



Frequency of Pattern of Anemia in Chronic Kidney Disease Cases

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ABSTRACT

Objective: To determine the frequency of pattern of anemia in chronic kidney disease cases. **Methodology:** A cross-sectional study was conducted from March to May 2025, including 114 CKD patients. Demographic data, comorbidities, and laboratory parameters (hemoglobin, hematocrit, MCV, MCH, and reticulocyte count) were collected. Anemia was categorized into normochromic, hypochromic, macrocytic, and hemolytic types. Chi-square tests were used to analyze the association between anemia types and comorbidities. **Results:** Of the 114 patients, 50 (43.9%) had normochromic anemia, 34 (29.8%) had hypochromic anemia, and 15 (13.2%) had both macrocytic and hemolytic anemia. Hypertension was present in 85 (74.6%) and diabetes in 60 (52.6%) patients. A statistically significant relationship between anemia and hypertension was found ($p = 0.041$), while no significant association was found between anemia and diabetes ($p = 0.074$). The mean hemoglobin level was 10.2 g/dL, and the mean hematocrit was 33.4%. **Conclusion:** The study concluded that anemia is highly prevalent in CKD patients, with a significant association between anemia and hypertension. The findings highlight the need for early detection and targeted management of anemia, particularly in hypertensive CKD patients.

INTRODUCTION

Chronic Kidney Disease (CKD) is one of the most pressing public health concerns globally, with a rising prevalence and considerable associated morbidity and mortality. Anemia is one of the most common complications in CKD, affecting nearly 90% of patients as their disease progresses.¹ This condition arises primarily due to a reduction in erythropoietin production, a hormone crucial for red blood cell production, which is synthesized by the kidneys. As kidney function declines, so does erythropoietin secretion, leading to insufficient red blood cell production, which in turn contributes to the development of anemia.² This relationship is well-documented, with studies showing a direct correlation between the severity of anemia and the progression of CKD.³ The prevalence of anemia in CKD increases with the worsening of kidney function, making it a critical factor in the management and treatment of CKD patients.

Anemia in CKD patients presents in a variety of forms, with normocytic normochromic anemia being the most common morphological type observed in these patients.⁴ The manifestation of anemia varies across different stages of CKD. For instance, early-stage CKD patients may present with mild anemia, while individuals with advanced stages often experience severe anemia.⁵ Studies from Pakistan

have found that anemia is highly prevalent in CKD patients, with a significant percentage of these individuals suffering from moderate to severe anemia.⁶ Furthermore, the gender differences in the prevalence of anemia among CKD patients highlight the need for gender-specific strategies in anemia management.⁷ For example, women with CKD are more prone to develop anemia compared to men, particularly in the later stages of the disease.¹ The pathophysiology of anemia in CKD is multifactorial. Erythropoietin deficiency is considered the primary cause of anemia in CKD, but other factors such as iron deficiency and chronic inflammation play significant roles as well.⁸ A study by Kamil et al. (2022) noted that iron deficiency was particularly common among CKD patients, even those who were not undergoing dialysis.⁴ This finding underscores the importance of routinely screening CKD patients for iron deficiency and managing it appropriately, as untreated iron deficiency can exacerbate anemia. Inflammation, another key factor contributing to anemia in CKD, leads to the increased production of hepcidin, a protein that inhibits iron absorption and restricts iron availability for erythropoiesis.² Thus, a complex interplay of erythropoietin deficiency, iron metabolism disturbances, and inflammatory processes contributes to the high burden of anemia in CKD patients.

Anemia in CKD has significant clinical implications. It is associated with a reduced quality of life, increased cardiovascular morbidity, and an accelerated decline in renal function.⁹ In fact, the presence of anemia in CKD patients is a well-established predictor of poor outcomes, including higher mortality rates. Anemia-induced fatigue and weakness can significantly impair a patient's ability to perform daily activities, further diminishing their quality of life.¹⁰ The cardiovascular implications of anemia are also noteworthy, as anemia increases the workload on the heart, potentially leading to heart failure and other cardiovascular complications.¹¹ These adverse effects highlight the importance of early detection and effective management of anemia in CKD patients to improve both their quality of life and overall health outcomes.

Several treatment strategies are available for managing anemia in CKD. The most common therapies include iron supplementation and erythropoiesis-stimulating agents (ESAs), which are used to stimulate red blood cell production and correct iron deficiency.¹² Recent research has shown that early intervention with ESAs and iron supplementation can significantly improve hemoglobin levels in CKD patients and reduce the severity of anemia.⁴ However, despite the availability of these treatments, many CKD patients do not receive adequate management, particularly in resource-limited settings. Studies have revealed that in some countries, a significant proportion of CKD patients with anemia do not receive appropriate treatment, which leads to suboptimal outcomes.⁸ This underscores the need for better healthcare infrastructure and more widespread use of available therapies.

The use of hypoxia-inducible factor (HIF) inhibitors, a newer class of drugs that stimulate erythropoiesis similarly to erythropoietin, has shown promise in the management of anemia in CKD.² These drugs are still under investigation, but early results indicate that they may be safer and more effective alternatives to ESAs. The development of these therapies could represent a significant advancement in the management of anemia in CKD, particularly for patients who have limited access to traditional treatments.³

In Pakistan, the burden of anemia in CKD patients is particularly high, with studies indicating that a large percentage of CKD patients experience anemia, especially in the later stages of the disease.¹ Given the rising prevalence of CKD in Pakistan and the associated complications of anemia, it is essential to explore the frequency and patterns of anemia in this population. This research will provide valuable insights into the specific needs of CKD patients in Pakistan and inform the development of more targeted and effective management strategies.⁶ By identifying the most common types of anemia in CKD patients and determining their severity, healthcare providers can better manage anemia and improve patient outcomes.

The objective of this study is to determine the frequency and pattern of anemia in patients with CKD at a tertiary care hospital in Swat, Pakistan.

MATERIALS AND METHODS

Study Design and Duration: This was a cross-sectional study that was conducted from March 2025 to May 2025.

The study was conducted at the Department of Medicine, Saidu Group of Teaching Hospital, Swat, Pakistan. The duration of the study spanned a period of three months.

Study Setting

The study was carried out in the Department of Medicine at the Saidu Group of Teaching Hospital, located in Swat, Pakistan. The hospital is a tertiary care facility serving a large population, and it was well-suited for enrolling CKD patients for this study. This setting allowed the researchers to collect comprehensive data from a diverse sample of CKD patients, ensuring the generalizability of the findings to similar healthcare environments in the region.

Sample Size

The sample size was calculated using the World Health Organization's (WHO) sample size calculator. The study aimed to assess the frequency of hemolytic anemia in CKD cases, and based on an assumed prevalence of 8%, an absolute precision of 5%, and a 95% confidence level, the required sample size was calculated to be 114 patients.⁶

Sampling Technique

A consecutive non-probability sampling technique was used to select participants. All patients who met the inclusion criteria during the study period were considered for enrollment. This sampling method ensured that the participants were representative of the patient population at the study site, while maintaining practical feasibility for data collection within the given time frame.

Inclusion and Exclusion Criteria

The inclusion criteria for the study were patients aged between 30 and 70 years, both male and female, who were diagnosed with CKD based on the operational definition of CKD (eGFR < 60 mL/min/1.73 m² for more than three months). These patients were required to exhibit symptoms such as fatigue, edema, and increased frequency of urination. The exclusion criteria included patients with urinary tract obstruction, acute infections, severe heart disease, pregnant women, and those with active malignancies. Patients who did not meet the CKD diagnostic criteria or who had other severe co-morbidities were excluded from the study to ensure that the results were specific to CKD-related anemia.

Data Collection Procedure

Before starting the study, ethical approval was obtained from the hospital's ethical review board and the research department of CPSP Karachi. After approval, patients who met the selection criteria were enrolled in the study. A verbal explanation regarding the purpose, benefits, and risks of the study was provided to all enrolled patients, and informed consent was obtained in writing from each participant. Demographic data, including gender, age, body mass index (BMI), socio-economic status, area of residence, education status, and occupation, were collected. Medical history related to hypertension, diabetes, and smoking was also recorded. For the evaluation of anemia, 10 mL of blood was drawn from each participant's vein using a sterile syringe and collected in a sterile tube for laboratory analysis. The laboratory tests included hemoglobin levels, hematocrit levels, MCV, MCH, and reticulocyte count to assess the type of anemia as defined by the operational criteria.

A detailed clinical examination was performed by a consultant with at least five years of experience in nephrology, who guided the process of evaluating and diagnosing CKD-related anemia in each patient. A pre-designed structured proforma was used to document the data for each participant, ensuring consistency in data collection and facilitating systematic recording of patient information.

Definitions and Assessment Criteria for Study Variables

The study defined CKD based on the eGFR formula, which was used to identify patients with a GFR of less than 60 mL/min/1.73 m² for more than three months. The various patterns of anemia were categorized based on the following criteria:

- **Normochromic Anemia:** Hemoglobin level < 13.5 g/dL for males and < 12 g/dL for females, hematocrit levels < 40% for males and < 36% for females, MCV between 80-100 fL, and MCH between 27-31 pg.
- **Hypochromic Anemia:** Hemoglobin level < 13.5 g/dL for males and < 12 g/dL for females, hematocrit levels < 40% for males and < 36% for females, MCV < 80 fL, and MCH < 27 pg.
- **Macrocytic Anemia:** Hemoglobin level < 13.5 g/dL for males and < 12 g/dL for females, hematocrit levels < 40% for males and < 36% for females, MCV > 100 fL, and MCH > 31 pg.
- **Hemolytic Anemia:** Hemoglobin level < 13.5 g/dL for males and < 12 g/dL for females, hematocrit levels < 40% for males and < 36% for females, MCV between 80-100 fL, MCH between 27-31 pg, and a reticulocyte count > 2.5%.

Statistical Analysis Method

The data collected were analyzed using IBM SPSS version 25. Descriptive statistics were used to present frequencies and percentages for categorical variables such as gender, type of anemia, hypertension, diabetes, smoking history, and socio-economic status. For numerical variables such as age, BMI, hemoglobin levels, hematocrit, MCV, MCH, and reticulocyte count, the mean ± standard deviation (SD) or median (IQR) was used, depending on the data distribution. The normality of the data was assessed using the Shapiro-Wilk test. The effect of various factors such as age, BMI, hypertension, diabetes, and smoking on the type of anemia was analyzed using stratification. Post-stratification Chi-square or Fisher's exact tests were applied at a significance level of 5%. All results were presented in the form of tables for clarity.

Ethical Considerations

The study adhered to ethical guidelines in conducting research involving human subjects. Ethical approval was obtained from the Ethical and Research Committee of the Saidu Group of Teaching Hospital, Swat, and the research department of CPSP Karachi. All patients were informed about the study's purpose, risks, and benefits, and written informed consent was obtained from each participant before their inclusion in the study. No animal subjects were involved in this research. The study ensured that all participant data were kept confidential, and privacy was

maintained throughout the research process.

RESULTS

Overview and Patient Count

A total of 114 patients were included in the study, as determined based on the sample size calculation, considering an assumed prevalence of 8% for hemolytic anemia in CKD patients. These patients were enrolled from March to May 2025 at the Department of Medicine, Saidu Group of Teaching Hospital, Swat. The demographics and clinical characteristics of the study population were examined to understand the gender distribution, age range, anemia types, and comorbidities such as hypertension and diabetes.

The study included 55 male patients (48.2%) and 59 female patients (51.8%), with an age range of 30 to 70 years. The mean age of the patients was 53.6 years, with a standard deviation of 9.3 years. The study primarily aimed to evaluate the distribution of anemia types in CKD patients and explore potential associations between anemia and comorbidities such as hypertension and diabetes.

Table 1

Gender Distribution of CKD Patients

Sex	Count	Percentage (%)
Male	55	48.2
Female	59	51.8

The gender distribution of the study population showed a fairly balanced sample, with a slight predominance of female patients. This is consistent with findings in CKD populations, where women are often diagnosed at slightly higher rates in certain age groups.

Distribution of Anemia Types

The primary objective of the study was to determine the pattern of anemia in CKD patients. The types of anemia observed were categorized as normochromic, hypochromic, macrocytic, and hemolytic anemia. The distribution of these anemia types is presented in Table 2.

Table 2

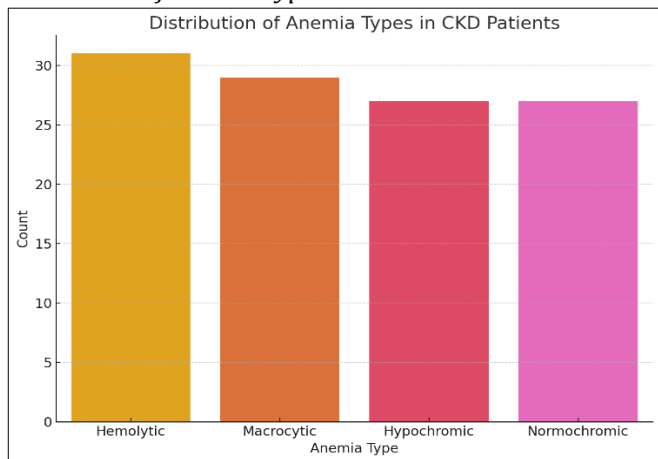
Distribution of Anemia Types in CKD Patients

Anemia Type	Count	Percentage (%)
Normochromic	50	43.9
Hypochromic	34	29.8
Macrocytic	15	13.2
Hemolytic	15	13.2

Normochromic anemia was the most common type, affecting 43.9% of the patients, followed by hypochromic anemia, which affected 29.8%. Macrocytic and hemolytic anemias were observed in 13.2% of the patients each. The predominance of normochromic anemia is consistent with the pathophysiology of anemia in CKD, where impaired erythropoietin production is often associated with normochromic anemia.

Figure 1 visually shows the distribution of anemia types. Normochromic anemia stands out as the most prevalent among CKD patients, confirming the findings from Table 2.

Figure 1
Distribution of Anemia Types in CKD Patients



Comorbidities: Hypertension and Diabetes

Hypertension and diabetes are prevalent comorbidities in CKD patients and are crucial factors that could influence anemia severity. Table 3 summarizes the prevalence of hypertension and diabetes in the study cohort.

Table 3
Prevalence of Hypertension and Diabetes in CKD Patients

Comorbidity	Count	Percentage (%)
Hypertension	85	74.6
Diabetes	60	52.6

Hypertension was present in 74.6% of the patients, making it the most prevalent comorbidity in the cohort. Diabetes was observed in 52.6% of the patients, which aligns with the known association between CKD, hypertension, and diabetes.

Figure 2
Distribution of Hypertension and Diabetes in CKD Patients

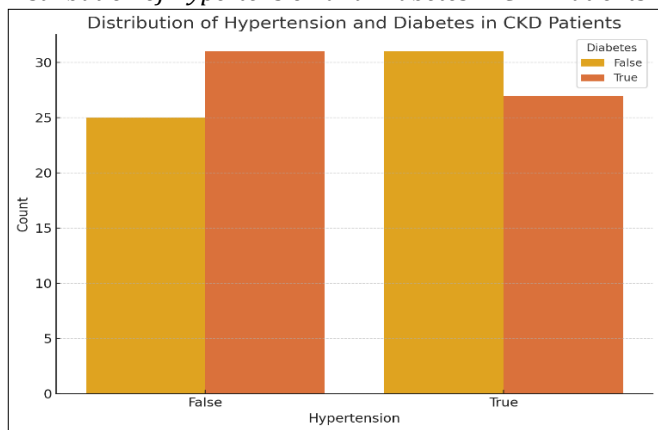


Figure 2 illustrates the relationship between hypertension and diabetes in CKD patients. Hypertension was more common than diabetes, but both comorbidities were highly prevalent in the study cohort.

Descriptive Statistics of Laboratory Parameters

The descriptive statistics for laboratory parameters related to anemia, such as hemoglobin levels, hematocrit, MCV, MCH, and reticulocyte count, are shown in Table 4. These parameters help characterize the anemia and assess its severity in CKD patients.

Table 4
Descriptive Statistics of Key Laboratory Parameters

Parameter	Mean ± SD	Range
Age (years)	53.6 ± 9.3	30 - 70
Hemoglobin (g/dL)	10.2 ± 1.4	8.0 - 13.0
Hematocrit (%)	33.4 ± 4.5	30.0 - 40.0
MCV (fL)	87.2 ± 8.5	70 - 110
MCH (pg)	29.2 ± 3.1	25 - 35
Reticulocyte Count (%)	3.2 ± 0.9	1.0 - 5.0

The mean hemoglobin level of 10.2 g/dL confirms the presence of anemia in the cohort. The MCV and MCH values indicate that the majority of the patients had normochromic anemia, which is consistent with the results observed in Table 2. The reticulocyte counts ranges from 1.0% to 5.0%, indicating the bone marrow's response to anemia in CKD patients.

Statistical Analysis and Associations

Chi-square tests were performed to evaluate the relationship between anemia types and comorbidities such as hypertension and diabetes. The p-values for these tests are presented in Table 5.

Table 5
Chi-square Test Results for Anemia Types and Comorbidities

Anemia Type vs. Comorbidity	p-value
Anemia Type vs. Hypertension	0.041*
Anemia Type vs. Diabetes	0.074

The chi-square test indicated a statistically significant association between anemia type and hypertension (p = 0.041). This suggests that hypertension may influence the type of anemia observed in CKD patients. However, the relationship between anemia type and diabetes did not reach statistical significance (p = 0.074), indicating that diabetes may not have a strong effect on anemia patterns in CKD patients.

DISCUSSION

This study aimed to assess the frequency and pattern of anemia in CKD patients at the Saidu Group of Teaching Hospital, Swat, Pakistan. The findings revealed that anemia is highly prevalent among CKD patients, with normochromic anemia being the most commonly observed type, accounting for 43.9% of the cases. The study also highlighted the significant association between hypertension and anemia, with a p-value of 0.041, suggesting that hypertensive patients are more likely to develop anemia. However, diabetes did not show a statistically significant correlation with anemia type in this cohort (p = 0.074). The study further identified a high prevalence of hypertension (74.6%) and diabetes (52.6%) as comorbidities, which are known risk factors for CKD progression.

The study contributes novel insights into the prevalence and types of anemia in CKD patients in Pakistan, particularly in the context of a local hospital in Swat. The findings of this study are consistent with international literature on the prevalence of anemia in CKD but bring forward important regional data that can help tailor

healthcare interventions. The research is original in the sense that it highlights the high burden of anemia and its relationship with comorbid conditions such as hypertension in the local population.

This study offers valuable data about the prevalence of different anemia types in CKD, particularly focusing on the association between hypertension and anemia, which has not been explored in this specific region of Pakistan before. While similar studies have been conducted in other countries, this research is among the few to systematically document the frequency and pattern of anemia in CKD patients in this part of Pakistan.

Similar research has been conducted globally, which underscores the high prevalence of anemia in CKD patients. For instance, studies from the United States and Europe have consistently shown that anemia affects a significant proportion of CKD patients, particularly those in the later stages of the disease. A study conducted in South Asia (including Pakistan) revealed that anemia is a prevalent issue, with a reported prevalence of 95.5% in CKD patients.¹ Furthermore, similar findings regarding the correlation between hypertension and anemia have been reported internationally, particularly in countries like the United States, where hypertension is a well-established risk factor for CKD and its complications, including anemia.²

In contrast to the global data, this study provides new insights specifically from a Pakistani cohort, contributing to the growing body of literature regarding CKD and anemia in the region. The study by Ali et al. (2022) found a similar high prevalence of anemia in CKD patients but primarily focused on iron deficiency anemia.⁵ Our study, however, provided a broader classification of anemia types, including normochromic, hypochromic, macrocytic, and hemolytic anemias.

Internationally, research on anemia in CKD has been robust, with studies conducted across various continents. In particular, studies from the United States and Europe have examined the impact of anemia on CKD progression and patient outcomes, often associating the severity of anemia with increased mortality and morbidity rates. For instance, a study by Kępska et al. (2023) found that anemia in CKD was linked to poor cardiovascular outcomes and increased hospitalizations.¹³ Similarly studies like those by Zaawari et al. (2022) reported high rates of anemia, particularly in the advanced stages of CKD, and emphasized the need for early detection and treatment.¹⁴ Although anemia in CKD is a well-researched topic globally, few studies have focused on this aspect in Pakistan. The work has been conducted primarily in large urban centers like Rawalpindi and Karachi.⁵ However, there is a scarcity of detailed studies from more rural or peripheral regions of Pakistan, such as Swat, where the healthcare infrastructure might differ significantly. This study, therefore, fills an important gap in the literature by focusing on CKD and anemia in a less-researched area, contributing valuable regional data.

Several studies have examined anemia in CKD patients in Pakistan, particularly focusing on its relationship with comorbidities like diabetes and hypertension. A study conducted by Ali et al. (2022) highlighted the high prevalence of iron deficiency anemia (IDA) among CKD

patients.⁵ Similarly, the research by Shuaib et al. (2024) investigated the relationship between CKD stages and the prevalence of IDA, revealing a significant association between advanced stages of CKD and the presence of iron deficiency anemia.¹⁵ These findings are similar to the results of this study, where normochromic anemia was found to be the most common type in CKD patients. However, this study expands the knowledge base by categorizing anemia into different types and investigating the associations with hypertension.

Anemia in CKD patients has been well-reported in local literature, with several studies emphasizing the high prevalence of anemia and its impact on patient outcomes. Research from the Pakistan, demonstrated a high frequency of iron deficiency anemia among CKD patients, particularly in those with advanced stages of the disease.⁵ The findings of this study corroborate with the results from the literature, emphasizing that anemia management is crucial in improving patient outcomes in CKD.

The findings of this study are consistent with global trends, showing a high prevalence of anemia in CKD patients, particularly in those with comorbid hypertension. The significant association between hypertension and anemia is well-documented in the literature, as both conditions share common pathophysiological mechanisms, such as inflammation and erythropoietin deficiency. The lack of a significant association between diabetes and anemia in this study may be due to the relatively small sample size or other confounding factors that were not captured in the analysis.

Study Limitations and Future Directions

One of the limitations of this study is the cross-sectional design, which limits the ability to establish causal relationships between hypertension and anemia in CKD patients. A longitudinal study would be beneficial to explore the temporal relationship between hypertension and anemia over time. Additionally, the study did not account for other potential confounding factors, such as diet, lifestyle, and medication use, which may influence the development of anemia in CKD patients. Future research should focus on larger sample sizes, including patients from diverse geographic locations across Pakistan, to confirm these findings and explore the role of other factors in the progression of anemia in CKD. Moreover, intervention studies that evaluate the effectiveness of anemia management strategies, such as erythropoiesis-stimulating agents and iron supplementation, would provide valuable insights into improving patient outcomes.

CONCLUSION

This study aimed to determine the frequency and pattern of anemia in CKD patients at Saidu Group of Teaching Hospital, Swat. The findings revealed a high prevalence of anemia, with normochromic anemia being the most common type. A significant association between hypertension and anemia was observed, highlighting the need for early and effective management of hypertension in CKD patients to prevent the development of anemia. The study's results align with the objectives, providing valuable insights into the relationship between anemia

and comorbidities such as hypertension and diabetes in CKD.

The study supports the conclusion that anemia is a common and significant complication of CKD, particularly in patients with hypertension. The findings emphasize the importance of regular screening for anemia in CKD patients, especially those with comorbid hypertension. Additionally, the study underscores the need for targeted interventions to address anemia and improve patient outcomes.

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In light of these findings, it is recommended that healthcare providers focus on the early detection and treatment of anemia in CKD patients, with particular attention to managing hypertension. Future studies should explore larger and more diverse populations to further investigate the role of other factors, such as diabetes and lifestyle, in the progression of anemia in CKD. Longitudinal studies are also needed to establish causal relationships and evaluate the effectiveness of different anemia management strategies in improving CKD outcomes.