<0.001**	**<0.001**	0.074	**<0.001**	0.400	0.208	0.749	

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

The bivariate correlation analysis revealed several significant relationships between RDW and other biochemical parameters. RDW showed a significant negative correlation with hemoglobin ($r = -0.435$, $p < 0.001$), MCV ($r = -0.664$, $p < 0.001$), and neutrophils ($r = -0.214$, $p = 0.028$), indicating that as RDW increases, these parameters tend to decrease. A positive correlation was found between RDW and RBC count ($r = 0.315$, $p = 0.001$) as well as ESR ($r = 0.225$, $p = 0.041$), suggesting that higher RDW is associated with elevated RBC counts and ESR levels. No significant correlations were observed between RDW and platelet count ($r = 0.097$, $p = 0.328$) or hematocrit ($r = -0.027$, $p = 0.786$). Additionally, hemoglobin was strongly positively correlated with hematocrit ($r = 0.825$, $p < 0.001$) and MCV ($r = 0.420$, $p < 0.001$), and negatively correlated with ESR ($r = -0.397$, $p < 0.001$).

IV. Discussion

The present study aimed to evaluate the diagnostic utility of Red Cell Distribution Width (RDW) in identifying Iron Deficiency Anemia (IDA) within a cohort of Bangladeshi patients, using hematological indices such as hemoglobin, Mean Corpuscular Volume (MCV), and RBC count. The results revealed that 92.45% of the participants exhibited elevated RDW values, with a mean RDW of 17.59±3.33%, aligning with the widely recognized role of RDW in distinguishing between microcytic anemias, particularly IDA and β-thalassemia trait

(β-TT). Previous studies, such as those by Mondal et al. and Jameel et al., found similarly elevated RDW in IDA patients, particularly when compared to other microcytic conditions like β-TT (15,16). The significant negative correlation between RDW and both hemoglobin ($r = -0.435$, $p < 0.001$) and MCV ($r = -0.664$, $p < 0.001$) observed in this study is consistent with earlier reports by Das Gupta et al. and Viswanath et al., both of which underscored the inverse relationship between RDW and hemoglobin in IDA, further validating RDW as a sensitive marker for diagnosing and monitoring the severity of iron deficiency (12,17). The correlation between RDW and RBC count ($r = 0.315$, $p = 0.001$), as well as ESR ($r = 0.225$, $p = 0.041$), highlights the inflammatory dimension of IDA in this cohort, suggesting that elevated RDW could reflect both anemia severity and underlying inflammation. This finding is supported by Badrick et al., who demonstrated that RDW could predict anemia-related inflammatory responses, and Baynes et al., who reported a similar association between RDW and inflammatory markers like ESR and C-reactive protein (CRP) (18,19). The elevation in ESR observed in this study mirrors the findings of similar studies, where elevated ESR and RDW were both markers of chronic inflammation and anemia (20,21). The demographic analysis showed that younger age groups (≤20 years) and females were disproportionately represented, with females accounting for 76.42% of the participants. These findings are consistent with global trends indicating that females, particularly those of reproductive age, are more prone to IDA due to physiological demands and nutritional factors. Studies by Levi et al. and Mejía-Rodríguez et al. similarly reported higher IDA prevalence among young women in low-resource settings (22,23). Furthermore, the finding that 98.11% of participants had low hematocrit (HCT ≤36%) with a mean hematocrit of 29.39±3.49% also aligns with previous literature, which emphasizes that both hematocrit and hemoglobin levels are crucial in the clinical assessment of anemia. The comparative behavior of RBC indices in studies such as those by Mondal et al. and Jassim et al. also showed that IDA patients typically present with significantly lower hematocrit values when compared to β-TT, reinforcing the diagnostic relevance of hematocrit alongside RDW in IDA (15,24). Moreover, 88.68% of the participants exhibited low MCV, with a mean MCV of 69.77±9.71 fL, reflecting the microcytic nature of anemia in this cohort. This trend is comparable to the findings from studies by Flynn et al. and Sim et al., where low MCV was a distinguishing factor in diagnosing microcytic anemias like IDA (25,26). These studies highlighted that the combination of elevated RDW and low MCV significantly improves the diagnostic accuracy of IDA, especially in settings where more advanced iron-status markers like serum ferritin are unavailable. The comparative analysis between MCV and RDW in distinguishing between IDA and other forms of anemia, such as β-TT, has been a recurring theme in hematological studies, further cementing their utility in resource-limited settings like Bangladesh (12,15,24). In summary, the current study's findings align with global and regional research, underscoring the diagnostic value of RDW in identifying IDA, especially when used in conjunction with other hematological parameters such as hemoglobin, MCV, and RBC count. RDW's significant correlations with hemoglobin and MCV affirm its role as a critical diagnostic tool, as demonstrated by multiple comparative studies (12,15–18). Additionally, the high prevalence of elevated RDW and low MCV in this study mirrors the diagnostic profiles observed in populations with a high burden of IDA, as reported in studies across various regions (12,17,23). These findings emphasize the need for incorporating RDW into routine anemia screening protocols, particularly in resource-constrained settings like Bangladesh, where access to more expensive diagnostic tools remains limited.

Limitations of The Study

The study was conducted in a retrospective manner with a small sample size. So, the results may not represent the whole community.

V. Conclusion

The findings of this study underscore the diagnostic value of Red Cell Distribution Width (RDW) in identifying Iron Deficiency Anemia (IDA) in resource-constrained settings such as Bangladesh. Elevated RDW, in conjunction with other hematological parameters such as hemoglobin, Mean Corpuscular Volume (MCV), and Red Blood Cell (RBC) count, offers a reliable, cost-effective, and accessible diagnostic tool for early detection of IDA, especially in populations where advanced diagnostic resources are limited. The strong correlations observed between RDW, hemoglobin, and MCV further validate RDW's utility as a key marker in the diagnosis and management of microcytic anemias. Integrating RDW into routine anemia screening protocols could significantly enhance the accuracy of IDA detection, improve patient outcomes, and reduce healthcare costs in low-resource settings. Future research should focus on further validating RDW across different demographic groups and exploring its prognostic potential in more complex clinical conditions.

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