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Patterns and predictors of anaemia in haemodialysis patients: relationship with comorbidities and dialysis exposure time

Gede Eka Handrean [1]✉, I Made Mahadinata Putra MN [1], I Gede Laksmana Pratama Putra[1]

[1] *Medical Education Program, Faculty of Medicine, Universitas Mahasaraswati Denpasar, Denpasar, Bali, Indonesia*

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CORRESPONDENCE

Phone: +62 815-1588-0388
E-mail: handrean@unmas.ac.id

A B S T R A C T

Background: Anaemia is a common and serious complication in patients with chronic kidney disease (CKD) undergoing haemodialysis, contributing to increased morbidity, mortality, and reduced quality of life. Its prevalence and predictors vary across populations, and evidence from Indonesian cohorts remains limited.

Objective: This study aimed to investigate the prevalence, severity, and predictors of anaemia in haemodialysis patients, with a particular focus on the influence of comorbidities and dialysis duration.

Methods: A cross-sectional analytic study was conducted among 71 CKD patients undergoing regular haemodialysis at Kenak Medika Ubud Hospital between July and August 2024. Data on demographics, dialysis duration, comorbidities, and laboratory parameters (Hb, BUN, SC, MCV, MCH) were extracted from medical records. Anaemia severity was classified according to WHO and KDIGO guidelines. Statistical analysis included descriptive statistics, Chi-square tests, ANOVA, correlation analysis, and multivariate linear regression.

Results: The prevalence of anaemia was 70.4%, with moderate anaemia being the most common presentation (52.1%). Patients with dialysis duration >24 months had significantly lower haemoglobin levels compared to those with shorter treatment exposure ($p = 0.014$). Multivariate regression analysis identified hypertension ($p = 0.009$) and cardiovascular disease ($p = 0.013$) as significant predictors of haemoglobin levels, while diabetes mellitus, BUN, SC, MCV, and MCH showed no significant associations.

Conclusion: Anaemia remains highly prevalent in haemodialysis patients, with dialysis duration and cardiovascular comorbidities emerging as key predictors. These findings underscore the importance of routine anaemia monitoring, individualized treatment strategies, and integrated management of cardiovascular comorbidities to optimize outcomes in haemodialysis populations.

INTRODUCTION

Anaemia is a prevalent and clinically significant complication in patients with chronic kidney disease (CKD), particularly those undergoing maintenance haemodialysis. In Indonesia, the prevalence of anaemia in CKD patients on haemodialysis ranges from 80% to 90%, contributing substantially to morbidity, mortality, and diminished quality of life.[1,2] The pathophysiology of anaemia in this population is multifactorial, including decreased erythropoietin (EPO) production, chronic inflammation, iron deficiency, and repeated blood loss during dialysis sessions.[3] Anaemia in haemodialysis patients is strongly associated with adverse clinical outcomes such as fatigue, reduced physical functioning, cardiovascular complications, and increased hospitalization rates.[4] The complexity of anaemia management is further compounded by the presence of comorbidities such as diabetes mellitus, hypertension, and cardiovascular disease, which may exacerbate the severity of anaemia and influence treatment responsiveness.[3,5,6]

Previous studies have extensively documented the prevalence of anaemia in haemodialysis populations, reporting rates ranging from 50% to 90% worldwide.[7–9] However, most of these investigations have been descriptive in nature, focusing primarily on anaemia burden rather than identifying predictive factors. Research has established associations between anaemia and individual comorbidities or laboratory markers,[10–13] but few studies have simultaneously evaluated the combined influence of dialysis duration, comorbidity burden, and biochemical

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parameters. Furthermore, while longer dialysis duration has been linked to worsening anaemia through mechanisms such as progressive EPO decline, iron depletion, and cumulative blood loss, evidence remains inconsistent regarding which comorbidities or laboratory indices most strongly predict anaemia severity.[14–16]

Importantly, there is a paucity of data from semi-urban Indonesian populations, where variations in healthcare access, nutritional status, and comorbidity profiles may influence anaemia outcomes differently compared to metropolitan or high-resource settings. Existing studies in Indonesia have largely reported prevalence estimates without stratifying anaemia risk or assessing its clinical predictors. This leaves a critical knowledge gap in understanding the patterns and predictors of anaemia severity that are specific to local populations.

This study addresses these gaps by moving beyond descriptive prevalence and exploring the predictors of anaemia severity in haemodialysis patients. Specifically, it examines the relationships between dialysis duration, comorbidities, and laboratory parameters in shaping anaemia outcomes. By adopting an analytical approach, this study provides more actionable insights to guide targeted interventions, individualized anaemia management, and evidence-based policy development in haemodialysis care. The objective is to identify the clinical and biochemical predictors of anaemia in haemodialysis patients, and to examine the relationship between comorbidities, dialysis exposure time, and anaemia severity.

METHOD

Study Design

This study employed an observational, cross-sectional analytic design to investigate the patterns and clinical predictors of anaemia in patients with CKD undergoing maintenance haemodialysis.[17]

Study Setting and Participants

The study was conducted at the Haemodialysis Unit of Kenak Medika Ubud Hospital, Bali, Indonesia, between July and August 2024. The study population consisted of all CKD patients receiving regular haemodialysis at the facility. A total of 71 patients were included in the final sample using a total sampling technique, after applying inclusion and exclusion criteria.[18] Inclusion criteria: diagnosed with CKD and undergoing haemodialysis at least twice weekly, aged ≥18 years, complete medical and laboratory records available, provided informed consent to participate in the study. Exclusion criteria: Acute conditions affecting haemoglobin levels (e.g., active bleeding, recent blood transfusion within the past 3 months, acute infections, or malignancy) and incomplete medical records.

Variables and Data Collection

The dependent variable was anaemia, measured both as a continuous variable (haemoglobin level in g/dL) and a categorical variable (normal, mild, moderate, or severe, based on WHO and KDIGO guidelines). The independent variables included: sociodemographic (age, gender). Clinical (duration of haemodialysis (in months), presence of comorbidities (hypertension, diabetes mellitus, cardiovascular diseases, chronic heart failure)). Laboratory parameters (Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH), Blood Urea Nitrogen (BUN), and Serum Creatinine (SC)). Data were collected retrospectively through structured extraction from patient medical records. Anaemia classification followed international guidelines: Normal: Hb ≥ 11.0 g/dL; Mild: Hb 10.0–10.9 g/dL; Moderate: Hb 7.0–9.9 g/dL; Severe: Hb < 7.0 g/dL.[19] Comorbidities were identified using ICD-10 codes, while dialysis duration was calculated from the first recorded dialysis session to the date of data collection.

Data Analysis

All statistical analyses were performed using SPSS version 21.0. Descriptive statistics were used to summarize baseline characteristics (frequencies, percentages, means ± standard deviations). Bivariate analysis was conducted to explore relationships between anaemia severity (or haemoglobin level) and independent variables: Chi-square tests for categorical associations (e.g., comorbidity vs anaemia severity), and ANOVA for numerical comparisons (e.g., Hb vs dialysis duration). Pearson correlation for continuous variable relationships (e.g., Hb vs BUN). Multivariate analysis using linear regression (for continuous Hb outcome) was performed to identify independent predictors of anaemia severity. A p-value of <0.05 was considered statistically significant.[20–22]

Ethical Considerations

This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Kenak Medika Ubud Hospital (Approval No. KMU/EC/2024/07/015). All patient data were anonymized and handled confidentially. Written informed consent was obtained from all participants prior to data inclusion.

RESULTS

Patient Characteristics

A total of 71 patients undergoing maintenance haemodialysis were included in this study (Table 1). The majority of participants were male (66.2%), while females accounted for 33.8%. Most patients were between 45–60 years of age (63.4%), followed by those older than 60 years (21.1%) and younger than 45 years (15.5%). With respect to dialysis duration, 40.8% had been on haemodialysis for ≤12 months, 42.3% for 13–24 months, and 16.9% for more than 24 months. These findings indicate that the study population was predominantly middle-aged, male, and with a relatively shorter dialysis exposure (<2 years).

Prevalence and Severity of Anaemia

The distribution of anaemia severity among haemodialysis patients is shown in Table 2 and Figure 1. Overall, the

prevalence of anaemia was 70.4%. Moderate anaemia was the most common presentation, affecting more than half of the patients (52.1%), followed by mild anaemia (18.3%). Interestingly, no cases of severe anaemia were observed in this cohort. Only 29.6% of patients had normal haemoglobin levels (≥11 g/dL). These results highlight that anaemia remains a substantial clinical problem in haemodialysis patients, with moderate anaemia being the predominant form.

Association between Comorbidities and Anaemia Severity

Hypertension and diabetes mellitus were common comorbidities but did not show a statistically significant association with anaemia severity (p=0.106 and p=0.567, respectively). In contrast, cardiovascular disease (CAD or CHF) was significantly associated with anaemia severity (p=0.013). Patients with cardiovascular comorbidity were more likely to maintain normal haemoglobin levels compared to those without, although moderate anaemia was still present in one-third of this group (Table 2).

Association between Dialysis Duration and Anaemia Severity

Patients with a dialysis duration of more than 24 months had the lowest mean haemoglobin level (8.91 ± 0.91 g/dL) and the highest proportion of moderate anaemia (90%). By contrast, patients with shorter dialysis exposure (≤24 months) had higher mean haemoglobin levels and a greater proportion of normal Hb values. The difference in haemoglobin levels across the three groups was statistically significant (p = 0.014), indicating that dialysis duration is an important factor associated with anaemia severity (Table 3).

Correlation between Laboratory Parameters and Haemoglobin Levels

None of the laboratory parameters (BUN, SC, MCV, MCH) showed a statistically significant correlation with haemoglobin levels (all p > 0.05). The correlation coefficients were weak (r < 0.2), suggesting that these parameters were not strong predictors of haemoglobin variation in this cohort (Table 4).

Multivariate Predictors of Haemoglobin Levels

Table 5 shown the regression model explained about 25.1% of the variance in haemoglobin levels. Hypertension (p = 0.009) and cardiovascular disease (CAD/CHF) (p = 0.013) emerged as significant predictors of higher haemoglobin levels after adjusting for other covariates. Dialysis duration showed a negative trend toward lower Hb, but did not reach statistical significance (p = 0.089). Other variables (age, sex, diabetes mellitus, BUN, serum creatinine, MCV, and MCH) were not significantly associated with haemoglobin levels.

Table 1. Characteristics of Haemodialysis Patients (n = 71)

Characteristic	Results
Sex	
Male	47 (66.2%)
Female	24 (33.8%)
Age, yr	
<45	11 (15.5%)
45–60	45 (63.4%)
>60	15 (21.1%)
Dialysis duration, months	
≤12	29 (40.8%)
13–24	30 (42.3%)
>24	12 (16.9%)

Table 4. Correlation Between Haemoglobin Levels and Laboratory Parameters

Laboratory Parameters	Correlation coefficient (r)	p-value
BUN	–0.128	0.287
SC	–0.109	0.364
MCV	0.018	0.885
MCH	0.081	0.501

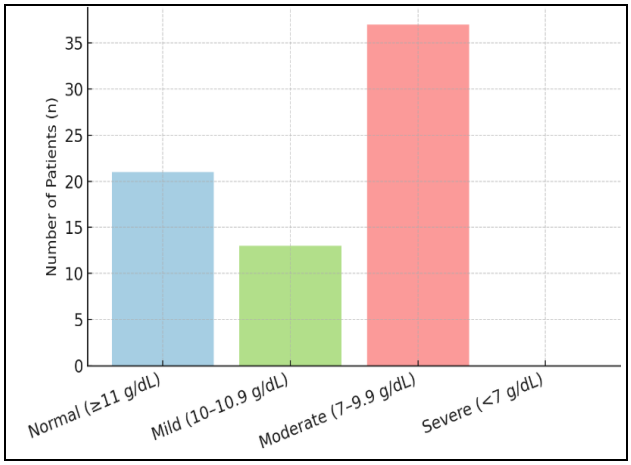

Figure 1. Distribution of Anaemia Severity in Haemodialysis Patients

Table 2. Association Between Comorbidities and Anaemia Severity Among Haemodialysis Patients

Comorbidity	Anaemia Severity (n, %)			p-value
	Normal (≥11 g/dL)	Mild (10–10.9 g/dL)	Moderate (7–9.9 g/dL)	
Hypertension				
No (n=23)	3 (13.0)	5 (21.7)	15 (65.2)	0.106
Yes (n=48)	18 (37.5)	8 (16.7)	22 (45.8)	
Diabetes mellitus				
No (n=36)	12 (33.3)	5 (13.9)	19 (52.8)	0.567
Yes (n=35)	9 (25.7)	8 (22.9)	18 (51.4)	
Cardiovascular disease (CAD/CHF)				
No (n=56)	12 (21.4)	12 (21.4)	32 (57.2)	0.013
Yes (n=15)	9 (60.0)	1 (6.7)	5 (33.3)	

Table 3. Haemoglobin Level and Anaemia Severity According to Dialysis Duration

Dialysis duration	Mean Hb ± SD (g/dL)	Normal (≥11 g/dL)	Mild (10–10.9 g/dL)	Moderate (7–9.9 g/dL)
≤12 months (n=28)	10.00 ± 1.69	9 (32.1%)	4 (14.3%)	15 (53.6%)
13–24 months (n=33)	10.33 ± 0.98	12 (36.4%)	8 (24.2%)	13 (39.4%)
>24 months (n=10)	8.91 ± 0.91	0 (0.0%)	1 (10.0%)	9 (90.0%)

ANOVA test: p = 0.014

Table 5. Multivariate Linear Regression Analysis of Predictors of Haemoglobin Level

Variable	β (Coefficient)	SE	t	p-value
Age (years)	–0.011	0.016	–0.660	0.512
Sex (Female vs Male)	–0.129	0.355	–0.363	0.718
Dialysis duration (mo)	–0.028	0.016	–1.729	0.089
Hypertension	+0.983	0.365	2.691	0.009
Diabetes mellitus	–0.070	0.338	–0.208	0.836
Cardiovascular disease	+0.992	0.385	2.575	0.013
BUN (mg/dL)	–0.004	0.006	–0.577	0.566
SC (mg/dL)	–0.054	0.069	–0.777	0.440
MCV (fL)	+0.007	0.019	0.362	0.718
MCH (pg)	+0.016	0.021	0.735	0.465

Model summary: $R^2 = 0.251$, Adjusted $R^2 = 0.127$, F = 2.015, p = 0.047

DISCUSSION

This study investigated the patterns and predictors of anaemia in patients with chronic kidney disease undergoing haemodialysis. The prevalence of anaemia was 70.4%, with moderate anaemia being the most common presentation (52.1%). Dialysis duration longer than 24 months was significantly associated with lower haemoglobin levels, and hypertension and cardiovascular disease were identified as significant predictors of haemoglobin variation. In contrast, diabetes mellitus, BUN, SC, MCV, and MCH were not significantly correlated with haemoglobin levels in this cohort.

The prevalence of anaemia observed in this study is consistent with prior reports indicating that between 50% and 90% of patients undergoing haemodialysis experience some form of anaemia.[7,8] Studies from different geographic regions, including Asia, have confirmed similarly high prevalence rates, reflecting the global significance of anaemia in dialysis populations.[23,24] Our findings also demonstrated that prolonged dialysis duration is associated with worsening anaemia severity, which is in line with evidence from previous study.[15,16]

Interestingly, diabetes mellitus was not associated with anaemia severity in this cohort, a finding that contrasts with several studies that have identified diabetes as a strong predictor of anaemia.[10,11] Similarly, laboratory markers such as BUN, SC, MCV, and MCH, which have been reported as relevant predictors in previous studies,[12,13] were not significantly associated with haemoglobin levels in this study, possibly due to sample size limitations or differences in treatment practices.

Several mechanisms may explain these findings. The pathophysiology of anaemia in CKD is complex, primarily driven by erythropoietin (EPO) deficiency, chronic inflammation, and iron dysregulation.[25,26] The significant association between dialysis duration and lower haemoglobin levels can be attributed to cumulative effects, including progressive decline in endogenous EPO production, iron depletion from repeated blood loss (estimated at 1,000–3,000 mg/year), and chronic inflammation.[14,27,28] Hypertension, while generally associated with impaired renal oxygenation and reduced EPO synthesis, was paradoxically associated with higher haemoglobin in this study, likely reflecting closer clinical monitoring and treatment intensity in hypertensive patients.[29,30]

Cardiovascular disease also emerged as a significant predictor of haemoglobin variation. Prior studies have highlighted the bidirectional relationship between anaemia and cardiovascular disease, where anaemia exacerbates left ventricular hypertrophy (LVH) and cardiac dysfunction, while cardiovascular disease worsens renal hypoxia and EPO resistance.[24,31] The absence of a significant association between diabetes and anaemia may be explained by variability in glycaemic control, the relatively small sample size, or the presence of competing clinical factors.

The clinical and public health implications of these findings are substantial. Anaemia remains a highly prevalent complication in haemodialysis patients, even in the era of erythropoiesis-stimulating agents (ESA) and intravenous iron therapy.[32,33] Routine monitoring of haemoglobin levels, early identification of at-risk groups such as patients with longer dialysis duration, and tailored therapeutic strategies are crucial to improve patient outcomes. Optimizing ESA and iron dosing, minimizing cumulative blood loss during dialysis procedures, and integrating cardiovascular risk management into anaemia care protocols should be prioritized. Regional differences in anaemia management practices, as observed in Taiwan compared to other countries,[23] further underscore the need for context-specific strategies to improve outcomes in Indonesian dialysis populations.

This study has several strengths, including the use of real-world clinical data and the simultaneous some limitations should be noted. The cross-sectional design precludes

causal inference, and the single-centre nature with a relatively small sample size limits generalizability. Furthermore, important biomarkers such as ferritin, transferrin saturation, hepcidin, and C-reactive protein (CRP) were not available, which restricted the ability to fully assess iron status and inflammation. These factors may have contributed to the lack of significant associations between haemoglobin and BUN, SC, MCV, and MCH.

Future research should address these limitations by conducting longitudinal, multi-centre studies to confirm the predictors of anaemia and evaluate changes over time. Incorporating additional biomarkers, such as hepcidin, ferritin, and the erythropoietin resistance index, will provide a more comprehensive understanding of anaemia pathophysiology in haemodialysis patients. Furthermore, exploring the malnutrition–inflammation–anaemia axis and evaluating interventional strategies tailored to comorbidity profiles may yield important insights to improve anaemia management and patient outcomes.

CONCLUSIONS AND RECOMMENDATION

This study demonstrates that anaemia remains a major complication among haemodialysis patients, with a prevalence of 70.4% and moderate anaemia being the most common severity. Dialysis duration of more than 24 months was significantly associated with lower haemoglobin levels, underscoring the cumulative impact of prolonged treatment on anaemia outcomes. Among comorbidities, hypertension and cardiovascular disease were identified as significant predictors of haemoglobin levels, whereas diabetes mellitus, BUN, SC, MCV, and MCH did not show significant associations. These findings highlight the complex interplay between dialysis exposure, comorbid conditions, and anaemia severity in haemodialysis populations.

Routine monitoring of haemoglobin levels and anaemia severity should be integrated into standard haemodialysis care, with special attention to patients with prolonged dialysis exposure and those with cardiovascular comorbidities. Development of context-specific anaemia management protocols is needed in Indonesia to align with international best practices while addressing local resource constraints. Larger, multi-centre longitudinal studies incorporating biomarkers of iron status and inflammation are recommended to better delineate predictors of anaemia and guide more precise therapeutic strategies.

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