e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2026; 18(9); 1491-1496

Original Research Article

Prevalence and Factors Associated with Anemia in Patients with Chronic Kidney Disease Receiving Maintenance Hemodialysis: A Retrospective Cross-Sectional Study from a Tertiary Care Teaching Hospital in Bihar

Satyam Mohan[1], Majibullah Ansari[2], Rajaram Yadav[3], Gopal Prasad[4], Harshvardhan[5]

[1]Assistant Professor, Department of Nephrology, Patna Medical College & Hospital, Patna, Bihar, India
[2]Assistant Professor, Department of Nephrology, Patna Medical College & Hospital, Patna, Bihar, India
[3]Assistant Professor, Department of Nephrology, Patna Medical College & Hospital, Patna, Bihar, India
[4]Professor, Department of Nephrology, Patna Medical College & Hospital, Patna, Bihar, India
[5]Professor, Department of Nephrology, Patna Medical College & Hospital, Patna, Bihar, India

Received: 20-07-2026 / Revised: 24-08-2026 / Accepted: 27-09-2026
Corresponding Author: Dr. Harshvardhan
Conflict of interest: Nil

Abstract:

Background: Anemia is a frequent complication of advanced chronic kidney disease (CKD) and is particularly important in patients receiving maintenance hemodialysis because erythropoietin deficiency, iron restriction, inflammation, blood loss, and nutritional factors may coexist.

Methods: This retrospective cross-sectional study included 600 adults with chronic kidney disease (CKD) G5 receiving maintenance hemodialysis for at least 3 months at Patna Medical College and Hospital, Patna, Bihar, India. Clinical records, dialysis registers, and laboratory reports documented from December 2024 through December 2025 were reviewed. Demographic characteristics, primary kidney disease, dialysis-related variables, hemoglobin, red-cell indices, serum ferritin, transferrin saturation (TSAT), serum albumin, C-reactive protein (CRP), and anemia-related treatment records were assessed.

Results: Anemia was present in 532/600 patients (88.67%; 95% CI 85.87%-91.08%). Among anemic patients, 132 (24.81%) had Hb >=10.0 g/dL within the sex-specific anemia range, 278 (52.26%) had Hb 7.0-9.9 g/dL, and 122 (22.93%) had Hb <7.0 g/dL. Normocytic normochromic morphology predominated (61.65%), followed by microcytic hypochromic (32.14%) and dimorphic patterns (6.21%). Absolute iron deficiency (ferritin <100 ng/mL and TSAT <20%) was present in 34.17%, while low TSAT despite ferritin >=100 ng/mL was present in 48.50%. Factors independently associated with Hb <10.0 g/dL included hemodialysis duration >12 months (adjusted odds ratio [AOR] 2.45), ferritin <100 ng/mL (AOR 3.12), TSAT <20% (AOR 2.88), albumin <3.5 g/dL (AOR 2.18), CRP >=10 mg/L (AOR 1.95), and inadequate/non-adherent erythropoiesis-stimulating agent (ESA) therapy (AOR 3.65).

Conclusion: Anemia was highly prevalent in this maintenance-hemodialysis cohort. Iron-restricted erythropoiesis, inflammation, hypoalbuminemia, longer dialysis vintage, and inadequate/non-adherent ESA therapy were associated with lower hemoglobin. These findings support structured monitoring and individualized correction of reversible contributors to anemia.

Keywords: Chronic Kidney Disease; Hemodialysis; Anemia; Iron Deficiency; Erythropoiesis-Stimulating Agent; Inflammation; India.

DOI: 10.25258/ijcpr.18.9.204

This is an Open Access article that uses a funding model which does not charge readers or their institutions for access and distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0) and the Budapest Open Access Initiative (http://www.budapestopenaccessinitiative.org/read), which permit unrestricted use, distribution, and reproduction in any medium, provided original work is properly credited.

Introduction

Chronic kidney disease (CKD) is a major global health problem, and the burden of advanced CKD is substantial in both high-income and low- and middle-income settings [1,2]. Anemia becomes increasingly common as kidney function declines and is an important complication of advanced CKD and kidney failure [3].

The pathophysiology of anemia in CKD is multifactorial. Reduced renal erythropoietin production is central, but iron deficiency, inflammation, hepcidin-mediated iron sequestration, shortened red-cell survival, dialysis-related blood loss, repeated phlebotomy, and nutritional deficiencies can also contribute [3-7]. Inflammation increases hepcidin and restricts iron availability for erythropoiesis even when storage iron is present [5,6].

Anemia in patients with kidney failure is associated with fatigue, impaired functional status, transfusion requirements, and adverse cardiovascular and

clinical outcomes. Contemporary management therefore emphasizes evaluation of iron status, correction of reversible causes, and appropriate use of ESAs and iron therapy [7,8]. The 2026 KDIGO anemia guideline recommends structured assessment and treatment of anemia in CKD. In CKD G5 receiving hemodialysis, KDIGO suggests initiating iron when ferritin is <=500 ng/mL and TSAT is <=30%, with intravenous iron preferred when iron therapy is initiated; ESA therapy is generally considered after correction of reversible causes, and hemoglobin should not be maintained at >=11.5 g/dL with ESA therapy [8].

Data from public-sector tertiary centers in eastern India remain useful for understanding real-world treatment gaps, particularly where dialysis and ESA costs may affect continuity of care [9]. This study assessed the prevalence, severity, morphological patterns, laboratory correlates, and factors associated with moderate-to-severe anemia among adults with CKD G5 receiving maintenance hemodialysis at PMCH, Patna.

Materials and Methods

Study Design and Setting: This retrospective cross-sectional observational study was conducted by the Department of Pharmacology in collaboration with the Department of Nephrology and Hemodialysis Unit, Patna Medical College and Hospital (PMCH), Patna, Bihar, India, a tertiary care teaching and referral hospital.

Study Period and Participants: Clinical records, laboratory reports, and dialysis registers documented as spanning December 2024 through December 2025 were reviewed. The analysis included 600 adults with CKD G5 who had received maintenance hemodialysis for at least 3 months and met the predefined eligibility criteria. Consecutive eligible records with the required clinical and laboratory data were included.

Eligibility Criteria: Inclusion criteria were age >=18 years, CKD G5 (eGFR <15 mL/min/1.73 m²), maintenance hemodialysis for >=3 months with at least twice-weekly treatment, and availability of the required clinical and laboratory data. Exclusion criteria were acute kidney injury or acute-on-chronic kidney injury without established kidney failure; active gastrointestinal bleeding or other acute blood loss; major blood transfusion within 30 days before the index laboratory assessment; hematological malignancy, active non-renal malignancy, hemoglobinopathy, or bone-marrow disorder; and pregnancy or lactation.

Definitions: Anemia was defined as hemoglobin <13.0 g/dL in adult men and <12.0 g/dL in non-pregnant adult women, consistent with commonly used diagnostic thresholds in CKD literature [3,10]. For descriptive analysis within the anemic subgroup, hemoglobin was categorized as >=10.0 g/dL (within the sex-specific anemia range), 7.0-9.9 g/dL, and <7.0 g/dL. These are study-defined severity categories and are not presented as KDIGO severity grades.

Morphology was classified using mean corpuscular volume (MCV) and peripheral blood smear as normocytic normochromic (MCV 80-100 fL), microcytic hypochromic (MCV <80 fL), macrocytic (MCV >100 fL), or dimorphic. Absolute iron deficiency was operationally defined as ferritin <100 ng/mL with TSAT <20%. Low iron availability with preserved/elevated ferritin was defined as ferritin >=100 ng/mL with TSAT <20%, a pattern compatible with iron-restricted erythropoiesis in inflammatory CKD [5,6]. Systemic inflammation was defined for this analysis as CRP >=10 mg/L.

Data Collection: Variables extracted from records included age, sex, residence, primary kidney disease, duration and frequency of hemodialysis, vascular access history, blood pressure, body mass index, hemoglobin, hematocrit, red-cell indices, leukocyte and platelet counts, serum iron, total iron-binding capacity, ferritin, TSAT, albumin, urea, creatinine, electrolytes, CRP, intact parathyroid hormone, ESA use, iron therapy, and transfusion history.

Statistical Analysis: Analyses were reported as performed in the study using SPSS version 26.0 and Python (SciPy/Statsmodels). Continuous variables were summarized as mean +/- standard deviation or median [interquartile range], as appropriate, and categorical variables as n (%). Between-group comparisons used chi-square or Fisher exact tests for categorical variables and Student t test or Mann-Whitney U test for continuous variables. Variables meeting the univariable screening criterion ($p<0.10$) were entered into multivariable binary logistic regression. Adjusted odds ratios (AORs) with 95% confidence intervals (CIs) are reported; two-sided $p<0.05$ was considered statistically significant.

Results

Baseline Characteristics: The study included 600 adults receiving maintenance hemodialysis. Mean age was 51.4 +/- 12.8 years (range 19-78); 375 (62.50%) were men and 225 (37.50%) were women. Diabetic nephropathy was the most frequently recorded primary kidney disease (41.17%), followed by hypertensive nephrosclerosis (28.83%). Median dialysis duration was 14.2 months [IQR 6.5-28.0]; 350 (58.33%) patients received twice-weekly and 250 (41.67%) thrice-weekly hemodialysis (Table 1).

Table 1: Baseline demographic and clinical characteristics

Characteristic	Value
Age, years, mean +/- SD	51.4 +/- 12.8
Age <50 years	262 (43.67%)
Age >=50 years	338 (56.33%)
Male / Female	375 (62.50%) / 225 (37.50%)
Rural / Urban residence	382 (63.67%) / 218 (36.33%)
Diabetic nephropathy	247 (41.17%)
Hypertensive nephrosclerosis	173 (28.83%)
Chronic glomerulonephritis	87 (14.50%)
Chronic pyelonephritis / obstructive uropathy	43 (7.17%)
ADPKD / other or unknown	50 (8.33%)
Hemodialysis twice weekly	350 (58.33%)
Hemodialysis thrice weekly	250 (41.67%)
Dialysis duration, months, median [IQR]	14.2 [6.5-28.0]

Prevalence, hemoglobin categories, and morphology: Anemia was identified in 532/600 patients, giving a prevalence of 88.67% (95% CI 85.87%-91.08%). Prevalence was 87.20% (327/375) in men and 91.11% (205/225) in women (chi-square=2.14, p=0.143). Among the 532 anemic patients, 132 (24.81%) had Hb >=10.0 g/dL within the sex-specific anemia range, 278 (52.26%) had Hb 7.0-9.9 g/dL, and 122 (22.93%) had Hb <7.0 g/dL (Table 2).

Table 2: Hemoglobin categories among anemic patients by sex

Hemoglobin category	Men (n=327)	Women (n=205)	Total (n=532)
>=10.0 g/dL within sex-specific anemia range	88 (26.91%)	44 (21.46%)	132 (24.81%)
7.0-9.9 g/dL	172 (52.60%)	106 (51.71%)	278 (52.26%)
<7.0 g/dL	67 (20.49%)	55 (26.83%)	122 (22.93%)

Morphological evaluation showed normocytic normochromic anemia in 328 (61.65%), microcytic hypochromic anemia in 171 (32.14%), and dimorphic anemia in 33 (6.21%) patients. No macrocytic cases were recorded (Figure 1).

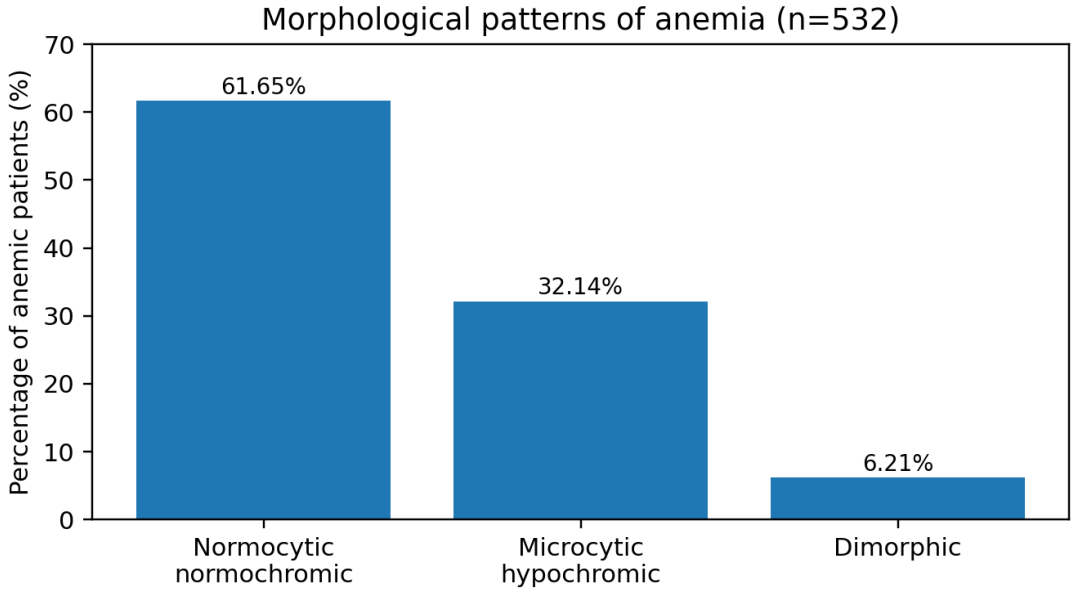


Figure 1: Morphological patterns of anemia among anemic maintenance-hemodialysis patients (n=532).

Laboratory parameters and iron status: Patients with Hb <10.0 g/dL had lower ferritin, TSAT, and albumin and higher CRP, blood urea nitrogen, and creatinine than patients with Hb >=10.0 g/dL (all reported p<0.001) (Table 3).

Table 3: Laboratory parameters according to hemoglobin group

Parameter	Hb >=10.0 g/dL (n=200)	Hb <10.0 g/dL (n=400)	p value
Hemoglobin (g/dL), mean +/- SD	10.82 +/- 0.68	7.64 +/- 1.12	<0.001
Hematocrit (%)	32.8 +/- 2.4	23.1 +/- 3.5	<0.001
MCV (fL)	88.4 +/- 6.2	81.2 +/- 8.9	<0.001
Ferritin (ng/mL), median [IQR]	285.0 [160-450]	112.5 [45-210]	<0.001
TSAT (%)	26.4 +/- 6.8	16.2 +/- 5.4	<0.001
Albumin (g/dL)	3.62 +/- 0.45	3.08 +/- 0.52	<0.001
CRP (mg/L)	6.4 +/- 3.1	18.5 +/- 9.2	<0.001
Blood urea nitrogen (mg/dL)	62.4 +/- 15.1	78.9 +/- 21.4	<0.001
Creatinine (mg/dL)	7.8 +/- 1.9	9.4 +/- 2.6	<0.001

Across the full cohort, 205 (34.17%) met the study definition of absolute iron deficiency (ferritin <100 ng/mL and TSAT <20%), 291 (48.50%) had ferritin >=100 ng/mL with TSAT <20%, and 104 (17.33%) were classified as iron sufficient by the study criteria.

Factors associated with Hb <10.0 g/dL: In multivariable analysis, inadequate/non-adherent ESA therapy had the largest reported association with Hb <10.0 g/dL (AOR 3.65, 95% CI 2.05-6.50), followed by ferritin <100 ng/mL (AOR 3.12, 95% CI 1.82-5.35), TSAT <20% (AOR 2.88, 95% CI 1.65-5.03), hemodialysis duration >12 months (AOR 2.45, 95% CI 1.48-4.06), albumin <3.5 g/dL (AOR 2.18, 95% CI 1.29-3.68), and CRP >=10 mg/L (AOR 1.95, 95% CI 1.12-3.39). Dialysis frequency <3 sessions/week was not independently significant after adjustment (AOR 1.52, 95% CI 0.91-2.54; p=0.108) (Table 4).

Table 4: Multivariable logistic regression for Hb <10.0 g/dL

Factor	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted p
Hemodialysis duration >12 months	2.15 (1.38-3.35)	2.45 (1.48-4.06)	<0.001
Ferritin <100 ng/mL	3.48 (2.12-5.72)	3.12 (1.82-5.35)	<0.001
TSAT <20%	3.10 (1.88-5.10)	2.88 (1.65-5.03)	<0.001
Albumin <3.5 g/dL	2.54 (1.58-4.08)	2.18 (1.29-3.68)	0.004
CRP >=10 mg/L	2.20 (1.35-3.58)	1.95 (1.12-3.39)	0.018
Inadequate/non-adherent ESA therapy	4.12 (2.45-6.92)	3.65 (2.05-6.50)	<0.001
Dialysis frequency <3 sessions/week	1.82 (1.14-2.91)	1.52 (0.91-2.54)	0.108

Discussion

This cohort showed a very high burden of anemia: 88.67% of 600 maintenance-hemodialysis patients met the study anemia definition, and 75.19% of anemic patients had Hb <10.0 g/dL. The finding is biologically plausible in advanced CKD, where impaired erythropoietin production, iron restriction, inflammation, dialysis-related blood loss, and nutritional factors frequently coexist [3-7]. Population studies also show that anemia becomes more prevalent with worsening CKD stage [10], although direct prevalence comparisons should be made cautiously because case mix, anemia definitions, dialysis exposure, and treatment availability differ across studies.

Normocytic normochromic anemia was the dominant morphological pattern, consistent with hypoproliferative anemia of kidney failure [3,7]. Nearly one-third of anemic patients had a microcytic hypochromic pattern, supporting a substantial contribution from iron deficiency. The study also found a high frequency of low TSAT. In CKD, inflammation-driven hepcidin elevation can reduce intestinal iron absorption and trap iron in macrophages, producing iron-restricted erythropoiesis despite preserved or elevated ferritin [5,6].

The multivariable model identified low ferritin, low TSAT, hypoalbuminemia, elevated CRP, longer dialysis vintage, and inadequate/non-adherent ESA therapy as factors associated with Hb <10.0 g/dL. These associations fit established mechanisms: iron deficiency limits erythropoiesis [6], inflammation contributes to functional iron restriction and ESA hyporesponsiveness [5,11], and hypoalbuminemia may reflect the malnutrition-inflammation complex described in dialysis populations [11].

The association with inadequate/non-adherent ESA therapy is clinically important in a resource-constrained setting. Dialysis and ESA-related costs have historically posed major barriers to sustained kidney-failure care in India [9]. Nevertheless, this retrospective study cannot determine whether financial constraints caused non-adherence, and the manuscript did not include a formal economic assessment. That interpretation should therefore remain cautious.

Current KDIGO guidance supports structured

evaluation of anemia and regular assessment of hemoglobin, ferritin, and TSAT in hemodialysis patients [8]. For CKD G5 receiving hemodialysis, KDIGO 2026 suggests initiating iron when ferritin is <=500 ng/mL and TSAT is <=30%, generally using intravenous iron when iron therapy is started, while withholding routine iron at high iron indices and individualizing ESA treatment [8]. The present findings support a local pathway that evaluates iron availability, inflammation or infection, nutritional status, dialysis adequacy, occult blood loss, and treatment adherence before escalating ESA therapy. The observational results should not be interpreted as evidence for indiscriminate intravenous iron or ESA escalation.

Limitations: The study has several limitations. Its retrospective cross-sectional design precludes causal inference, and its single-center setting limits generalizability. Only records with the required clinical and laboratory data were eligible, which may introduce selection bias. Serum erythropoietin, hepcidin, and soluble transferrin receptor were not routinely available, and long-term cardiovascular, transfusion, and survival outcomes were not prospectively tracked.

Conclusion

Anemia affected 88.67% of adults receiving maintenance hemodialysis in this PMCH cohort. Most anemic patients had Hb <10.0 g/dL, and normocytic normochromic morphology predominated. Low ferritin, low TSAT, hypoalbuminemia, elevated CRP, longer dialysis duration, and inadequate/non-adherent ESA therapy were independently associated with Hb <10.0 g/dL in the reported multivariable model. Structured monitoring of hemoglobin and iron status, evaluation of inflammation and nutrition, and guideline-concordant optimization of iron and ESA therapy may improve anemia management in this population.

Declarations

Ethics Approval and Consent to Participate: The study was conducted in accordance with applicable institutional ethical standards and the principles of the Declaration of Helsinki, as applicable to retrospective research. Ethics approval was obtained from the Institutional Ethics Committee of Patna Medical College and Hospital, Patna, Bihar, India.

Consent for Publication: Not applicable. No personally identifiable patient information is reported in this article.

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

Data Availability: The data supporting the findings of this study are derived from hospital medical records and laboratory registers. Access to the underlying data is subject to institutional policies, patient confidentiality requirements, and applicable ethical approvals. De-identified data may be made available by the corresponding author upon reasonable request, subject to institutional permission.

Acknowledgements: The authors may acknowledge the Department of Nephrology, Department of Pharmacology, and Hemodialysis Unit of Patna Medical College and Hospital, Patna, Bihar, India, for institutional support, where applicable.

References

1. Webster AC, Nagler EV, Morton RL, Masson P. Chronic kidney disease. Lancet. 2017;389(10075):1238-1252. doi:10.1016/S0140-6736(16)32064-5.
2. Kidney Disease: Improving Global Outcomes (KDIGO) CKD Work Group. KDIGO 2024 Clinical Practice Guideline for the Evaluation and Management of Chronic Kidney Disease. Kidney Int. 2024;105(4S):S117-S314.
3. Babitt JL, Lin HY. Mechanisms of anemia in CKD. J Am Soc Nephrol. 2012;23(10):1631-1634. doi:10.1681/ASN.2011111078.
4. Koury MJ, Haase VH. Anaemia in kidney disease: harnessing hypoxia responses for therapy. Nat Rev Nephrol. 2015;11(7):394-410. doi:10.1038/nrneph.2015.82.
5. Ganz T. Anemia of inflammation. N Engl J Med. 2019;381(12):1148-1157. doi:10.1056/NEJMra1804281.
6. Batchelor EK, Kapitsinou P, Pergola PE, Kovesdy CP, Jalal DI. Iron deficiency in chronic kidney disease: updates on pathophysiology, diagnosis, and treatment. J Am Soc Nephrol. 2020;31(3):456-468. doi:10.1681/ASN.2019020213.
7. Fishbane S, Spinowitz B. Update on anemia in ESRD and earlier stages of CKD: Core Curriculum 2018. Am J Kidney Dis. 2018;71(3):423-435. doi:10.1053/j.ajkd.2017.09.026.
8. Kidney Disease: Improving Global Outcomes (KDIGO) Anemia Work Group. KDIGO 2026 Clinical Practice Guideline for the Management of Anemia in Chronic Kidney Disease (CKD). Kidney Int. 2026;109(1S):S1-S99. doi:10.1016/j.kint.2025.06.006.
9. Khanna U. The economics of dialysis in India. Indian J Nephrol. 2009;19(1):1-4. doi:10.4103/0971-4065.50671.
10. Stauffer ME, Fan T. Prevalence of anemia in chronic kidney disease in the United States. PLoS One. 2014;9(1):e84943. doi:10.1371/journal.pone.0084943.
11. Kalantar-Zadeh K, Ikizler TA, Block G, Avram MM, Kopple JD. Malnutrition-

inflammation complex syndrome in dialysis patients: causes and consequences. Am J Kidney Dis. 2003;42(5):864-881. doi:10.1016/j.ajkd.2003.07.016.