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Assessment of Iron Profile and Hematological Indices among Iron Deficiency Anemic Patients: A Pilot Cross-Sectional Study

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ABSTRACT: Background: Iron deficiency anaemia (IDA) is commonly associated with changes in haematological indices and iron-status parameters. This pilot study evaluated these parameters across different degrees of anaemia severity.

Methods: A pilot cross-sectional study was conducted among 50 patients with physician-confirmed IDA attending the Department of General Medicine, Teerthanker Mahaveer Hospital and Research Centre, Moradabad, India. Participants were recruited consecutively and classified into mild (n=15), moderate (n=25), and severe (n=10) anaemia groups based on haemoglobin concentration. Complete blood count and iron-profile parameters were assessed. Between-group differences were evaluated using one-way ANOVA with eta-squared effect size, while Pearson's correlation was used to examine associations between haematological and iron-status parameters.

Results: Significant differences were observed across severity groups for haemoglobin, RBC count, PCV, MCV, MCH, RDW, platelet count, serum iron, ferritin, TIBC, UIBC, transferrin and TSAT ($P < 0.001$). Severe anaemia showed lower haemoglobin (6.73 ± 0.44 g/dL), serum iron (27.69 ± 8.09 µg/dL), ferritin (6.51 ± 2.78) and TSAT ($6.27 \pm 1.85\%$), with higher RDW, platelet count, TIBC, UIBC and transferrin. Haemoglobin correlated positively with ferritin ($r = 0.75$) and negatively with UIBC ($r = -0.72$; both $P < 0.001$).

Conclusion: Increasing IDA severity was associated with progressive deterioration of haematological indices and iron availability. Combined assessment of CBC and iron-profile parameters may provide a comprehensive laboratory assessment of IDA severity.

INTRODUCTION

Iron deficiency is one of the most common nutritional deficiencies worldwide and remains an important cause of anaemia, particularly in low- and middle-income countries^[1]. Iron deficiency anaemia (IDA) develops when iron availability becomes inadequate to support normal erythropoiesis and haemoglobin synthesis. It is associated with fatigue, reduced physical capacity, impaired cognitive performance and reduced quality of life, making its early recognition clinically important^[2]. India continues to face a substantial burden of anaemia across different population groups^[3]. A recent systematic review and meta-analysis of studies conducted in India reported considerable variation in anaemia prevalence across age groups and geographical regions, highlighting the continuing importance of anaemia as a public health concern in the country^[3]. However, anaemia is a heterogeneous condition with multiple nutritional, inflammatory, infectious, genetic and chronic disease-related causes^[4]. Therefore, identifying iron deficiency as an underlying cause requires assessment beyond haemoglobin concentration alone^[5]. The updated World Health Organization (WHO) guideline also emphasizes the importance of appropriate haemoglobin thresholds for the identification and classification of anaemia^[6]. Laboratory evaluation of IDA generally combines haematological indices with biochemical markers of iron status. Haemoglobin, mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC), and red cell distribution width (RDW) provide information about the effect of iron deficiency on erythropoiesis. Iron deficiency commonly results in a microcytic and hypochromic red-cell pattern; however, these findings may overlap with other causes of microcytic anaemia. Assessment of serum ferritin, serum iron, total iron-binding capacity (TIBC) and transferrin saturation (TSAT) provides complementary information regarding iron stores and iron availability. Ferritin is a useful marker of iron stores, although its interpretation may be affected by inflammation because it also behaves as an acute-phase protein^[7]. Although individual haematological and biochemical parameters are routinely used in the evaluation of IDA, their relationships may vary according to the degree of iron deficiency and characteristics of the studied population^[8]. Evaluating these parameters together may provide a more comprehensive description of the laboratory profile of patients with IDA and may help identify patterns relevant to routine diagnostic assessment. Therefore, this pilot cross-sectional study aimed to assess the iron profile and haematological indices among patients with iron deficiency anaemia and to evaluate the relationship between biochemical indicators of iron status and routinely measured haematological parameters. The findings will provide preliminary evidence for larger studies investigating laboratory markers and diagnostic patterns of IDA.

MATERIAL AND METHODS

Study design and study setting: A pilot cross-sectional study was conducted by the Department of Medical Laboratory Techniques, College of Paramedical Sciences, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India. The study included 50 patients with physician-confirmed IDA attending the Department of General Medicine, Teerthanker Mahaveer Hospital and Research Centre, Moradabad, Uttar Pradesh, India.

Study population and recruitment: Eligible patients clinically diagnosed with IDA by the treating physician were approached for participation. Patients were recruited consecutively during the study period after meeting the predefined eligibility criteria.

Ethical considerations: The study was approved by the Institutional Ethics Committee of Teerthanker Mahaveer University, Moradabad, India (Approval No. TMU/IEC/2024-25/049). All methods were performed in accordance with the relevant institutional guidelines and regulations and the ethical principles of the Declaration of Helsinki. Written informed consent was obtained from all participants before enrolment. Participant confidentiality was maintained throughout the study.

Eligibility criteria

Inclusion criteria

- Patients with a physician-confirmed diagnosis of iron deficiency anaemia (IDA).
- Patients willing to participate and provide written informed consent.

- Patients available for the required clinical and laboratory investigations.

Exclusion criteria

- Patients with anaemia due to causes other than iron deficiency.
- Patients with previously diagnosed haematological disorders or haemoglobinopathies.
- Patients unwilling to provide a blood sample.
- Patients with incomplete clinical or laboratory information required for analysis.

Data collection: A structured data collection form was used to obtain relevant demographic and lifestyle information. The recorded variables included age, sex, place of residence, educational status, dietary pattern, smoking status, alcohol consumption and exercise level. For female participants, menstrual characteristics, including menstrual regularity and history of heavy menstrual bleeding, were also documented. Each participant was assigned a unique study identification code. Personal identifiers were excluded from the analytical dataset, and the collected information was handled confidentially.

Blood collection and sample processing: Approximately 5 mL of venous blood was collected from each participant using standard venipuncture procedures and appropriate aseptic precautions. Approximately 2 mL was transferred into an EDTA-containing tube for haematological analysis, while approximately 3 mL was collected into a plain tube for serum-based iron-profile investigations. The samples were transported to the laboratory under standard sample-handling conditions. Blood collected in plain tubes was allowed to clot at room temperature for approximately 30 min and was subsequently centrifuged at 3000 rpm for 5 min. The separated serum was carefully transferred into appropriately labelled aliquots and processed for the relevant biochemical and immunoassay investigations.

Laboratory Analysis

Haematological assessment: Complete blood count parameters, including haemoglobin, RBC count, PCV, MCV, MCH, MCHC, RDW, WBC count and platelet count, were measured using the Beckman Coulter DxH 900 automated haematology analyzer.

Iron-profile assessment: Serum iron and UIBC were measured using the DxC 700 AU Chemistry Analyzer (Beckman Coulter, USA) employing the respective automated photometric/colorimetric assays according to the manufacturer's instructions. Total iron-binding capacity was calculated from serum iron and UIBC: TIBC ($\mu\text{g/dL}$) = Serum iron ($\mu\text{g/dL}$) + UIBC ($\mu\text{g/dL}$). Serum ferritin was measured using the Access 2 Immunoassay System (Beckman Coulter, USA). Serum transferrin was measured using an automated immunochemical assay. Transferrin saturation was calculated as: TSAT (%) = [Serum iron ($\mu\text{g/dL}$) / TIBC ($\mu\text{g/dL}$)] $\times$ 100. Internal quality control was maintained throughout the laboratory analysis using appropriate control materials.

Anaemia severity classification: Anaemia severity was classified according to haemoglobin concentration. Participants were categorized as having mild anaemia (Hb 10.0–11.9 g/dL), moderate anaemia (Hb 8.0–9.9 g/dL), or severe anaemia (Hb <8.0 g/dL). These categories were used to compare haematological indices and iron-profile parameters across the three severity groups.

Data management and statistical analysis: The collected data were initially entered into Microsoft Excel and checked for completeness, consistency and potential data-entry errors. The cleaned dataset was subsequently imported into IBM SPSS Statistics for analysis. Categorical variables were summarised as frequencies and percentages, whereas continuous variables were expressed as mean $\pm$ standard deviation (SD). Differences in continuous variables among the mild, moderate and severe anaemia groups were assessed using one-way analysis of variance (ANOVA). Eta-squared (η^2) was reported as an effect-size measure to quantify the magnitude of between-group differences. Associations between haematological indices and iron-profile parameters were evaluated using Pearson's correlation coefficient (r). The corresponding P-values were reported for each correlation. A two-tailed $P < 0.05$ was considered statistically significant.

RESULTS

Sociodemographic, lifestyle and menstrual characteristics

The sociodemographic, lifestyle and menstrual characteristics of the study participants are presented in Table 1. Among the 50 participants, moderate severity was most frequently observed (25, 50.0%), followed by mild (15, 30.0%) and severe (10, 20.0%). The majority of participants were female (43, 86.0%) and resided in urban areas (31, 62.0%). Secondary education was the most common educational level (18, 36.0%), followed by primary education (13, 26.0%). Most participants were vegetarian (32, 64.0%), did not smoke (39, 78.0%) and did not consume alcohol (44, 88.0%). Moderate exercise was reported by 22 (44.0%) participants. Among the 43 participants with available menstrual data, 13 (30.2%) reported heavy menstrual bleeding and 14 (32.6%) had irregular menstrual cycles.

Table 1. Sociodemographic, lifestyle and menstrual characteristics of study participants

Characteristics	Category	Frequency (%)
Severity	Mild	15 (30.0)
	Moderate	25 (50.0)
	Severe	10 (20.0)
Residence	Urban	31 (62.0)
	Rural	19 (38.0)
Sex	Female	43 (86.0)
	Male	7 (14.0)
Education	Illiterate	7 (14.0)
	Primary	13 (26.0)
	Secondary	18 (36.0)
	Graduate and above	12 (24.0)
Diet	Vegetarian	32 (64.0)
	Non-vegetarian	18 (36.0)
Smoking	No	39 (78.0)
	Yes	11 (22.0)
Alcohol use	No	44 (88.0)
	Yes	6 (12.0)
Exercise level	Low	19 (38.0)
	Moderate	22 (44.0)
	High	9 (18.0)
Heavy menstrual bleeding*	No	30 (69.8)
	Yes	13 (30.2)
Menstrual status*	Regular	29 (67.4)
	Irregular	14 (32.6)

Percentages for menstrual variables were calculated among 43 participants with valid responses. Values are expressed as frequency and percentage (%).

Haematological parameters according to severity

The comparison of haematological parameters across mild, moderate and severe severity groups is presented in Table 2. Significant differences were observed for haemoglobin, RBC count, PCV, MCV, MCH, RDW and platelet count across the three severity groups (all $P < 0.001$). Haemoglobin, RBC count, PCV, MCV and MCH progressively decreased with increasing severity, whereas RDW and platelet count increased. The largest effect sizes were observed for haemoglobin ($\eta^2 = 0.87$), PCV ($\eta^2 = 0.81$) and RBC count and MCV (both $\eta^2 = 0.69$). Age, MCHC and total WBC count did not show significant differences among the severity groups.

Table 2. Comparison of haematological parameters according to severity

Variable	Mild (n=15)	Moderate (n=25)	Severe (n=10)	F (df=2,47)	P	η^2
Age (years)	38.73 $\pm$ 12.07	39.80 $\pm$ 11.88	46.00 $\pm$ 12.20	1.25	0.297	0.05
Haemoglobin (g/dL)	10.69 $\pm$ 0.45	8.86 $\pm$ 0.62	6.73 $\pm$ 0.44	162.89	<0.001	0.87
RBC (million/ μ L)	3.72 $\pm$ 0.22	3.28 $\pm$ 0.18	2.84 $\pm$ 0.27	52.91	<0.001	0.69
PCV (%)	32.03 $\pm$ 2.07	26.32 $\pm$ 2.18	20.83 $\pm$ 0.95	99.59	<0.001	0.81
MCV (fL)	77.56 $\pm$ 0.79	72.40 $\pm$ 3.95	62.16 $\pm$ 5.38	52.42	<0.001	0.69
MCH (pg)	23.09 $\pm$ 1.17	21.53 $\pm$ 1.42	19.16 $\pm$ 1.46	25.15	<0.001	0.52
MCHC (g/dL)	29.91 $\pm$ 0.81	30.15 $\pm$ 0.78	29.29 $\pm$ 1.42	2.93	0.063	0.11
RDW (%)	16.49 $\pm$ 0.92	17.39 $\pm$ 1.25	18.64 $\pm$ 0.73	12.01	<0.001	0.34
Total WBC ($\times 10^3/\mu$ L)	7.53 $\pm$ 1.12	7.62 $\pm$ 1.52	7.96 $\pm$ 2.00	0.26	0.771	0.01
Platelets ($\times 10^3/\mu$ L)	255.07 $\pm$ 44.14	351.44 $\pm$ 49.21	410.70 $\pm$ 38.40	38.08	<0.001	0.62

Values are expressed as mean $\pm$ SD. One-way ANOVA was used for comparison among the three severity groups. η^2 , eta-squared. RBC, red blood cell; PCV, packed cell volume; MCV, mean corpuscular volume; MCH, mean corpuscular haemoglobin; MCHC, mean corpuscular haemoglobin concentration; RDW, red cell distribution width; WBC, white blood cell.

Iron profile according to severity

The comparison of iron-status parameters according to severity is presented in Table 3. Significant differences were observed in serum iron, serum ferritin, TIBC, UIBC, transferrin and transferrin saturation across the three severity groups (all $P < 0.001$). Serum iron, ferritin and transferrin saturation progressively decreased with increasing severity, whereas TIBC, UIBC and transferrin increased. The largest effect sizes were observed for transferrin saturation ($\eta^2 = 0.63$), serum iron ($\eta^2 = 0.57$) and serum ferritin ($\eta^2 = 0.53$), indicating substantial differences in iron status across severity categories.

Table 3. Comparison of iron-profile parameters according to severity

Variable	Mild (n=15)	Moderate (n=25)	Severe (n=10)	F (df=2,47)	P	η^2
Serum iron (μ g/dL)	43.99 $\pm$ 2.95	41.02 $\pm$ 5.13	27.69 $\pm$ 8.09	30.62	<0.001	0.57
Serum ferritin (ng/mL)	13.46 $\pm$ 1.54	11.82 $\pm$ 2.69	6.51 $\pm$ 2.78	26.08	<0.001	0.53
TIBC (μ g/dL)	410.05 $\pm$ 11.59	416.77 $\pm$ 14.37	441.80 $\pm$ 30.38	10.08	<0.001	0.30
UIBC (μ g/dL)	366.07 $\pm$ 11.49	375.76 $\pm$ 14.47	414.11 $\pm$ 29.42	24.01	<0.001	0.51
Transferrin (mg/dL)	287.04 $\pm$ 8.12	291.74 $\pm$ 10.05	309.25 $\pm$ 21.28	10.07	<0.001	0.30
Transferrin saturation (%)	10.71 $\pm$ 0.75	9.85 $\pm$ 1.23	6.27 $\pm$ 1.85	40.53	<0.001	0.63

Values are expressed as mean $\pm$ SD. One-way ANOVA was used for comparison among the three severity groups. η^2 , eta-squared; TIBC, total iron-binding capacity; UIBC, unsaturated iron-binding capacity

Correlation of iron profile with haematological parameters

Pearson correlation analysis demonstrated significant associations between iron-profile parameters and haematological indices (Table 4). Serum iron and serum ferritin were positively correlated with haemoglobin, RBC count, PCV, MCV and MCH (all $P < 0.001$). Transferrin saturation showed the strongest positive correlations with haemoglobin ($r = 0.79$, $P < 0.001$), PCV ($r = 0.73$, $P < 0.001$), MCV ($r = 0.71$, $P < 0.001$) and RBC count ($r = 0.70$, $P < 0.001$). In contrast, TIBC and UIBC demonstrated significant inverse correlations with these haematological indices. RDW was inversely correlated with serum iron, serum ferritin and transferrin saturation, whereas platelet count showed significant inverse correlations with serum iron, ferritin and transferrin saturation. MCHC and total WBC count showed no significant correlations with most iron-profile parameters.

Table 4. Correlation of iron-profile parameters with haematological indices

Haematological parameter	Serum iron, r (P)	Serum ferritin, r (P)	TIBC, r (P)	UIBC, r (P)	Transferrin, r (P)	Transferrin saturation, r (P)
Haemoglobin (g/dL)	0.74 (<0.001)	0.75 (<0.001)	-0.56 (<0.001)	-0.72 (<0.001)	-0.56 (<0.001)	0.79 (<0.001)
RBC (million/ μ L)	0.67 (<0.001)	0.53 (<0.001)	-0.46 (0.001)	-0.60 (<0.001)	-0.46 (0.001)	0.70 (<0.001)
PCV (%)	0.68 (<0.001)	0.68 (<0.001)	-0.50 (<0.001)	-0.65 (<0.001)	-0.50 (<0.001)	0.73 (<0.001)
MCV (fL)	0.66 (<0.001)	0.65 (<0.001)	-0.51 (<0.001)	-0.65 (<0.001)	-0.51 (<0.001)	0.71 (<0.001)
MCH (pg)	0.63 (<0.001)	0.66 (<0.001)	-0.54 (<0.001)	-0.66 (<0.001)	-0.54 (<0.001)	0.69 (<0.001)
MCHC (g/dL)	0.20 (0.159)	0.32 (0.025)	0.04 (0.803)	-0.03 (0.812)	0.04 (0.804)	0.19 (0.175)
RDW (%)	-0.43 (0.002)	-0.52 (<0.001)	0.33 (0.018)	0.42 (0.002)	0.33 (0.019)	-0.47 (0.001)
Total WBC ($\times 10^3/\mu$ L)	-0.17 (0.250)	-0.12 (0.403)	0.09 (0.541)	0.13 (0.372)	0.09 (0.542)	-0.16 (0.254)
Platelets ($\times 10^3/\mu$ L)	-0.57 (<0.001)	-0.62 (<0.001)	0.47 (0.001)	0.59 (<0.001)	0.47 (0.001)	-0.62 (<0.001)

Values are Pearson's correlation coefficient (r) with corresponding P-value in parentheses. $P < 0.05$ was considered statistically significant. RBC, red blood cell; PCV, packed cell volume; MCV, mean corpuscular volume; MCH, mean corpuscular haemoglobin; MCHC, mean corpuscular haemoglobin concentration; RDW, red cell distribution width; WBC, white blood cell; TIBC, total iron-binding capacity; UIBC, unsaturated iron-binding capacity.

DISCUSSION

The present pilot study demonstrated a clear gradient of haematological and iron-profile abnormalities across increasing severity of IDA. As haemoglobin-defined severity increased from mild to severe anaemia, haemoglobin, RBC count, PCV, MCV and MCH progressively declined, whereas RDW and platelet count increased. A similar pattern was observed for the biochemical indices of iron status, with lower serum iron, ferritin and transferrin saturation and higher TIBC, UIBC and transferrin in participants with more severe anaemia. The magnitude of these differences was substantial, with particularly large effect sizes

for haemoglobin, PCV, RBC count, MCV and TSAT, supporting the biological consistency of the severity-based grouping. The progressive reduction in haemoglobin across the three groups was expected because haemoglobin concentration forms the basis of anaemia severity classification. The mean haemoglobin values in the mild, moderate and severe groups were 10.69, 8.86 and 6.73 g/dL, respectively. The strong between-group effect ($\eta^2=0.87$) indicates that severity classification in this cohort was closely reflected by the measured haemoglobin concentrations. The updated WHO guidance continues to use haemoglobin concentration as the principal marker for defining anaemia severity, while emphasizing that haemoglobin thresholds vary according to age, sex and pregnancy status^[6]. RDW showed the opposite pattern, increasing from 16.49% in mild anaemia to 18.64% in severe anaemia. The significant trend suggests increasing heterogeneity in erythrocyte size as iron deficiency becomes more pronounced. RDW is particularly relevant because iron-restricted erythropoiesis does not affect all circulating erythrocytes uniformly; newly produced cells may become progressively smaller and more hypochromic, producing greater variation in cell size^[9]. Recent work examining CBC-based prediction of iron deficiency anaemia has also highlighted RDW, MCV, MCH, haemoglobin, haematocrit and RBC-related indices as informative features for identifying iron-restricted states^[10]. Interestingly, MCHC did not differ significantly between the severity groups ($P=0.063$), despite significant changes in MCV and MCH. This finding suggests that not every erythrocyte index changes proportionately with increasing severity of IDA. In contrast, the absence of a significant difference in WBC count ($P=0.771$) indicates that the observed haematological changes were predominantly related to the erythroid compartment rather than representing a generalized alteration in circulating leukocytes. Platelet counts increased progressively from $255.07 \times 10^3/\mu\text{L}$ in mild anaemia to $410.70 \times 10^3/\mu\text{L}$ in severe anaemia, with a large between-group effect ($\eta^2=0.62$). The inverse correlation between platelet counts and haemoglobin, as well as its negative association with serum iron and ferritin, further supports an association between worsening iron depletion and reactive thrombocytosis in this cohort^[11]. Although platelet elevation is not specific to iron deficiency, increased platelet production has been described in iron-deficient states and may become more apparent with greater severity^[12]. Therefore, the platelet findings should be interpreted as an accompanying haematological feature rather than a diagnostic marker of IDA. The iron-profile findings provide particularly strong support for progressive iron depletion. Serum iron decreased from 43.99 $\mu\text{g/dL}$ in the mild group to 27.69 $\mu\text{g/dL}$ in the severe group, while ferritin decreased from 13.46 to 6.51, indicating markedly reduced iron stores among participants with severe anaemia. At the same time, TIBC, UIBC and transferrin increased with severity. This reciprocal pattern is physiologically compatible with increasing iron deficiency: reduced circulating iron and depleted storage iron are accompanied by increased iron-binding capacity and increased iron transport capacity. Contemporary recommendations emphasise that iron deficiency should not be assessed using a single biomarker alone and that ferritin, serum iron availability and transferrin saturation provide complementary information^[13]. The reduction in TSAT was particularly pronounced, falling from 10.71% in mild anaemia to 6.27% in severe anaemia. The strong correlation between TSAT and haemoglobin ($r=0.79$, $P<0.001$), together with its correlation with MCV, MCH and PCV, suggests that reduced circulating iron availability was closely associated with impaired erythropoiesis in the study population. The importance of assessing several iron markers is also supported by recent population-level evidence. In a 2024 analysis of 8,021 US adults from NHANES, Tawfik et al. found that absolute and functional iron deficiency were both common and demonstrated that iron deficiency can occur across different clinical groups, including individuals without anaemia. Their analysis used ferritin, serum iron and UIBC, with TSAT calculated from iron and TIBC, highlighting the complementary value of these measurements in characterising iron status^[14]. Although that population-based study differs substantially from the present hospital-based pilot study, its findings reinforce the importance of interpreting iron status through a panel of biomarkers rather than haemoglobin alone. Serum iron and ferritin showed positive correlations with haemoglobin, RBC count, PCV, MCV and MCH, whereas RDW and platelet count were inversely associated with several iron parameters. Ferritin showed a strong positive correlation with haemoglobin ($r=0.75$, $P<0.001$), while UIBC showed a strong inverse correlation ($r=-0.72$, $P<0.001$), indicating that reduced iron availability was associated with greater impairment of erythropoiesis. However, ferritin should be interpreted cautiously in the presence of inflammation because it is an acute-phase reactant. Correlations among iron, TIBC, UIBC, transferrin and TSAT require cautious interpretation because some variables were mathematically derived from others. In particular, the strong correlation between serum iron and TSAT ($r=0.98$) and the perfect correlation between TIBC and transferrin ($r=1.00$) partly reflect their mathematical and analytical relationships rather than independent biological associations^[15]. The observed pattern of lower MCV, MCH and haematocrit with higher RDW in more severe IDA is consistent with recent studies evaluating haematological indices and iron-status biomarkers. These findings support the complementary use of CBC parameters and iron-profile markers for characterizing iron deficiency.

The study included physician-confirmed IDA cases recruited consecutively and evaluated both haematological indices and multiple iron-status markers. Reporting effect sizes alongside P-values also strengthened the interpretation of between-group differences. However, the small sample size, single-centre design and absence of a non-anaemic control group limit generalisability. The cross-sectional design also precludes causal inference. In addition, inflammatory biomarkers and soluble transferrin receptor were not assessed, which may have provided additional information for interpreting ferritin levels. Derived iron parameters should also be interpreted with caution because of their mathematical interdependence.

CONCLUSION

In this pilot study, increasing IDA severity was associated with progressive deterioration of erythrocyte indices and iron status. Severe anaemia was characterised by lower haemoglobin, RBC count, PCV, MCV, MCH, serum iron, ferritin and TSAT, together with higher RDW, platelet count, TIBC, UIBC and transferrin. The findings indicate that combined assessment of haematological indices and iron-profile parameters provides a more comprehensive picture of IDA severity than either group of markers alone. Larger multicentre studies are warranted to confirm these findings and establish their clinical applicability.

DECLARATIONS

Ethics approval and consent to participate: The study was approved by the Institutional Ethics Committee of Teerthanker Mahaveer University, Moradabad, under approval number TMU/IEC/2024-25/049. Written informed consent was obtained from all participants before enrolment.

Consent for publication: Not applicable.

Competing interests: The authors declare that they have no competing interests.

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Authors' contributions: All authors contributed to the conception and design of the study, data collection, analysis and interpretation of results, manuscript preparation, and critical revision of the manuscript. All authors approved the final version.

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Data availability: The datasets generated and/or analysed during the present study are available from the corresponding author on reasonable request.

Use of artificial intelligence: No generative artificial intelligence tool was used to generate, analyse or interpret the study data.

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