



Original Article

## Clinico-Haematological Profile of Anaemia in Patients with Chronic Kidney Disease

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### ABSTRACT

**Background:** Anaemia is a near-universal and clinically important complication of chronic kidney disease (CKD), contributing to reduced quality of life and adverse cardiovascular outcomes. Characterising its severity, morphology and underlying iron status is essential for rational management. This study aimed to evaluate the clinico-haematological profile of anaemia in patients with CKD and to examine its relationship with renal function.

**Methods:** A hospital-based, cross-sectional observational study was conducted over one year (June 2024–May 2025) on 60 patients with established CKD and anaemia. Demographic, clinical and laboratory data were recorded, including complete blood count, red cell indices, red cell distribution width (RDW), reticulocyte count, peripheral blood smear examination and iron studies (serum iron, ferritin, total iron-binding capacity and transferrin saturation). CKD was staged using the estimated glomerular filtration rate (eGFR). Data were analysed using descriptive statistics, Pearson correlation, one-way ANOVA and the chi-square test, with  $p < 0.05$  considered significant.

**Results:** The mean age was  $59.0 \pm 12.6$  years with a male predominance (male:female = 1.73:1). Pallor (100%), fatigue (86.7%) and weakness (66.7%) were the commonest clinical features. The mean haemoglobin was  $9.07 \pm 1.25$  g/dL; moderate anaemia was the most frequent grade (75.0%). Normocytic normochromic anaemia was the predominant morphological pattern (63.3%), followed by microcytic hypochromic anaemia (23.3%). The mean eGFR was  $25.6 \pm 14.8$  mL/min/1.73 m<sup>2</sup>. Haemoglobin correlated strongly and positively with eGFR ( $r = 0.699$ ,  $p < 0.001$ ) and declined significantly across advancing CKD stages (ANOVA,  $p < 0.001$ ). Iron studies revealed transferrin saturation below 20% in 58.3% of patients, with absolute and functional iron deficiency in 30.0% and 28.3% respectively.

**Conclusion:** Anaemia in CKD was predominantly moderate, normocytic and normochromic, and worsened with declining renal function. A substantial proportion of patients showed iron deficiency, underscoring the value of combined morphological and iron-profile assessment to guide individualised therapy.

**Keywords:** Chronic kidney disease; Anaemia; Haemoglobin; Red cell indices; Iron studies; Estimated glomerular filtration rate.

### INTRODUCTION

Chronic kidney disease (CKD) is a progressive disorder characterised by an irreversible decline in renal function and is recognised as a major global public-health problem. Anaemia is among the most frequent and clinically significant complications of CKD, and its prevalence rises steadily as renal function deteriorates. The anaemia of CKD is typically normocytic and normochromic, although iron deficiency, chronic inflammation, nutritional deficiencies and blood loss may modify its morphological character.

The pathogenesis of anaemia in CKD is multifactorial. Inadequate production of erythropoietin by the diseased kidney is the principal mechanism, but reduced red cell survival, uraemic inhibition of erythropoiesis, absolute and functional iron deficiency, and the suppressive effects of chronic inflammation through hepcidin-mediated impairment of iron utilisation also contribute. The net result is a hypoproliferative anaemia with an inappropriately low reticulocyte response.

Anaemia in CKD is not merely a laboratory abnormality. It is independently associated with fatigue, impaired physical capacity, reduced quality of life, increased risk of left ventricular hypertrophy, cardiovascular events and higher mortality. Early recognition, accurate morphological classification and assessment of the underlying iron status are therefore essential to guide rational management, including iron supplementation and erythropoiesis-stimulating agents.

Against this background, the present study was undertaken to characterise the clinico-haematological profile of anaemia in patients with CKD attending a tertiary-care centre, to describe the morphological patterns and iron status of the anaemia, and to examine the relationship between haemoglobin concentration and the severity of renal dysfunction.

## Aims and Objectives

### The objectives of the study were:

- To study the clinical presentation of anaemia in patients with chronic kidney disease.

  1. To evaluate the haematological profile, including haemoglobin concentration, red cell indices, RDW, reticulocyte count and peripheral smear morphology.
  2. To assess the iron status (serum iron, ferritin, TIBC and transferrin saturation) of the study population.
  3. To correlate the severity of anaemia with the stage of CKD and the estimated glomerular filtration rate.

## MATERIALS AND METHODS

**Study design and setting:** This was a hospital-based, cross-sectional, observational study conducted in the Department of Pathology of a tertiary-care teaching hospital over a period of one year, from June 2024 to May 2025, in collaboration with the Department of Nephrology/Medicine.

**Study population:** A total of 60 patients with an established diagnosis of CKD and associated anaemia were enrolled by consecutive sampling after obtaining informed consent.

**Inclusion criteria:** Adult patients ( $\geq 18$  years) of either sex with diagnosed CKD (eGFR  $< 60$  mL/min/1.73 m<sup>2</sup> or evidence of kidney damage persisting for  $\geq 3$  months) and a haemoglobin concentration below the age- and sex-specific reference range.

**Exclusion criteria:** Patients with acute kidney injury, those who had received a blood transfusion within the preceding three months, patients with known primary haematological malignancy, and pregnant women were excluded.

**Data collection and laboratory methods:** A detailed clinical history and examination were recorded for each patient using a structured proforma. Venous blood samples were analysed for complete blood count and red cell indices (MCV, MCH, MCHC and RDW) on an automated haematology analyser. Peripheral blood smears stained with Leishman stain were examined for red cell morphology. Reticulocyte counts and iron studies—serum iron, serum ferritin and total iron-binding capacity (TIBC)—were performed, and transferrin saturation was calculated as (serum iron / TIBC)  $\times 100$ .

**Definitions:** Anaemia severity was graded by haemoglobin concentration as mild (10.0–11.9 g/dL), moderate (7.0–9.9 g/dL) and severe ( $< 7.0$  g/dL). CKD was staged by eGFR as Stage 3a (45–59), Stage 3b (30–44), Stage 4 (15–29) and Stage 5 ( $< 15$  mL/min/1.73 m<sup>2</sup>). Transferrin saturation below 20% with serum ferritin below 100 ng/mL was taken to indicate absolute iron deficiency, whereas transferrin saturation below 20% with ferritin of 100 ng/mL or more was regarded as functional iron deficiency.

**Statistical analysis:** Data were entered in a spreadsheet and analysed using standard statistical software. Continuous variables were expressed as mean  $\pm$  standard deviation and categorical variables as frequencies and percentages. The Pearson correlation coefficient was used to assess the relationship between haemoglobin and continuous variables; one-way analysis of variance (ANOVA) compared haemoglobin across CKD stages; and the chi-square test examined associations between categorical variables. A p-value  $< 0.05$  was considered statistically significant.

**Ethics:** The study was conducted in accordance with the principles of the Declaration of Helsinki after approval by the Institutional Ethics Committee, and informed consent was obtained from all participants.

## RESULTS

Sixty patients with CKD and anaemia were studied. The mean age was  $59.0 \pm 12.6$  years (range 31–85), and the largest proportion of patients belonged to the 60–69 year age group. There was a clear male preponderance, with 38 males (63.3%)

and 22 females (36.7%), giving a male-to-female ratio of 1.73:1. The demographic and baseline characteristics are summarised in Table 1.

Characteristic	Value	—
Number of patients	60	100%
Mean age (years)	59.0 ± 12.6	Range 31–85
Male	38	63.3%
Female	22	36.7%
Male : Female ratio	1.73 : 1	
Mean CKD duration (months)	39.1 ± 27.3	Range 3–126
Mean eGFR (mL/min/1.73 m <sup>2</sup> )	25.6 ± 14.8	Range 5.3–55.6

**Table 1. Demographic and baseline characteristics of the study population (n = 60).**

The age distribution of the cohort is shown in Table 2, with most patients concentrated in the fifth to seventh decades of life.

Age group (years)	Number of patients	Percentage
< 40	6	10.0%
40–49	9	15.0%
50–59	12	20.0%
60–69	21	35.0%
≥ 70	12	20.0%

**Table 2. Age distribution of the study population.**

Hypertension and diabetes mellitus were the dominant comorbid and aetiological associations. Hypertension was present, alone or in combination, in 39 patients (65.0%) and diabetes mellitus in 29 patients (48.3%). The distribution of major comorbidities is presented in Table 3.

Major comorbidity / association	Number	Percentage
Hypertension (alone)	20	33.3%
Diabetes mellitus + Hypertension	17	28.3%
Diabetes mellitus (alone)	12	20.0%
Others / Unknown	8	13.3%
Hypertension + Cardiovascular disease	2	3.3%
Chronic glomerulonephritis	1	1.7%

**Table 3. Distribution of major comorbidities and associations.**

Clinically, all patients presented with pallor (100%). Fatigue was reported in 52 patients (86.7%) and generalised weakness in 40 (66.7%). Symptoms reflecting the cardiovascular impact of anaemia—dyspnoea on exertion and palpitation—were seen in 25.0% and 15.0% of patients respectively (Table 4).

Clinical symptom	Number	Percentage
Pallor	60	100.0%
Fatigue	52	86.7%
Weakness	40	66.7%
Dyspnoea on exertion	15	25.0%
Palpitation	9	15.0%

**Table 4. Frequency of clinical symptoms (a patient may have more than one symptom).**

The mean haemoglobin concentration was 9.07 ± 1.25 g/dL. The mean corpuscular volume (MCV) of 84.3 ± 8.2 fL and mean corpuscular haemoglobin (MCH) of 27.4 ± 3.3 pg were consistent with a predominantly normocytic, normochromic process, while the elevated RDW (16.0 ± 2.9%) reflected anisocytosis in a subset of patients. The mean reticulocyte count was low at 0.99 ± 0.34%, indicating an inadequate marrow response. The complete haematological and iron-profile parameters are presented in Table 5.

Parameter	Mean ± SD	Range
Haemoglobin (g/dL)	9.07 ± 1.25	6.8 – 11.9
MCV (fL)	84.27 ± 8.20	66.2 – 104.9
MCH (pg)	27.41 ± 3.29	20.0 – 34.7
MCHC (g/dL)	32.37 ± 1.48	29.1 – 34.5
RDW (%)	15.97 ± 2.92	12.6 – 24.0
Reticulocyte count (%)	0.99 ± 0.34	0.3 – 1.6
Serum iron (µg/dL)	47.95 ± 14.17	18 – 81
Serum ferritin (ng/mL)	255.65 ± 190.75	14 – 643
TIBC (µg/dL)	282.42 ± 56.09	212 – 413

Transferrin saturation (%)	18.08 ± 7.12	4.4 – 32.7
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**Table 5. Haematological and iron-profile parameters of the study population (n = 60).**

On grading by haemoglobin concentration, moderate anaemia was the commonest, seen in 45 patients (75.0%), followed by mild anaemia in 13 (21.7%) and severe anaemia in 2 (3.3%). The mean haemoglobin was marginally lower in females (8.87 ± 1.35 g/dL) than in males (9.18 ± 1.20 g/dL); this difference was not statistically significant (t = 0.94, p = 0.35).

Anaemia grade	Number	Percentage
Mild (Hb 10.0–11.9 g/dL)	13	21.7%
Moderate (Hb 7.0–9.9 g/dL)	45	75.0%
Severe (Hb < 7.0 g/dL)	2	3.3%

**Table 6. Distribution of anaemia by severity grade.**

Peripheral smear examination demonstrated that normocytic normochromic anaemia was the predominant morphological type, present in 38 patients (63.3%). Microcytic hypochromic anaemia was seen in 14 patients (23.3%), dimorphic anaemia in 6 (10.0%) and macrocytic anaemia in 2 (3.3%) (Table 7, Figure 3). The microcytic hypochromic and dimorphic groups had the lowest mean serum ferritin (49.7 and 95.0 ng/mL respectively) and the highest mean RDW (18.7% and 21.0%), consistent with a contribution from iron deficiency.

Peripheral smear morphology	Number	Percentage
Normocytic normochromic	38	63.3%
Microcytic hypochromic	14	23.3%
Dimorphic	6	10.0%
Macrocytic	2	3.3%

**Table 7. Morphological classification of anaemia on peripheral blood smear.**

Patients were distributed across CKD stages as follows: Stage 3a, 8 (13.3%); Stage 3b, 12 (20.0%); Stage 4, 20 (33.3%); and Stage 5, 20 (33.3%). A clear inverse relationship was observed between renal function and the degree of anaemia. The mean haemoglobin fell progressively from 10.70 ± 1.04 g/dL in Stage 3a to 8.00 ± 0.83 g/dL in Stage 5, and this decline across stages was highly significant on one-way ANOVA (F = 19.33, p < 0.001) (Table 8, Figure 2).

CKD stage	n	%	Mean eGFR	Mean Hb (g/dL)
Stage 3a	8	13.3	52.1 ± 3.7	10.70 ± 1.04
Stage 3b	12	20.0	37.5 ± 3.9	9.54 ± 0.74
Stage 4	20	33.3	23.1 ± 4.8	9.20 ± 1.00
Stage 5	20	33.3	10.3 ± 2.8	8.00 ± 0.83

**Table 8. Distribution of patients by CKD stage with mean eGFR and haemoglobin.**

Haemoglobin showed a strong, statistically significant positive correlation with eGFR (Pearson r = 0.699, p < 0.001; Spearman ρ = 0.717), confirming that anaemia worsened as renal function declined (Figure 1). Linear regression indicated that haemoglobin increased by approximately 0.06 g/dL for every 1 mL/min/1.73 m<sup>2</sup> rise in eGFR (r<sup>2</sup> = 0.49). Correlations of haemoglobin with CKD duration (r = -0.23, p = 0.07) and age (r = -0.18, p = 0.17) showed a negative trend but did not reach statistical significance. Haemoglobin did not correlate significantly with serum ferritin (r = 0.04) or transferrin saturation (r = 0.15).

The distribution of anaemia severity across CKD stages is shown in Table 9 and Figure 4. Mild anaemia was confined largely to the earlier stages, whereas all cases of severe anaemia and the great majority of moderate anaemia occurred in Stages 4 and 5. The association between anaemia severity and CKD stage was statistically significant (χ<sup>2</sup> = 15.12, p = 0.0045).

CKD stage	Mild	Moderate	Severe	Total
Stage 3a	5	3	0	8
Stage 3b	4	8	0	12
Stage 4	4	16	0	20
Stage 5	0	18	2	20
Total	13	45	2	60

**Table 9. Cross-tabulation of anaemia severity with CKD stage (χ<sup>2</sup> = 15.12, p = 0.0045).**

Assessment of iron status revealed that transferrin saturation was below 20% in 35 patients (58.3%) and serum ferritin was below 100 ng/mL in 18 patients (30.0%). Using combined criteria, absolute iron deficiency (ferritin < 100 ng/mL and transferrin saturation < 20%) was identified in 18 patients (30.0%), and functional iron deficiency (ferritin ≥ 100 ng/mL

with transferrin saturation < 20%) in 17 patients (28.3%). A reticulocyte count below 2% in all patients confirmed the hypoproliferative nature of the anaemia (Table 10).

Iron-status category	Number	Percentage
Transferrin saturation < 20%	35	58.3%
Serum ferritin < 100 ng/mL	18	30.0%
Absolute iron deficiency	18	30.0%
Functional iron deficiency	17	28.3%
Inadequate reticulocyte response (< 2%)	60	100.0%

Table 10. Iron status of the study population.

## Figures

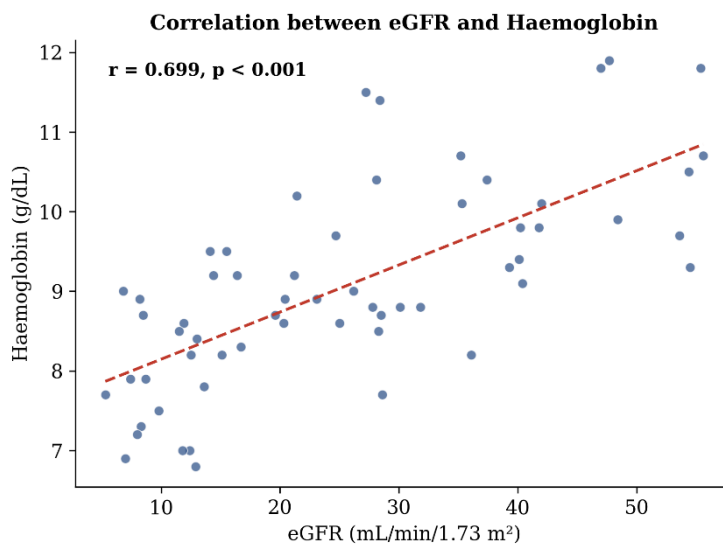


Figure 1. Scatter plot showing the strong positive correlation between estimated glomerular filtration rate (eGFR) and haemoglobin ( $r = 0.699, p < 0.001$ ).

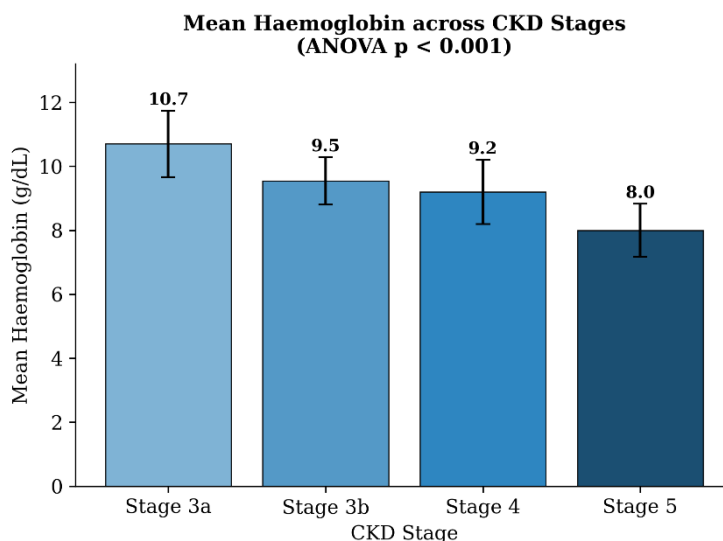


Figure 2. Mean haemoglobin concentration across CKD stages, showing a progressive decline with advancing disease (ANOVA,  $p < 0.001$ ).

### Peripheral Smear Morphology of Anaemia

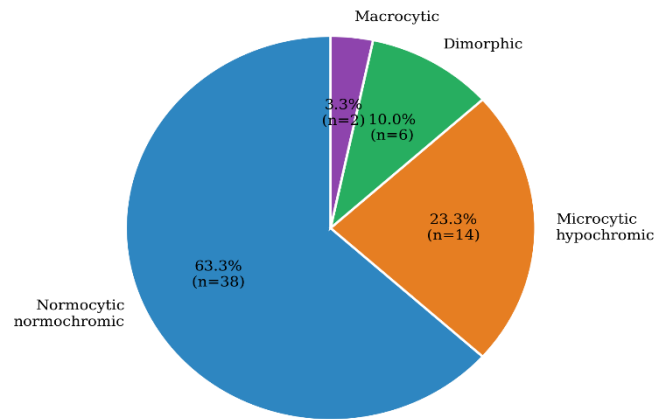


Figure 3. Distribution of peripheral smear morphology, with normocytic normochromic anaemia predominating.

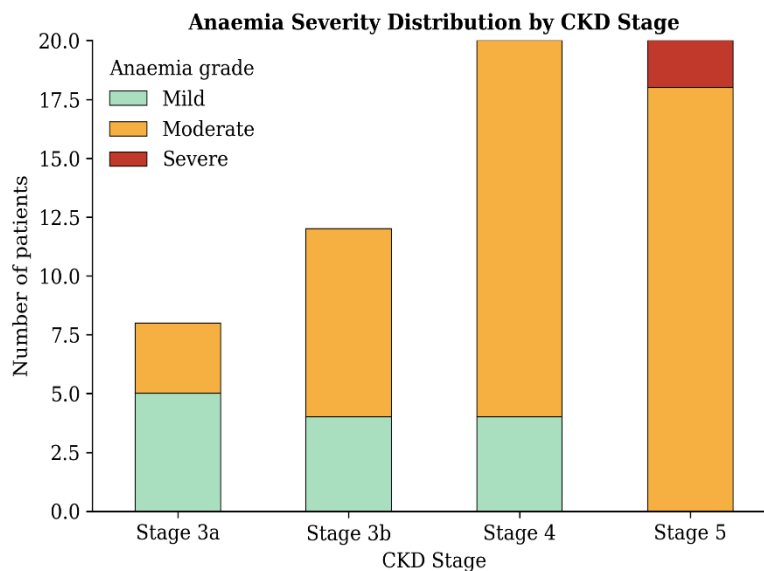


Figure 4. Distribution of anaemia severity across CKD stages.

## DISCUSSION

Anaemia is one of the earliest and most consistent systemic manifestations of progressive renal disease, and its assessment forms an integral part of the management of CKD. The present cross-sectional study of 60 patients characterised the clinical features, haematological indices, morphological pattern and iron status of anaemia in CKD and examined its relationship with renal function.

The mean age of 59 years and the male preponderance (1.73:1) observed in this study are in keeping with the demographic profile reported in several Indian and international series of CKD, in which middle-aged and older men predominate, partly reflecting the higher burden of diabetes and hypertension in this group. Hypertension and diabetes mellitus together accounted for the majority of associated comorbidities, consistent with their established role as the leading causes of CKD worldwide.

Clinically, pallor, fatigue and weakness were the dominant symptoms, mirroring the non-specific but pervasive impact of anaemia on functional status. The prominence of exertional dyspnoea and palpitation in a quarter and a sixth of patients respectively highlights the cardiovascular consequences of chronic anaemia, which contribute to the excess cardiovascular morbidity that characterises advanced CKD.

The mean haemoglobin of 9.07 g/dL, with moderate anaemia predominating, indicates a clinically meaningful burden of anaemia in this population. The predominance of normocytic normochromic morphology (63.3%) is the classical pattern of the anaemia of CKD and reflects its principal mechanism—relative erythropoietin deficiency producing a hypoproliferative anaemia, supported here by the uniformly low reticulocyte response. The substantial minority with

microcytic hypochromic (23.3%) and dimorphic (10.0%) pictures, accompanied by lower ferritin and higher RDW, points to a superimposed contribution from iron deficiency, which is common in CKD owing to reduced dietary intake, impaired absorption, chronic blood loss and inflammation.

The central finding of this study is the strong, highly significant positive correlation between haemoglobin and eGFR ( $r = 0.699$ ,  $p < 0.001$ ) and the progressive fall in mean haemoglobin across advancing CKD stages (ANOVA,  $p < 0.001$ ). This dose-dependent relationship between the severity of renal dysfunction and the depth of anaemia is consistent with the underlying pathophysiology, in which declining functional renal mass leads to progressively inadequate erythropoietin production. Similar correlations have been reported widely in the literature, reinforcing the value of monitoring haemoglobin as renal function declines and of initiating anaemia evaluation early in the course of CKD.

The iron studies add an important practical dimension. With transferrin saturation below 20% in nearly three-fifths of patients and roughly comparable proportions of absolute and functional iron deficiency, the data emphasise that iron status must be evaluated in every CKD patient with anaemia before, and during, treatment with erythropoiesis-stimulating agents. The distinction between absolute and functional iron deficiency is therapeutically relevant, as it determines the likely response to iron and erythropoietic therapy. The relatively wide range of serum ferritin, with high values in some patients, is in keeping with its behaviour as an acute-phase reactant in the inflammatory milieu of CKD, which limits its reliability as a sole marker of iron stores and supports the combined use of transferrin saturation.

Taken together, these findings support a pragmatic, integrated diagnostic approach to anaemia in CKD that combines haemoglobin grading, red cell indices and peripheral smear morphology with a full iron profile. Such an approach allows the clinician to distinguish the pure erythropoietin-deficiency anaemia of CKD from the frequent and treatable component of iron deficiency, and thereby to individualise therapy.

### Limitations

This study has several limitations. It was a single-centre, cross-sectional study with a modest sample size of 60 patients, which limits the statistical power for subgroup analyses and the generalisability of the findings. The cross-sectional design precludes inferences about causality or about the temporal evolution of anaemia. Serum ferritin, an acute-phase reactant, may overestimate iron stores in the presence of inflammation, and markers such as C-reactive protein, hepcidin and the percentage of hypochromic red cells were not assessed. Erythropoietin levels and nutritional markers such as vitamin B12 and folate were not measured. Larger, prospective, multicentre studies with longitudinal follow-up would help to confirm and extend these observations.

### CONCLUSION

Anaemia in chronic kidney disease in this cohort was predominantly moderate in severity and normocytic normochromic in morphology, accompanied by an inadequate reticulocyte response consistent with erythropoietin deficiency. Haemoglobin correlated strongly with eGFR and declined significantly with advancing CKD stage, confirming that anaemia worsens in step with renal dysfunction. A considerable proportion of patients showed absolute or functional iron deficiency, underscoring the importance of routine iron-profile assessment alongside morphological evaluation. Integrating clinical assessment, red cell indices, peripheral smear examination and iron studies enables accurate characterisation of the anaemia and supports rational, individualised management aimed at improving quality of life and reducing the cardiovascular burden in patients with CKD.

### Declarations

**Conflict of interest:** The authors declare that they have no conflict of interest.

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**Ethical approval:** Obtained from the Institutional Ethics Committee.

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