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Research

A Cross-Sectional Evaluation of Anemia Characteristics Among CKD Patients in a Tertiary Care Hospital

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Abstract

Introduction: Chronic Kidney Disease remains a major global health issue, impacting between 8% and 16% of the population. A common complication among CKD patients is anemia, hyperkalemia, hypercalcemia, ongoing inflammation, typically resulting from inadequate RBC production, insufficient iron levels, metabolic acidosis and uremia.
Aim: To assess the prevalence, severity, and morphological patterns of anemia in patients with Chronic Kidney Disease (CKD) receiving care at a tertiary hospital, and to compare these characteristics with those observed in non-CKD individuals.
Methodology: Over a span of three months, a cross-sectional investigation was undertaken at a tertiary care facility. The study involved a total of 197 participants, comprising 80 individuals diagnosed with Chronic Kidney Disease and 117 without the condition. Laboratory evaluations were conducted to assess hemoglobin levels and analyze red blood cell morphology, aiming to identify the occurrence, degree, and classification of anemia.
In contrast, non-CKD individuals mostly had values between 0.5–1.5 mg/dL. In contrast, **non-CKD individuals** had significantly higher eGFR values (>90), consistent with normal renal function.
Conclusion: This study demonstrates statistically significant differences in hematological and renal biomarkers between CKD and non-CKD patients, with stronger distinctions observed in female patients. CKD patients show lower hemoglobin and serum iron levels, higher creatinine, and reduced eGFR, indicating compromised renal function and associated anemia. Age also plays a vital role, with middle-aged and elderly individuals showing higher CKD prevalence.

Keywords: P Value, Anemia, Stage of Anemia, Cross Sectional Study, RBC

INTRODUCTION

Chronic Kidney Disease (CKD) is a long-term condition marked by a gradual loss of kidney function, affecting millions worldwide. Among its many complications, anemia is one of the most prevalent, particularly in moderate to advanced stages of CKD. The development of anemia in CKD is primarily due to reduced erythropoietin production, iron deficiency, and chronic inflammation, all of which are consequences of declining renal function. Anemia in CKD significantly contributes to fatigue, decreased exercise tolerance, cardiovascular complications, and overall reduced quality of life. It also increases the risk of hospitalization and mortality. The severity and type of anemia—whether normocytic, microcytic hypochromic, or macrocytic—can provide important insights into underlying pathophysiological processes and help guide treatment strategies. Early identification and effective management of anemia are crucial to improving clinical outcomes in CKD patients, emphasizing the need for routine screening and a comprehensive approach to care. To assess the prevalence, severity, and morphological patterns of anemia in patients with Chronic Kidney Disease (CKD) receiving care at a tertiary hospital, and to compare these characteristics with those observed in non-CKD individuals.

MATERIALS AND METHODS

This study was conducted at a tertiary care hospital with a capacity of 205 inpatient beds, encompassing multiple clinical departments. The majority of cases were reported in the Department of Nephrology, where the cross-sectional study was specifically carried out. Data collection was performed over a three-month period and involved reviewing laboratory reports, physicians' progress notes, nursing records, and conducting one-on-one interviews with individual patients. All data were gathered within the hospital setting to ensure accuracy and completeness.

Based on hospital records of approximately 100 patients per month, a total of 300 patients were expected during the 3-month study period. Using a confidence level of 95%, a margin of error of 5%, and an estimated anemia prevalence of 80% among CKD patients, the minimum calculated sample size was 246. However, due to time and logistical constraints, a convenience sample of 197 patients was included in the final analysis."

Study Design:
Type of Study: Cross-sectional, observational study.
Study Duration: 3months.
Study Site: Teritary care hospital.

Inclusion Criteria:
Adults (≥18 years) diagnosed with CKD (Stages 1–5).
Patients attending nephrology clinics or admitted to nephrology wards.
Patients who consent to participate.

Exclusion Criteria:
- Patients receiving treatment for acute infections or malignancy.
- Pregnant women.

Patients who have received blood transfusion or erythropoiesis-stimulating agents in the past 3 months.

Data Collection:
Tools: Structured questionnaire and case record form.
Variables:
Demographics: Age, sex, occupation, residence.
Clinical data: CKD stage, duration of KD, comorbidities (e.g., diabetes, hypertension), medication history.
Laboratory parameters: Hemoglobin (Hb), hematocrit (HCT), red cell indices (MCV, MCH, MCHC), serum ferritin, transferrin saturation, serum iron, serum creatinine, eGFR.

RESULTS

Study Population Overview

A total of **197 patients** were included in this study, categorized based on their renal health status into two main groups:

Chronic Kidney Disease (CKD) Group

Comprised of **119 patients** diagnosed with **Chronic Kidney Disease (CKD)** based on clinical and laboratory criteria such as decreased glomerular filtration rate (eGFR) and elevated serum creatinine levels. CKD is a progressive condition that compromises kidney function over time, often leading to systemic complications including anemia, electrolyte imbalance, and bone mineral disorders.

Non-CKD Group

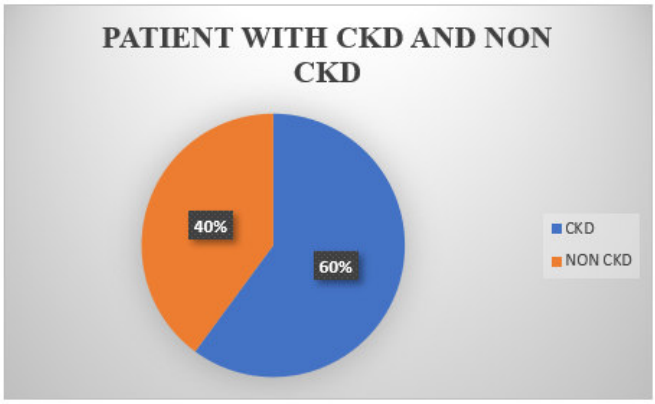
Consisted of **79 patients** who did not meet the diagnostic criteria for CKD. This group served as a comparative baseline to evaluate the deviation of various parameters observed in CKD patients.

Anemia and Its Correlation with CKD

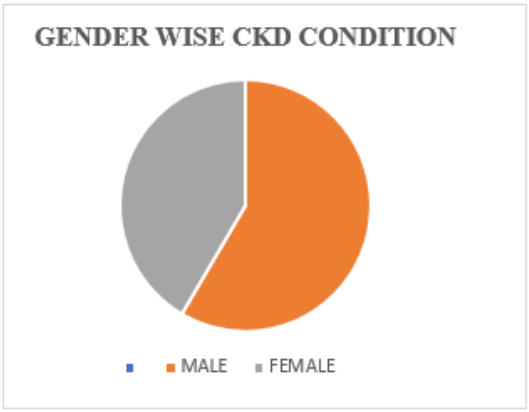
An important aspect of this study was to assess the **prevalence and correlation of anemia** in relation to chronic kidney disease. Anemia, typically defined by **hemoglobin levels less than 10 g/dL**, was significantly more prevalent among CKD patients. In the **CKD group**, a notably higher number of patients (both male and female) exhibited hemoglobin levels below the normal threshold, indicating a strong association between CKD and anemia. This is biologically plausible, as the kidneys play a critical role in erythropoietin production—a hormone essential for red blood cell formation. As kidney function declines in CKD, erythropoietin levels drop, leading to decreased red blood cell production and resulting in **anemia of chronic disease**.

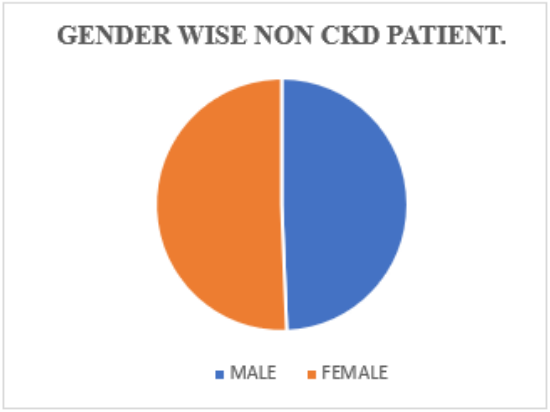
Statistical Analysis

Statistical analysis (such as the t-test and correlation studies) confirmed a **significant difference in hemoglobin levels between CKD and non-CKD patients**, underscoring anemia as a common and clinically important complication of CKD.



2.**GENDER WISE DISTRIBUTION OF CKD AND NON-CKD PATIENTS**.

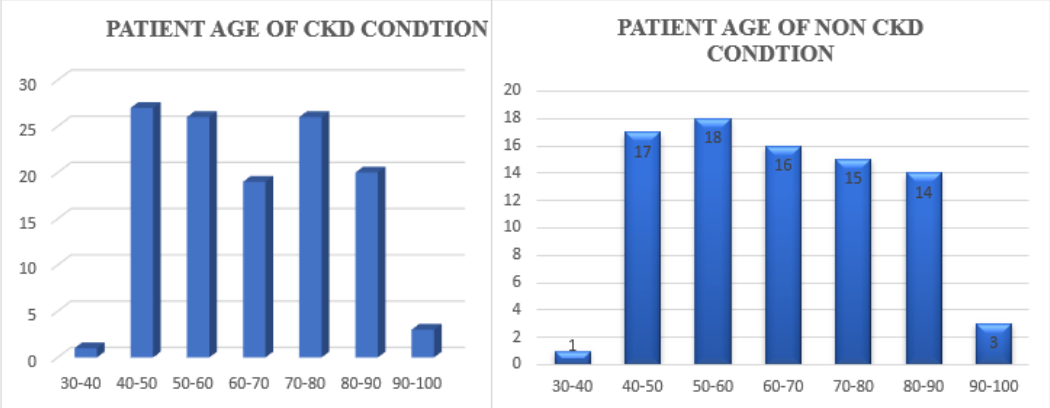




A total of **118 patients** were diagnosed with **Chronic Kidney Disease (CKD)**. Among these, **69 were male** and **49 were female**, indicating a slightly higher prevalence of CKD among male patients in the study population. In contrast, **79 patients** were found to be **non-CKD**. Within this group, **39 were male** and **40 were**

female, showing a nearly equal gender distribution among those without CKD. This data highlights a gender disparity in CKD prevalence, with a greater number of male patients affected compared to females.

3. Age-wise Distribution of CKD and Non-CKD Patients.

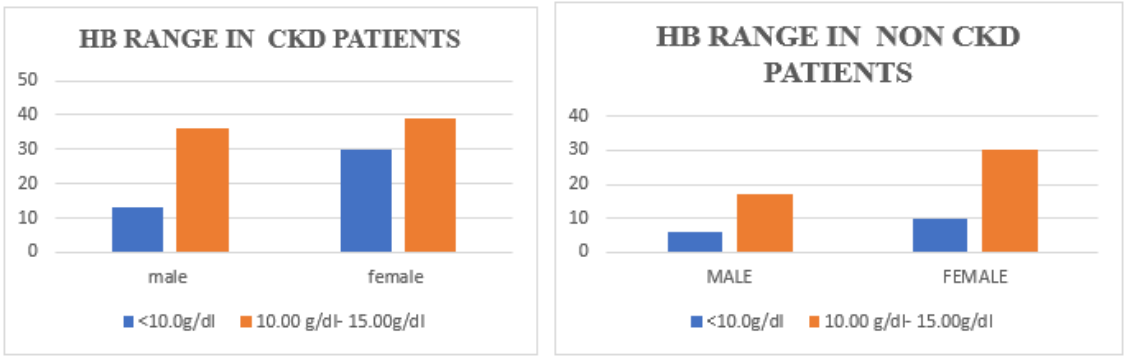


The age-wise distribution of patients diagnosed with Chronic Kidney Disease (CKD) shows that 0.85% were in the 30 to 40 age group, 23% in the 40 to 50 group, 22% in the 50 to 60 group, 16% in the 60 to 70 group, 22% in the 70 to 80 group, 17% in the 80 to 90 group, and 2.5% in the 90 to 100 age group. This indicates that the highest prevalence of CKD was observed among individuals aged between 40 to 50 and 70 to 80 years, while the lowest was in the 30 to 40 and 90 to 100 age groups.

In comparison, the age distribution among patients without CKD revealed that 1.5% were in the 30 to 40 age group, 21% in the 40 to 50 group, 23% in the 50 to 60 group, 20% in the 60 to 70 group, 19% in the 70 to 80 group, 18% in the 80 to 90 group, and 11% in the 90 to 100 age group. **The highest proportion of non-CKD patients was found in the 50 to 60 age group, while the 30 to 40 age group accounted for the lowest percentage.**

PATIENT AGE	CKD	NON CKD
30-40	0.85%	1.5%
40-50	23%	21%
50-60	22%	23%
60-70	16%	20%
70-80	22%	19%
80-90	17%	18%
90-100	2.5%	11%

4. Hb RANGE WISE CKD Vs NON CKD PATIENTS



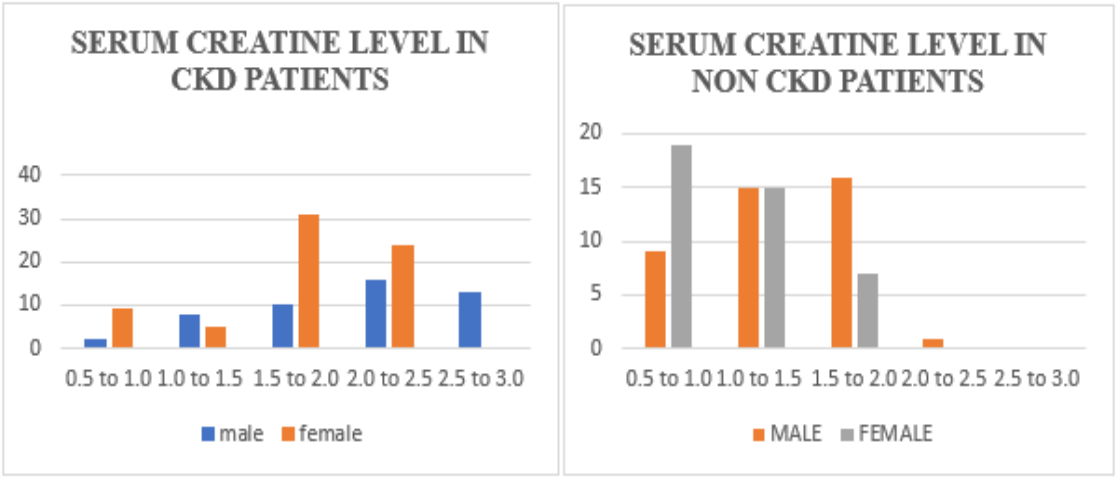
The distribution of hemoglobin levels was analyzed among male and female patients with and without Chronic Kidney Disease (CKD). Two hemoglobin ranges were considered: less than 10.0 g/dL and 10.0–15.0 g/dL. Among **male CKD patients**, 13 individuals had hemoglobin levels below 10.0 g/dL, while 36 fell within

the 10.0–15.0 g/dL range. In comparison, among **male non-CKD patients**, only 6 had levels below 10.0 g/dL, and 17 had levels between 10.0 and 15.0 g/dL. This shows a higher incidence of low hemoglobin (<10.0 g/dL) in males with CKD compared to those without CKD.

Among **female CKD patients**, a significant number 30 individuals had hemoglobin levels below 10.0 g/dL, while 39 had levels between 10.0 and 15.0 g/dL. For **female non-CKD patients**, 10 had hemoglobin levels below 10.0 g/dL, and 30 were within the normal range of 10.0–15.0 g/dL. Again, this reflects a notably higher occurrence of anemia (hemoglobin <10.0 g/dL) in females with CKD than in those without.

Overall, both male and female CKD patients exhibited a greater prevalence of low hemoglobin levels compared to their non-CKD counterparts. This suggests a strong association between CKD and anemia, particularly in female patients, where the number of individuals with hemoglobin below 10.0 g/dL was **three times higher than in the non-CKD group**. The findings underscore the importance of regular hemoglobin monitoring in CKD patients to manage and mitigate anemia-related complications.

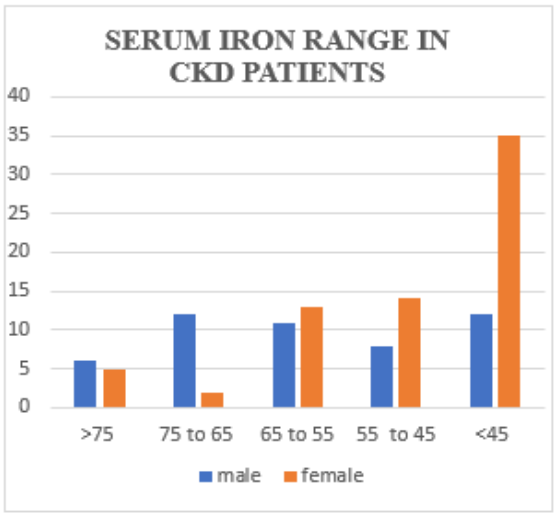
5.SERUM CREATINE RANGE WISE CKD Vs NON CKD PATIENTS.

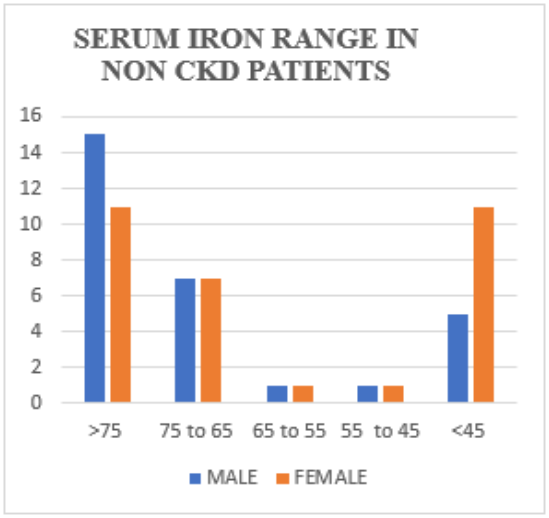


The analysis of serum creatinine levels revealed a clear distinction between CKD and non-CKD patients. Among **male CKD patients**, most had elevated levels: 10 patients were in the 1.5–2.0 mg/dL range, 16 in 2.0–2.5 mg/dL, and 13 in 2.5–3.0 mg/dL. In contrast, **male non-CKD patients** mostly had levels below 1.5 mg/dL, with only 1 patient in the 2.0–2.5 mg/dL range and none beyond. For **female CKD patients**, 31 were in the 1.5–2.0 mg/dL range and 24 in the 2.0–2.5 mg/dL range, indicating significant elevation. **Female non-CKD patients** had the majority in the 0.5–1.5 mg/dL range, with none above 2.0. mg/dL. Higher serum creatinine levels were predominantly observed in CKD patients of both genders, especially in the 1.5–3.0 mg/dL range, whereas non-CKD patients mostly remained within normal limits (below 1.5 mg/dL), **highlighting a strong association between elevated creatinine and CKD.**

Serum Creatinine (mg/dL)	RANGE	MALE_CKD	MALE NON CKD	FEMALE_CKD	FEMALE_NON CKD
	0.5 to 1.0mg/dl	3.00%	23.00%	18.00%	48.00%
	1.0 to 1.5 mg/dl	12.00%	38.00%	10.00%	38.00%
	1.5 to 2.0mg/dl	14.00%	41.00%	63.00%	18.00%
	2.0 to 2.5 mg/dl	23.00%	2.50%	48.00%	0.00%
	2.5 to 3.0 mg/dl	19.00%	0.00%	0.00%	0.00%

6. **SERUM IRON RANGE WISE CKD Vs NON CKD PATIENTS**



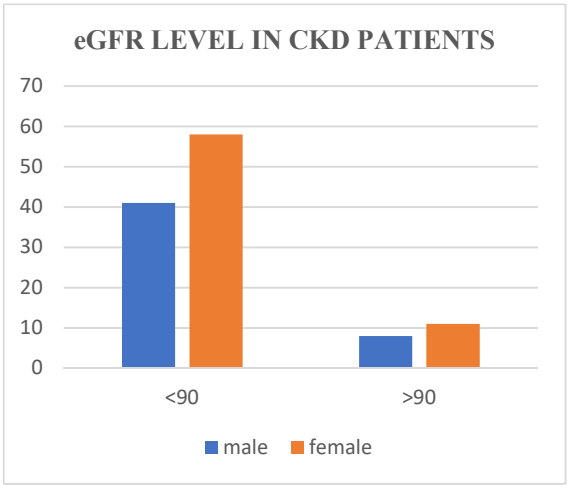


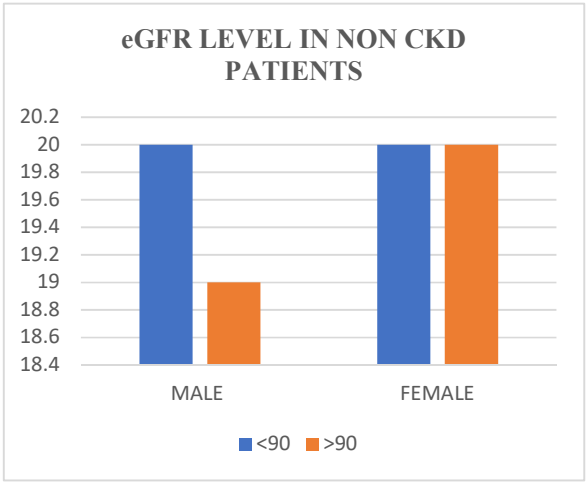
The distribution of serum iron levels shows a notable difference between CKD and non-CKD patients across both genders. In **male CKD patients**, 12 had serum iron levels below 45 mcg/dL, while only 6 had levels above 75 mcg/dL. Conversely, **male non-CKD patients** showed higher iron levels, with 15 having levels above 75 mcg/dL and only 5 falling below 45 mcg/dL. Among **female CKD patients**, the majority (35 individuals) had serum iron levels below 45 mcg/dL, indicating significant iron deficiency. In comparison, **female non-CKD patients** had a relatively more balanced distribution, with only 11 in the <45 mcg/dL range and 11 above 75 mcg/dL.

Low serum iron levels (<45 mcg/dL) were significantly more prevalent among CKD patients, particularly in females, suggesting a higher rate of iron deficiency. Non-CKD patients, especially males, tended to have higher serum iron levels, indicating better iron status. **This highlights a potential link between CKD and iron deficiency, possibly due to chronic inflammation or impaired iron absorption.**

Serum Iron (µg/dL)	RANGE	MALE_CKD	MALE_NON CKD	FEMALE_CKD	FEMALE_NON CKD
	>75 mcg/dl	9.00%	38.00%	10.00%	27.00%
	75 to 65 mcg/dl	17.00%	18.00%	4.00%	18.00%
	65 to 55mcg/dl	15.00%	2.50%	26.00%	2.50%
	55 to 45mcg/dl	12.00%	2.50%	28.00%	2.50%
	<45 mcg/dl	17.00%	12.00%	71.00%	28.00%

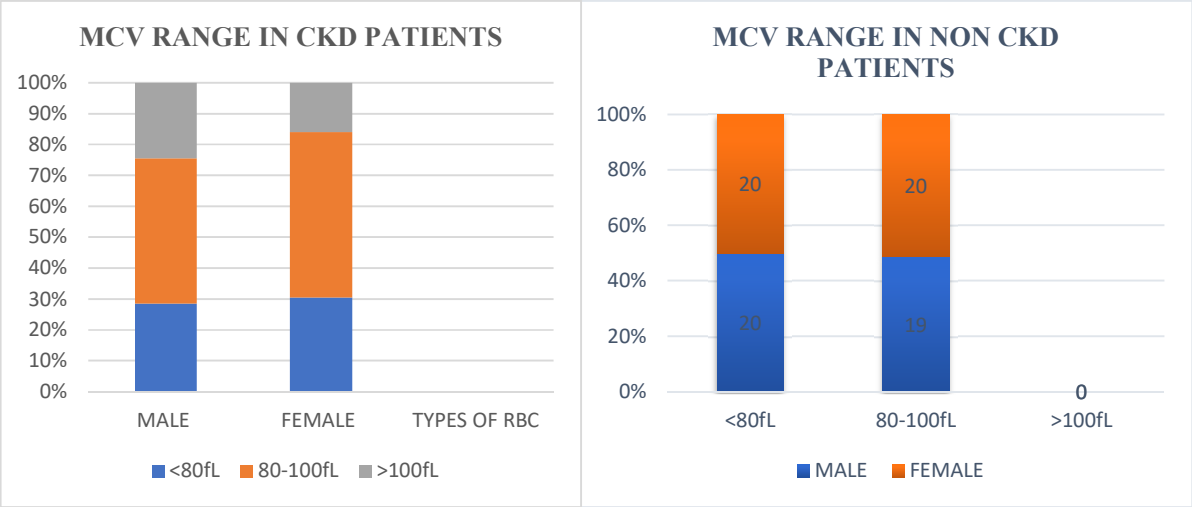
7. eGFR RATE OF CKD Vs NON CKD PATIENTS





The estimated glomerular filtration rate (eGFR) was categorized into two ranges: below 90 and above 90 mL/min/1.73m². These values help assess kidney function. Among **male CKD patients**, 59% had eGFR values below 90, indicating reduced kidney function, while only 12% had values above 90. In contrast, **male non-CKD patients** showed better kidney function, with 49% above 90 and 51% below. Similarly, **female CKD patients** had 58% with eGFR below 90 and only 16% above 90, reflecting impaired kidney performance. On the other hand, **female non-CKD patients** had an even distribution, with 50% in both eGFR categories. A larger proportion of CKD patients, both male and female, had eGFR values below 90, supporting their diagnosis. Non-CKD patients, particularly males, showed a higher percentage with normal eGFR (>90), indicating better renal function overall.

8. MCV RANGE OF CKD Vs NON CKD PATIENTS



The Mean Corpuscular Volume (MCV) values, which indicate red blood cell size, were classified into microcytic (<80 fL), normocytic (80–100 fL), and macrocytic (>100 fL) categories. Among **male CKD patients**, 20% had microcytic (<80 fL), 33% normocytic (80–100 fL), and 17% macrocytic (>100 fL) values. In contrast, **non-CKD males** showed a higher percentage of microcytic values at 51%, with 49% in the normocytic range and no macrocytic cases observed. In **female CKD patients**, 43% were microcytic, 75% normocytic, and 22% macrocytic. **Non-CKD females** had an even distribution between microcytic (50%) and normocytic (50%) values, with no occurrences of macrocytosis.

Macrocytic red blood cells (>100 fL) were seen exclusively in CKD patients, indicating possible associations with **chronic anemia** or underlying nutritional deficiencies commonly found in CKD. Microcytic values (<80 fL) were more prominent in non-CKD males and females, while normocytic levels (80–100 fL) were most frequently observed in CKD females. These findings highlight the variation in red blood cell morphology between CKD and non-CKD individuals.

9.DATA INTERPRETATION OF VARIBALE

Group	t-statistic	p-value	Interpretation
Male	4.23	0.0029	**Significant difference**
Female	16.45	1.88E-07	**Highly significant difference**

A p-value < 0.05 means the differences are statistically significant

DISCUSSIONS

The dataset compares various clinical parameters between Chronic Kidney Disease (CKD) and non-CKD patients, stratified by gender. It highlights notable differences in Hemoglobin, Serum Iron, Serum Creatinine, eGFR, and MCV levels, along with age distribution. The statistical analysis confirms significant differences, particularly when comparing male and female groups.

1. Hemoglobin (g/dL)

- A higher proportion of CKD females (25%) had hemoglobin levels below 10 g/dL compared to non-CKD females (61%), suggesting anemia is more prevalent in CKD.

- Similarly, CKD males (19%) had lower hemoglobin levels than their non-CKD counterparts (15%), although the difference is less pronounced than in females.

2. Serum Iron (µg/dL)

- CKD patients, especially **females**, had a significant prevalence of iron deficiency, with **71% of CKD females** having iron levels below 45 mcg/dL.
- Non-CKD patients had higher iron levels in general, suggesting a strong association between CKD and iron deficiency.

3. Serum Creatinine (mg/dL):

- A major indicator of kidney function, creatinine levels were markedly higher in CKD patients. For instance, **63% of CKD females** and **14% of CKD males** had creatinine levels between 1.5–2.0 mg/dL.
- In contrast, non-CKD individuals mostly had values between 0.5–1.5 mg/dL.

4. eGFR (mL/min/1.73m²):

- A large proportion of CKD patients had eGFR values below 90, reinforcing their impaired kidney function status (59% males, 58% females).
- In contrast, **non-CKD individuals** had significantly higher eGFR values (>90), consistent with normal renal function.

5. MCV (fL):

A notable percentage of **CKD females (22%)** and **males (17%)** had MCV >100 fL, possibly indicating macrocytic anemia a finding less observed in the non-CKD group.

6. Age Distribution:

- CKD was more prevalent in older age groups, particularly between 40–80 years.
- Younger age groups (30–40) showed minimal CKD prevalence, while the **90–100 age group** had a higher percentage of non-CKD individuals, possibly due to survival bias or small sample size.

Statistical Significance

The t-test analysis revealed:

- **Males:** Significant difference between CKD and non-CKD ($p = 0.0029$).
- **Females:** Highly significant difference ($p = 1.88E-07$), indicating gender-based physiological or pathological variation in CKD impact.

CONCLUSION

This study demonstrates statistically significant differences in hematological and renal biomarkers between CKD and non-CKD patients, with stronger distinctions observed in female patients. CKD patients show lower hemoglobin and serum iron levels, higher creatinine, and reduced eGFR, indicating compromised renal function and associated anemia. Age also plays a vital role, with middle-aged and elderly individuals showing higher CKD prevalence. These findings underscore the importance of early detection and gender-specific monitoring of kidney function, particularly focusing on anemia management and renal function assessment in CKD patients. The significant p-values validate the robustness of these observations, reinforcing the clinical relevance of these markers in CKD evaluation.

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