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# PREVALENCE AND RISK FACTORS OF ANAEMIA AMONG PATIENTS WITH CHRONIC KIDNEY DISEASE: A CROSS SECTIONAL OBSERVATIONAL STUDY

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**ABSTRACT**

**Background:** Anaemia is a common haematological complication of chronic kidney disease (CKD), contributing to increased morbidity, reduced functional capacity, and impaired quality of life. Its development is multifactorial, involving reduced erythropoietin production, iron deficiency, chronic inflammation, and progressive renal dysfunction. Early identification of associated risk factors is essential for effective clinical management. The aim is to assess the prevalence, severity, and associated risk factors of anaemia among patients with chronic kidney disease attending a tertiary care hospital.

**Materials and Methods:** The present hospital-based, cross-sectional observational study included 94 patients diagnosed with chronic kidney disease. Demographic characteristics, comorbidities, CKD stage, dialysis status, haematological indices, iron profile, and renal function parameters were evaluated. Anaemia was classified according to predefined haemoglobin thresholds. Data were analysed using SPSS version 27.0. A p-value <0.05 was considered statistically significant.

**Results:** Anaemia was observed in 70 patients (74.47%), with moderate anaemia being the predominant severity category (51.43%). Normocytic normochromic anaemia was the most common morphological pattern (67.14%). Anaemia prevalence increased significantly with advancing CKD stage, from 57.14% in stages G1–G3 to 95.45% in stage G5 (p=0.002). Significant associations were observed with diabetes mellitus (p=0.025), hypertension (p=0.046), longer CKD duration (p=0.018), haemodialysis (p=0.018), iron deficiency (p=0.005), and hypoalbuminaemia (p=0.013). Anaemic patients demonstrated significantly lower eGFR, transferrin saturation, and serum albumin levels, along with elevated serum creatinine (p<0.001).

**Conclusion:** Anaemia was highly prevalent among CKD patients and increased significantly with advancing renal dysfunction. Diabetes mellitus, hypertension, prolonged CKD, haemodialysis, iron deficiency, and hypoalbuminaemia were important associated factors. Routine screening and early management of anaemia may improve comprehensive CKD care.

**Keywords:** Anaemia; Chronic Kidney Disease; Haemoglobin; Iron Deficiency; Risk Factors.

## INTRODUCTION

Chronic kidney disease (CKD) is a major global public health concern characterised by progressive and often irreversible deterioration of renal structure and function. It represents a substantial clinical and socioeconomic burden because of its increasing occurrence, associated complications, and requirement for long-term medical care. The kidneys perform several essential physiological functions, including the regulation of fluid and electrolyte balance, maintenance of acid–base homeostasis, elimination of metabolic waste products, and production of hormones involved in blood pressure regulation and erythropoiesis. Progressive renal impairment consequently affects multiple organ

systems and contributes to considerable morbidity and mortality. Increasing life expectancy, diabetes mellitus, hypertension, obesity, and cardiovascular disorders have contributed to the growing burden of CKD. Early recognition of complications is therefore essential for improving clinical management and preventing further deterioration in affected individuals.[1]

Chronic kidney disease is defined by persistent abnormalities of kidney structure or function for at least three months, with implications for health. Diagnosis is established through reduced estimated glomerular filtration rate (eGFR), increased urinary albumin excretion, or other evidence of kidney damage. CKD is classified according to its underlying cause, glomerular filtration rate, and albuminuria category. As kidney function progressively declines, patients become increasingly susceptible to metabolic, cardiovascular, haematological, and nutritional complications. Among these, anaemia represents one of the most important and frequently encountered abnormalities. Although anaemia may occur during earlier stages of renal impairment, its clinical significance generally increases with advancing disease. Assessment of haemoglobin concentration alongside renal function parameters is therefore an essential component of comprehensive CKD evaluation.[2]

Anaemia associated with CKD is a complex, multifactorial condition primarily resulting from inadequate erythropoietin production by the diseased kidneys. Erythropoietin is a glycoprotein hormone responsible for stimulating red blood cell production in the bone marrow. Progressive renal damage reduces the ability of peritubular interstitial cells to produce sufficient erythropoietin in response to tissue hypoxia, leading to impaired erythropoiesis. Additional contributing mechanisms include shortened erythrocyte survival, chronic inflammation, uraemic toxins, bone marrow suppression, and nutritional deficiencies. Anaemia is commonly normocytic and normochromic, although microcytic and macrocytic patterns may also occur depending on associated deficiencies. The multifactorial nature of CKD-related anaemia necessitates comprehensive haematological evaluation rather than reliance on haemoglobin concentration alone.[3]

Iron deficiency is another important contributor to anaemia in patients with chronic kidney disease. It may occur because of inadequate dietary intake, reduced intestinal absorption, gastrointestinal blood loss, repeated blood sampling, and blood loss associated with haemodialysis procedures. Iron deficiency may be classified as absolute or functional. Absolute iron deficiency develops when body iron stores are depleted, whereas functional iron deficiency occurs when stored iron remains unavailable for effective erythropoiesis despite apparently adequate reserves. Chronic inflammation stimulates hepatic hepcidin production, which inhibits intestinal iron absorption and restricts iron release from storage sites. Consequently, serum ferritin levels may not accurately reflect available iron stores in inflammatory conditions. Assessment of transferrin saturation, serum ferritin, serum iron, and other haematological indices is therefore important for identifying iron abnormalities and guiding appropriate clinical management.[4]

The prevalence and severity of anaemia among CKD patients may vary according to geographical location, population characteristics, disease stage, comorbidities, nutritional status, and accessibility of healthcare services. Developing countries face additional challenges involving delayed diagnosis, limited access to specialised nephrology care, inadequate nutritional intake, and financial constraints affecting treatment adherence. In India, the coexistence of diabetes mellitus, hypertension, chronic inflammation, and nutritional deficiencies may contribute to the clinical complexity of CKD-related anaemia. Advanced age, prolonged kidney disease, declining eGFR, and dialysis dependence are additional factors requiring clinical evaluation. Understanding regional patterns of anaemia is particularly important because differences in healthcare accessibility and patient characteristics may influence its recognition and management.[5]

Anaemia substantially contributes to the clinical burden of chronic kidney disease by reducing oxygen delivery to peripheral tissues and increasing cardiovascular workload. Patients may experience persistent fatigue, generalised weakness, reduced exercise tolerance, breathlessness, dizziness, palpitations, and impaired concentration. These manifestations adversely affect functional capacity, occupational performance, and health-related quality of life. Persistent anaemia may also aggravate existing cardiovascular disease and complicate the overall management of renal dysfunction. Its clinical consequences extend beyond symptomatic impairment because it is associated with hospitalisation, cardiovascular complications, and unfavourable renal outcomes. Recognition of anaemia during routine clinical evaluation is therefore important for identifying patients requiring additional investigations and appropriate management.[6]

## MATERIALS AND METHODS

The present study was designed as a hospital-based, cross-sectional observational study conducted at a tertiary care hospital to assess the prevalence, severity, and associated risk factors of anaemia among patients with chronic kidney disease (CKD). The study was carried out in the Department of General Medicine in collaboration with the Department of Nephrology. Patients diagnosed with CKD and attending outpatient or inpatient services were evaluated for haematological abnormalities, renal function, biochemical parameters, and clinical factors associated with anaemia. A total of 94 patients

diagnosed with chronic kidney disease were included in the study. Patients aged 18 years and above with confirmed CKD were selected through consecutive sampling according to predefined eligibility criteria. Chronic kidney disease was defined as abnormalities of kidney structure or function persisting for at least three months, including an estimated glomerular filtration rate (eGFR) below 60 mL/min/1.73 m² or evidence of persistent kidney damage. Eligible patients were enrolled after obtaining written informed consent.

**Inclusion Criteria**

Patients aged 18 years and above with confirmed chronic kidney disease, irrespective of sex, were included. Patients with CKD stages G1–G5, including those receiving maintenance haemodialysis, were considered eligible. Participants who were clinically stable and willing to undergo the required clinical assessment and laboratory investigations were included in the study.

**Exclusion Criteria**

Patients with acute kidney injury, active gastrointestinal bleeding, recent major blood loss, known hereditary haemoglobinopathies, aplastic anaemia, or other primary haematological disorders were excluded. Patients with active malignancy receiving chemotherapy, severe acute infections, recent blood transfusion within three months, and pregnant women were also excluded to minimise factors that could independently influence haemoglobin levels.

**Methodology:** Demographic and clinical information was collected using a structured study proforma. Recorded parameters included age, sex, residence, socioeconomic status, body mass index (BMI), smoking history, alcohol consumption, duration of CKD, underlying aetiology, and family history of renal disease. Associated comorbidities, including diabetes mellitus, hypertension, cardiovascular disease, and other chronic illnesses, were documented. Clinical symptoms suggestive of anaemia, including fatigue, weakness, dizziness, exertional dyspnoea, palpitations, and pallor, were assessed. Blood pressure, height, weight, and BMI were recorded using standard procedures. Medication history, including iron supplementation, erythropoiesis-stimulating agents, antihypertensive drugs, and other relevant medications, was documented.

**Haematological Assessment:** Venous blood samples were collected under aseptic precautions for complete blood count and relevant haematological investigations. Haemoglobin concentration, total red blood cell count, haematocrit, mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC), red cell distribution width (RDW), total leucocyte count, and platelet count were recorded. Peripheral blood smear findings were evaluated to identify morphological patterns of anaemia. Serum ferritin, serum iron, total iron-binding capacity (TIBC), and transferrin saturation (TSAT) were assessed to evaluate iron status. Vitamin B12 and folate levels were assessed when clinically indicated.

**Definition and Classification of Anaemia:** Anaemia was defined according to World Health Organization haemoglobin thresholds as haemoglobin below 13.0 g/dL in adult males and below 12.0 g/dL in non-pregnant adult females. Anaemia was classified as mild (11.0–12.9 g/dL in males and 11.0–11.9 g/dL in females), moderate (8.0–10.9 g/dL), and severe (below 8.0 g/dL). Morphologically, anaemia was categorised as microcytic, normocytic, or macrocytic based on MCV values. Iron deficiency was evaluated using serum ferritin and transferrin saturation, considering the patient's inflammatory status and dialysis requirement.

**Assessment of Renal Function and Biochemical Parameters:** Renal function was evaluated using serum creatinine, blood urea, blood urea nitrogen, and estimated glomerular filtration rate calculated using the CKD-EPI equation. Patients were classified into CKD stages G1–G5 according to eGFR. Additional biochemical investigations included serum sodium, potassium, calcium, phosphorus, albumin, total protein, fasting blood glucose, and glycated haemoglobin (HbA1c), wherever applicable. Urine albumin-to-creatinine ratio (UACR) was assessed when available. Dialysis status and relevant treatment history were recorded.

**Assessment of Risk Factors:** Potential factors associated with anaemia were evaluated, including increasing age, female sex, advanced CKD stage, declining eGFR, longer duration of kidney disease, diabetes mellitus, hypertension, poor nutritional status, reduced BMI, iron deficiency, hypoalbuminaemia, proteinuria, and dialysis status. Associations between haemoglobin levels and renal function, iron indices, and other biochemical parameters were examined to identify significant predictors of anaemia.

**Statistical Analysis:** Data were entered into Microsoft Excel and analysed using Statistical Package for the Social Sciences (SPSS), version 27.0. Categorical variables were expressed as frequencies and percentages, while continuous variables were presented as mean ± standard deviation or median with interquartile range, as appropriate. The prevalence of anaemia was calculated as the proportion of CKD patients meeting the predefined haemoglobin criteria. The Chi-square test or Fisher's exact test was used to assess associations between categorical variables. The independent samples t-test or Mann–Whitney U test was applied for comparisons of continuous variables. Pearson's or Spearman's correlation coefficient was used to evaluate correlations between haemoglobin and renal function parameters. Logistic regression analysis was planned to identify independent factors associated with anaemia, subject to adequate outcome events. A p-value of less than 0.05 was considered statistically significant.

## RESULTS

[Table 1] Distribution of Demographic and Baseline Characteristics of CKD Patients (N=94)

[Table 1] presents the demographic and baseline characteristics of 94 patients with chronic kidney disease and their association with anaemia. The highest proportion of patients belonged to the age group ≥60 years (40.43%), followed by 45–59 years (36.17%) and 18–44 years (23.40%). The prevalence of anaemia increased with advancing age, from 63.64% among patients aged 18–44 years to 81.58% among those aged ≥60 years; however, this association was not statistically significant (p=0.304). Among the participants, 54.26% were males and 45.74% were females, with nearly identical anaemia prevalence of 74.51% and 74.42%, respectively (p=0.992). Rural residents constituted 60.64% of the study population and demonstrated a higher prevalence of anaemia (77.19%) compared with urban residents (70.27%), although the difference was statistically insignificant (p=0.452). Regarding body mass index, anaemia was present in 80.00% of patients with BMI ≥25 kg/m² compared with 70.37% of those with BMI <25 kg/m² (p=0.290). Overall, age, gender, residence, and BMI were not significantly associated with anaemia among the study participants.

[Table 2] Prevalence, Severity and Morphological Classification of Anaemia Among CKD Patients

[Table 2] illustrates the prevalence, severity, morphological characteristics, and iron deficiency status of anaemia among patients with chronic kidney disease. Of the 94 patients included in the study, 70 (74.47%) had anaemia, whereas 24 (25.53%) had normal haemoglobin levels according to the predefined criteria. Among the 70 anaemic patients, moderate anaemia was the most frequently observed category, affecting 36 patients (51.43%), followed by mild anaemia in 22 patients (31.43%) and severe anaemia in 12 patients (17.14%). Morphological examination demonstrated that normocytic normochromic anaemia was the predominant pattern, accounting for 47 patients (67.14%). Microcytic hypochromic anaemia was identified in 18 patients (25.71%), while macrocytic anaemia was observed in only 5 patients (7.14%). Iron deficiency was detected in 31 anaemic patients (44.29%), whereas 39 patients (55.71%) did not demonstrate iron deficiency. These findings indicated a high prevalence of anaemia among CKD patients, predominantly of moderate severity and normocytic normochromic morphology.

[Table 3] Association Between CKD Stage and Prevalence of Anaemia (N=94)

[Table 3] demonstrates the association between the severity of chronic kidney disease and the prevalence of anaemia among the 94 study participants. Among the patients, 42 (44.68%) belonged to CKD stages G1–G3, 30 (31.91%) were classified as stage G4, and 22 (23.40%) had stage G5 disease. Anaemia was present in 24 patients (57.14%) with CKD stages G1–G3, whereas 18 patients (42.86%) in this group did not have anaemia. In patients with CKD stage G4, the prevalence of anaemia increased to 83.33%, affecting 25 of the 30 patients. The highest prevalence was observed among patients with CKD stage G5, where 21 of 22 patients (95.45%) were anaemic, while only one patient (4.55%) had no anaemia. The association between CKD stage and anaemia was statistically significant (p=0.002), demonstrating an increasing prevalence of anaemia with advancing renal disease. These findings indicated that patients with advanced CKD, particularly stages G4 and G5, had a substantially greater burden of anaemia compared with those in earlier stages.

[Table 4] Association of Clinical and Biochemical Risk Factors with Anaemia Among CKD Patients (N=94)

[Table 4] presents the association of various clinical and biochemical risk factors with the occurrence of anaemia among patients with chronic kidney disease. Anaemia was significantly more prevalent among patients with diabetes mellitus (85.71%) compared with those without diabetes (65.38%; p=0.025), while patients with hypertension also demonstrated a significantly higher prevalence of anaemia (80.30% versus 60.71%; p=0.046). Patients with a CKD duration of ≥5 years had a greater prevalence of anaemia (86.05%) compared with those with a shorter disease duration (64.71%), and this association was statistically significant (p=0.018). Among patients receiving maintenance haemodialysis, 95.00% had anaemia compared with 68.92% of patients not receiving haemodialysis (p=0.018). Iron deficiency demonstrated a significant association with anaemia, with prevalence rates of 91.18% among iron-deficient patients and 65.00% among those without iron deficiency (p=0.005). Similarly, anaemia was significantly more frequent among patients with hypoalbuminaemia (90.32%) compared with those without hypoalbuminaemia (66.67%; p=0.013). Although patients with a smoking history demonstrated a higher prevalence of anaemia (83.33%) than non-smokers (71.43%), this association was not statistically significant (p=0.248).

[Table 5] Comparison of Haematological, Renal Function and Biochemical Parameters Between CKD Patients With and Without Anaemia

[Table 5] compares the haematological, renal function, and biochemical parameters between 70 CKD patients with anaemia and 24 patients without anaemia. The mean haemoglobin concentration was significantly lower among anaemic patients (9.45 ± 1.56 g/dL) compared with non-anaemic patients (13.28 ± 0.82 g/dL; p<0.001), while the difference in mean corpuscular volume (84.90 ± 9.80 versus 88.10 ± 7.40 fL) was not statistically significant (p=0.100). The mean estimated glomerular filtration rate was significantly lower in anaemic patients (26.90 ± 19.40 mL/min/1.73 m²) compared with non-anaemic patients (47.80 ± 23.30 mL/min/1.73 m²; p<0.001). Serum creatinine was significantly higher in anaemic

patients (3.42 ± 1.47 mg/dL) than in non-anaemic patients (2.11 ± 1.09 mg/dL; p<0.001), along with significantly elevated blood urea levels (98.60 ± 38.10 versus 76.20 ± 30.40 mg/dL; p=0.005). The mean serum ferritin level was comparatively lower among anaemic patients (183.50 ± 131.80 ng/mL) than non-anaemic patients (218.40 ± 128.50 ng/mL), although this difference was statistically insignificant (p=0.261). Transferrin saturation was significantly reduced among anaemic patients (18.40 ± 7.20%) compared with non-anaemic patients (25.60 ± 8.10%; p<0.001). Similarly, mean serum albumin was significantly lower in patients with anaemia (3.31 ± 0.55 g/dL) compared with those without anaemia (3.79 ± 0.49 g/dL; p<0.001), demonstrating significant associations of anaemia with impaired renal function, reduced transferrin saturation, and lower serum albumin levels.

**Table 1: Distribution of Demographic and Baseline Characteristics of CKD Patients (N=94)**

| Parameters | Total n (%) | Anaemia n (%) | No anaemia n (%) | p-value |
|---|---|---|---|---|
| Age (years) | | | | 0.304 |
| 18–44 | 22 (23.40%) | 14 (63.64%) | 8 (36.36%) | |
| 45–59 | 34 (36.17%) | 25 (73.53%) | 9 (26.47%) | |
| ≥60 | 38 (40.43%) | 31 (81.58%) | 7 (18.42%) | |
| Gender | | | | 0.992 |
| Male | 51 (54.26%) | 38 (74.51%) | 13 (25.49%) | |
| Female | 43 (45.74%) | 32 (74.42%) | 11 (25.58%) | |
| Residence | | | | 0.452 |
| Rural | 57 (60.64%) | 44 (77.19%) | 13 (22.81%) | |
| Urban | 37 (39.36%) | 26 (70.27%) | 11 (29.73%) | |
| BMI (kg/m²) | | | | 0.290 |
| <25 | 54 (57.45%) | 38 (70.37%) | 16 (29.63%) | |
| ≥25 | 40 (42.55%) | 32 (80.00%) | 8 (20.00%) | |

**Table 2: Prevalence, Severity and Morphological Classification of Anaemia Among CKD Patients**

| Parameters | Number (n) | Percentage (%) |
|---|---|---|
| Prevalence of anaemia (N=94) | | |
| Anaemia present | 70 | 74.47 |
| Anaemia absent | 24 | 25.53 |
| Severity of anaemia (n=70) | | |
| Mild anaemia | 22 | 31.43 |
| Moderate anaemia | 36 | 51.43 |
| Severe anaemia | 12 | 17.14 |
| Morphological classification (n=70) | | |
| Normocytic normochromic | 47 | 67.14 |
| Microcytic hypochromic | 18 | 25.71 |
| Macrocytic | 5 | 7.14 |
| Iron deficiency among anaemic patients (n=70) | | |
| Present | 31 | 44.29 |
| Absent | 39 | 55.71 |

**Table 3: Association Between CKD Stage and Prevalence of Anaemia (N=94)**

| CKD stage | Total patients n (%) | Anaemia present n (%) | Anaemia absent n (%) | p-value |
|---|---|---|---|---|
| Stages G1–G3 | 42 (44.68%) | 24 (57.14%) | 18 (42.86%) | |
| Stage G4 | 30 (31.91%) | 25 (83.33%) | 5 (16.67%) | |
| Stage G5 | 22 (23.40%) | 21 (95.45%) | 1 (4.55%) | |
| Total | 94 (100.00%) | 70 (74.47%) | 24 (25.53%) | 0.002 |

**Table 4: Association of Clinical and Biochemical Risk Factors with Anaemia Among CKD Patients (N=94)**

| Risk factors | Patients with factor (n) | Anaemia with factor n (%) | Anaemia without factor n (%) | p-value |
|---|---|---|---|---|
| Diabetes mellitus | 42 | 36 (85.71%) | 34 (65.38%) | 0.025 |
| Hypertension | 66 | 53 (80.30%) | 17 (60.71%) | 0.046 |
| CKD duration ≥5 years | 43 | 37 (86.05%) | 33 (64.71%) | 0.018 |
| Maintenance haemodialysis | 20 | 19 (95.00%) | 51 (68.92%) | 0.018 |
| Iron deficiency | 34 | 31 (91.18%) | 39 (65.00%) | 0.005 |
| Hypoalbuminaemia | 31 | 28 (90.32%) | 42 (66.67%) | 0.013 |
| Smoking history | 24 | 20 (83.33%) | 50 (71.43%) | 0.248 |

**Table 5: Comparison of Haematological, Renal Function and Biochemical Parameters Between CKD Patients With and Without Anaemia**

| Laboratory parameters | Anaemia present (n=70) Mean ± SD | Anaemia absent (n=24) Mean ± SD | p-value |
|---|---|---|---|
| Haemoglobin (g/dL) | 9.45 ± 1.56 | 13.28 ± 0.82 | <0.001 |
| Mean corpuscular volume (fL) | 84.90 ± 9.80 | 88.10 ± 7.40 | 0.100 |
| eGFR (mL/min/1.73 m²) | 26.90 ± 19.40 | 47.80 ± 23.30 | <0.001 |
| Serum creatinine (mg/dL) | 3.42 ± 1.47 | 2.11 ± 1.09 | <0.001 |
| Blood urea (mg/dL) | 98.60 ± 38.10 | 76.20 ± 30.40 | 0.005 |

| | | | |
|---|---|---|---|
| Serum ferritin (ng/mL) | 183.50 ± 131.80 | 218.40 ± 128.50 | 0.261 |
| Transferrin saturation (%) | 18.40 ± 7.20 | 25.60 ± 8.10 | <0.001 |
| Serum albumin (g/dL) | 3.31 ± 0.55 | 3.79 ± 0.49 | <0.001 |

## DISCUSSION

The present study included 94 patients with chronic kidney disease, among whom 40.43% were aged ≥60 years, 36.17% were aged 45–59 years, and 23.40% were aged 18–44 years. The prevalence of anaemia increased from 63.64% in younger patients to 81.58% among those aged ≥60 years, although this association was statistically insignificant (p=0.304). Male patients constituted 54.26% of the study population, and the prevalence of anaemia was comparable between males (74.51%) and females (74.42%; p=0.992). Similarly, no significant associations were observed with residence (p=0.452) or BMI (p=0.290). Shah et al. (2025) conducted a cross-sectional study involving 209 CKD patients and reported a mean age of 40.78 ± 6.37 years, with 72.20% males and 27.80% females. The mean BMI was 26.12 ± 4.11 kg/m². They observed no statistically significant associations between the morphological types of anaemia and age, gender, BMI, or duration of CKD. Although their outcome differed from the overall prevalence of anaemia assessed in the present study, both investigations highlighted the variable relationship between demographic factors and haematological abnormalities in CKD. Differences in age distribution and patient characteristics may explain the variation between the study populations.[7]

The overall prevalence of anaemia in the present study was 74.47%, affecting 70 of the 94 patients, while 25.53% had no anaemia. Among anaemic patients, moderate anaemia was the predominant category (51.43%), followed by mild anaemia (31.43%) and severe anaemia (17.14%). Normocytic normochromic anaemia was the most frequent morphological pattern, accounting for 67.14% of cases, whereas microcytic hypochromic and macrocytic anaemia were observed in 25.71% and 7.14%, respectively. Bhat et al. (2025), in a cross-sectional study involving 150 participants, including 60 CKD patients and 90 non-CKD individuals, reported anaemia in 90.00% of CKD patients. Moderate and severe anaemia accounted for 50.00% and 25.00% of CKD cases, respectively, while normocytic normochromic anaemia was observed in 75.00%. The prevalence of anaemia was therefore lower in the present study (74.47% versus 90.00%), although the proportion of moderate anaemia was comparable (51.43% versus 50.00%). Both studies demonstrated the predominance of normocytic normochromic anaemia, suggesting the importance of impaired erythropoietin production and chronic inflammation in CKD-associated anaemia.[8]

A statistically significant association was observed between CKD stage and anaemia prevalence in the present study (p=0.002). Among patients with CKD stages G1–G3, 57.14% had anaemia, whereas its prevalence increased to 83.33% in stage G4 and 95.45% in stage G5. These findings indicated a progressively increasing burden of anaemia with declining renal function. Kovesdy et al. (2023) analysed data from the United States National Health and Nutrition Examination Survey involving 2,926 adults with non-dialysis-dependent CKD stages 3–5. They reported an overall anaemia prevalence of 25.30%, while 1.90% had haemoglobin levels below 10 g/dL. The prevalence of anaemia increased from 17.10% among patients with stage G3a CKD to 66.10% among those with stage G5 disease. Furthermore, mean haemoglobin decreased from 14.00 g/dL in stage G3a to 11.97 g/dL in stage G5. Although their reported prevalence was lower than that in the present study, both investigations demonstrated increasing anaemia prevalence with advancing CKD. Differences in dialysis inclusion, disease severity, and population selection may have contributed to the variation in prevalence estimates.[9]

The present study demonstrated significant associations of diabetes mellitus, hypertension, and longer CKD duration with anaemia. The prevalence of anaemia was 85.71% among diabetic patients compared with 65.38% among non-diabetic patients (p=0.025). Similarly, anaemia was observed in 80.30% of hypertensive patients compared with 60.71% of those without hypertension (p=0.046). Patients with CKD duration ≥5 years also demonstrated a significantly higher prevalence of anaemia (86.05%) compared with those with a shorter disease duration (64.71%; p=0.018). Loutradis et al. (2016) conducted a nested case-control study involving 368 CKD patients, comprising 184 diabetic and 184 non-diabetic individuals matched for age, sex, and renal function. They reported that anaemia was significantly more prevalent among diabetic patients (47.80%) than non-diabetic patients (33.20%; p=0.004). Among patients with stage G3a CKD, anaemia prevalence was 60.40% in diabetic patients compared with 26.40% in non-diabetic patients. Multivariable analysis identified diabetes mellitus as an independent factor associated with anaemia (OR=2.206; 95% CI: 1.196–4.069). These findings supported the higher anaemia prevalence observed among diabetic patients in the present study, although independent associations could not be established without adjusted regression analysis of the present dataset.[10]

Maintenance haemodialysis demonstrated a significant association with anaemia in the present study, with 95.00% of patients undergoing haemodialysis being anaemic compared with 68.92% of patients not receiving haemodialysis (p=0.018). This high prevalence indicated a substantial burden of anaemia among patients requiring renal replacement therapy. Khan et al. (2024) evaluated the prevalence and management of anaemia among

patients with chronic kidney disease and those undergoing dialysis. They reported that anaemia was present in 78.70% of patients with CKD stages 3–5 at baseline, increasing from 61.50% in stage G3 to 79.80% in stage G4 and 88.60% in stage G5. Among patients receiving dialysis, the prevalence of anaemia was 92.60% at baseline and increased to 94.70% at the six-month assessment. The prevalence of anaemia among haemodialysis patients in the present study (95.00%) was closely comparable to the 94.70% reported at follow-up in their investigation. These findings highlighted the substantial burden of anaemia among dialysis-dependent CKD patients and the importance of regular haemoglobin monitoring and appropriate anaemia management.[11] Iron deficiency was identified in 31 of the 70 anaemic patients (44.29%) in the present study, whereas 55.71% of anaemic patients did not demonstrate iron deficiency. Among all patients, anaemia was significantly more prevalent in those with iron deficiency (91.18%) compared with those without iron deficiency (65.00%; p=0.005). The morphological assessment also demonstrated normocytic normochromic anaemia in 67.14% and microcytic hypochromic anaemia in 25.71% of anaemic patients. Parate et al. (2025) conducted a cross-sectional observational study involving 100 non-dialysis-dependent CKD patients with stages 3–5 disease. They reported anaemia in 91 patients, among whom 31 (34.06%) had iron deficiency anaemia. Normocytic normochromic morphology was observed in 51.00% of patients, while microcytic hypochromic morphology accounted for 29.00%. The proportion of iron deficiency among anaemic patients was higher in the present study (44.29% versus 34.06%), whereas the predominance of normocytic normochromic anaemia was consistent across both investigations. Differences in CKD stage distribution, dialysis status, and iron deficiency criteria could explain the observed variation.[12]

Biochemical comparison in the present study demonstrated significant differences between anaemic and non-anaemic CKD patients. Mean haemoglobin was significantly lower among anaemic patients (9.45 ± 1.56 g/dL) compared with non-anaemic patients (13.28 ± 0.82 g/dL; p<0.001). The mean eGFR was also significantly reduced in anaemic patients (26.90 ± 19.40 versus 47.80 ± 23.30 mL/min/1.73 m²; p<0.001), while serum creatinine was significantly elevated (3.42 ± 1.47 versus 2.11 ± 1.09 mg/dL; p<0.001). Transferrin saturation was significantly lower among anaemic patients (18.40 ± 7.20% versus 25.60 ± 8.10%; p<0.001), along with reduced serum albumin (3.31 ± 0.55 versus 3.79 ± 0.49 g/dL; p<0.001). Yu et al. (2021) investigated 2,500 patients with CKD stages 1–4 and demonstrated that patients with both low transferrin saturation and low serum iron had significantly greater odds of anaemia (adjusted OR=2.36; 95% CI: 1.76–3.18) compared with patients with normal transferrin saturation and iron levels. Even patients with normal transferrin saturation but low serum iron had increased odds of anaemia (OR=1.56; 95% CI: 1.13–2.16). They also demonstrated an association of reduced total iron-binding capacity with hypoalbuminaemia and inflammation. These findings supported the relevance of the lower transferrin saturation and serum albumin levels observed in the present study, indicating that altered iron availability, inflammation, and nutritional status may contribute to anaemia in CKD.[13]

## CONCLUSION

The present study demonstrated a high prevalence of anaemia (74.47%) among patients with chronic kidney disease, with moderate and normocytic normochromic anaemia being the predominant patterns. The prevalence of anaemia increased significantly with advancing CKD stage, particularly among patients with stages G4 and G5. Diabetes mellitus, hypertension, longer CKD duration, maintenance haemodialysis, iron deficiency, and hypoalbuminaemia were significantly associated with anaemia. Lower eGFR, reduced transferrin saturation, and elevated serum creatinine were also associated with anaemia. Early screening, regular monitoring of haemoglobin and iron status, and appropriate management of associated risk factors are essential for improving patient care and clinical outcomes.

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