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MANAGING MEDICATION IN PATIENTS WITH RENAL IMPAIRMENT

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ABSTRACT

Chronic kidney disease (CKD) is associated with significant alterations in drug pharmacokinetics and pharmacodynamics, which increase the risk of medication-related complications and therapeutic challenges. The present study was conducted to evaluate medication management practices in patients with renal impairment, with particular emphasis on prescribing patterns, dose adjustment practices, and the relationship between renal function and clinical parameters. A prospective observational approach was adopted, and relevant data including patient demographics, comorbid conditions, laboratory findings, and prescribed medications were systematically collected and analyzed. Renal function was assessed using standard indicators such as serum creatinine and estimated glomerular filtration rate (eGFR). Statistical analysis was performed using *SPSS version 16.0*, applying descriptive statistics, one-way ANOVA, chi-square test, and cross-tabulation methods to determine associations between variables. The findings demonstrated a high prevalence of polypharmacy among CKD patients, along with variable adherence to renal dose adjustment guidelines. Although commonly prescribed therapies such as erythropoietin, iron supplementation, and antihypertensive agents were appropriately utilized in many cases, instances of inappropriate dosing and continued use of potentially nephrotoxic drugs were identified. A statistically significant association between CKD stage and serum creatinine levels was observed, highlighting the importance of renal function–based dose modification. Furthermore, gaps in medication adherence and lifestyle practices were evident among patients. Overall, the study underscores the importance of rational prescribing, individualized dose adjustment, and continuous monitoring to ensure safe and effective pharmacotherapy in patients with renal impairment, and emphasizes the need for enhanced clinical awareness, multidisciplinary involvement, and adherence to evidence-based guidelines to improve patient outcomes.

KEYWORDS: Chronic Kidney Disease (CKD), Renal Impairment, Medication Management, Dose Adjustment, Pharmacokinetics, Polypharmacy, Nephrotoxicity, eGFR, Drug Safety, Clinical Pharmacotherapy.

INTRODUCTION

MANAGING MEDICATION IN PATIENTS WITH RENAL IMPAIRMENT

Renal impairment is a significant global health concern that affects millions of individuals worldwide and poses substantial challenges in medication management. The kidneys play a **vital role in drug elimination, metabolism, and maintenance of fluid and electrolyte balance**. When renal function declines, the pharmacokinetics and pharmacodynamics of many drugs are altered, which may lead to **drug accumulation, toxicity, therapeutic failure, and adverse drug reactions**. Therefore, careful medication management in patients with renal impairment is essential to ensure **safe and effective pharmacotherapy**.[1,2]

Patients with renal impairment frequently present with **multiple comorbid conditions** such as hypertension, diabetes mellitus, cardiovascular diseases, anemia, and infections. These conditions often require **polypharmacy**, which increases the risk of medication-related problems including **drug interactions, inappropriate dosing, and adverse drug reactions**. Appropriate dose adjustment, monitoring, and individualized therapeutic planning are crucial to optimize treatment outcomes and minimize complications.[3,4]

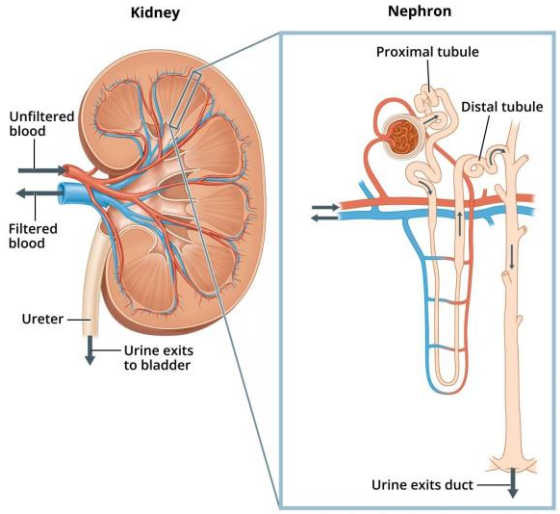
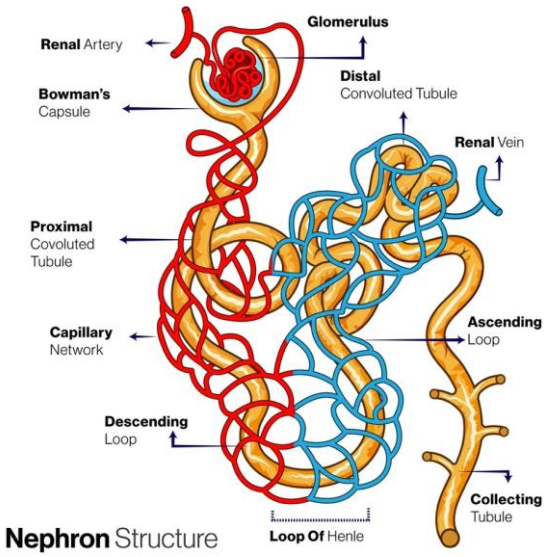
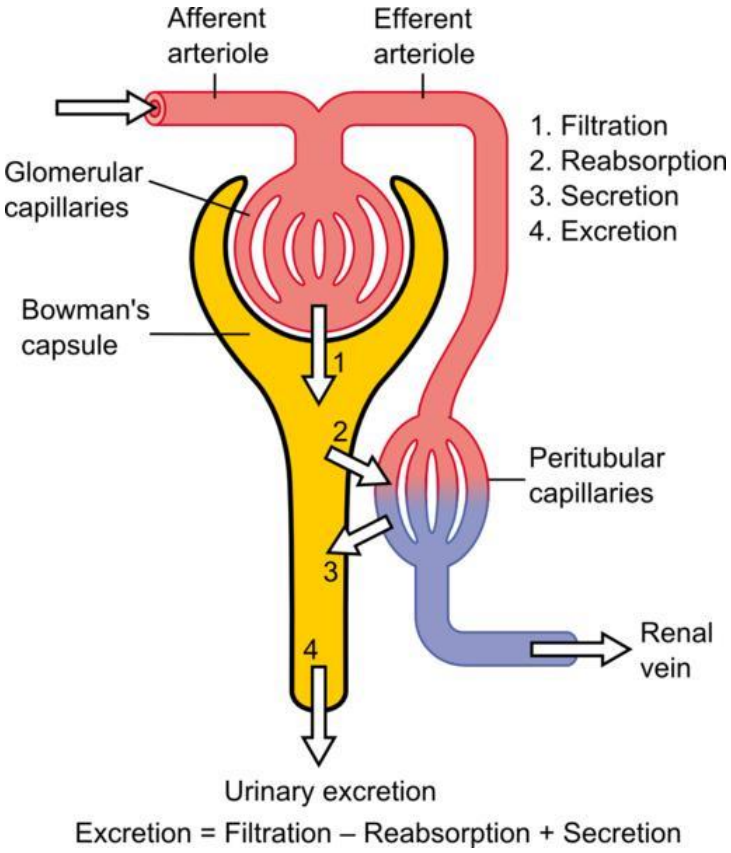
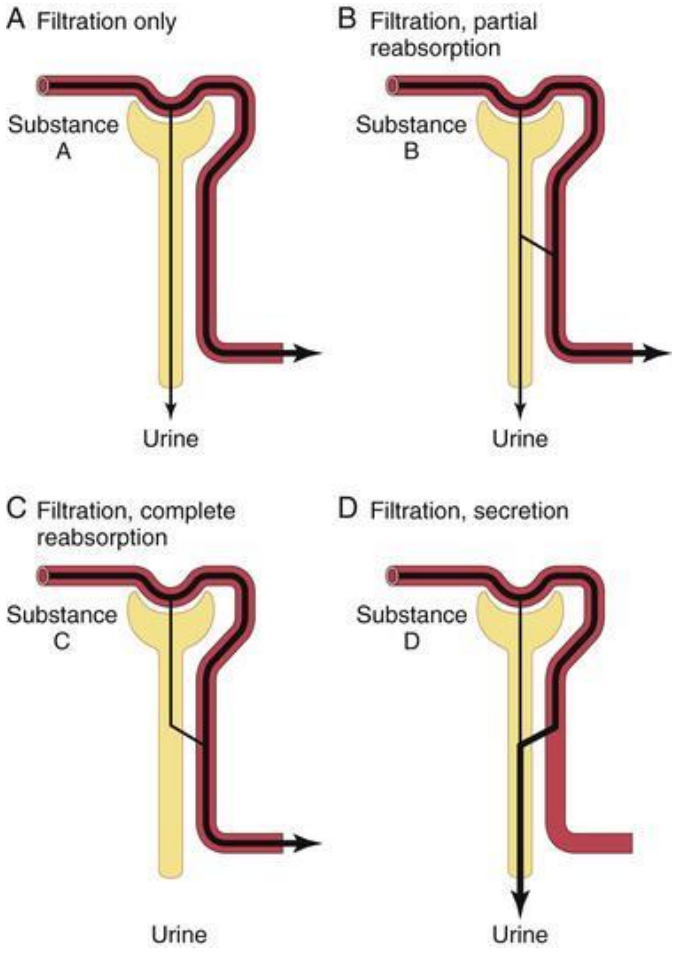
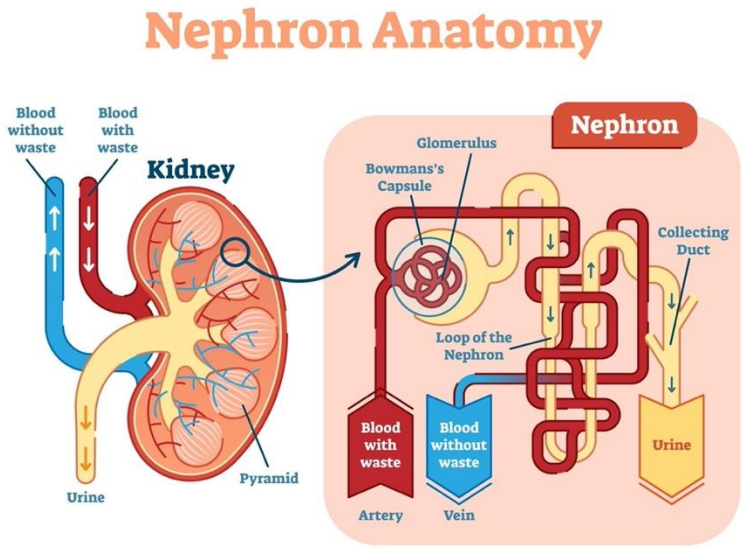


Figure 1: Role of Kidneys in Drug Elimination.




Afferent arteriole
Efferent arteriole
1. Filtration
2. Reabsorption
3. Secretion
4. Excretion
Glomerular capillaries
Bowman's capsule
1
2
3
4
Peritubular capillaries
Renal vein
Urinary excretion
Excretion = Filtration – Reabsorption + Secretion


A Filtration only
Substance A
Urine
B Filtration, partial reabsorption
Substance B
Urine
C Filtration, complete reabsorption
Substance C
Urine
D Filtration, secretion
Substance D
Urine



The kidneys are responsible for **filtration, secretion, and reabsorption of drugs and their metabolites**. These processes determine the rate at which drugs are eliminated from the body. Glomerular filtration rate (GFR) is widely used to assess kidney function and determine appropriate drug dosing. A reduction in renal function results in **decreased drug clearance, prolonged half-life, and accumulation of drugs**, which increases the risk of toxicity.[5,6]

In patients with renal impairment, physiological changes may include:

- Reduced glomerular filtration rate
- Altered tubular secretion
- Impaired drug metabolism
- Changes in plasma protein binding
- Fluid and electrolyte imbalance

These alterations significantly impact drug disposition and require **careful dose adjustment and therapeutic monitoring** to prevent adverse outcomes.[7,8]

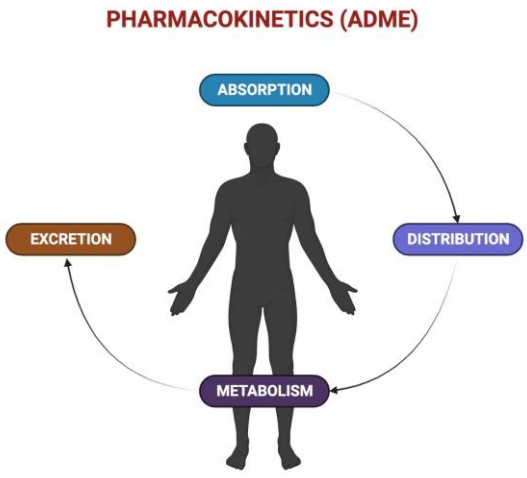
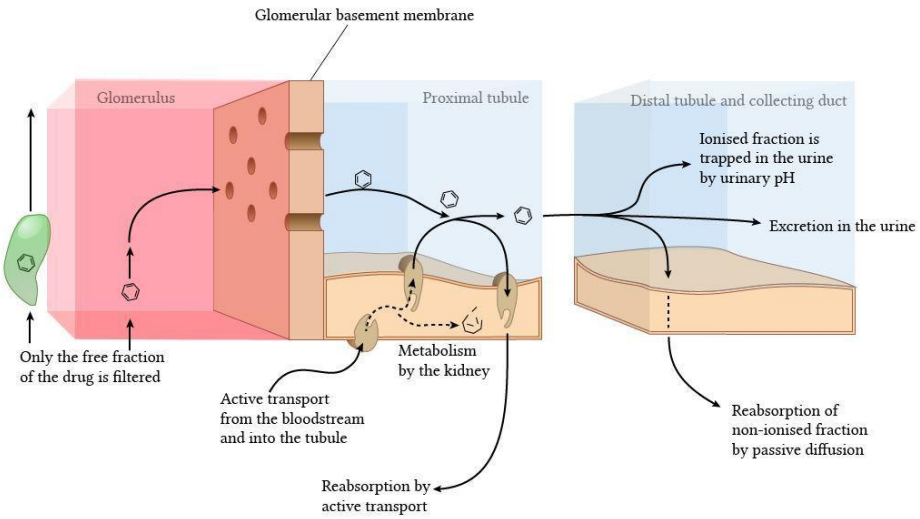
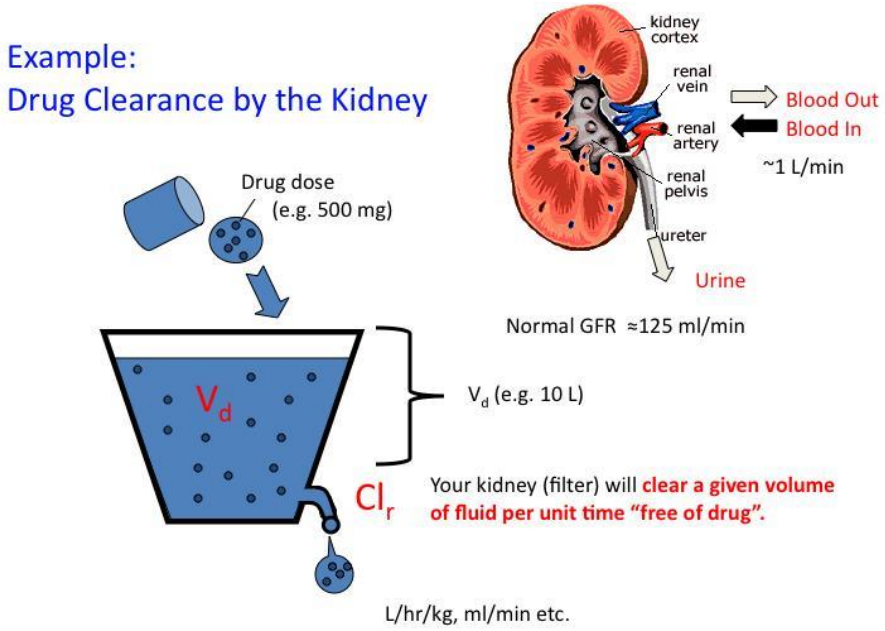


Figure 2: Pharmacokinetic Changes in Renal Impairment.


Glomerular basement membrane
Glomerulus
Proximal tubule
Distal tubule and collecting duct
Ionised fraction is trapped in the urine by urinary pH
Excretion in the urine
Only the free fraction of the drug is filtered
Metabolism by the kidney
Active transport from the bloodstream and into the tubule
Reabsorption of non-ionised fraction by passive diffusion
Reabsorption by active transport


Example:
Drug Clearance by the Kidney
kidney cortex
renal vein
renal artery
renal pelvis
ureter
Urine
Blood Out
Blood In
~1 L/min
Drug dose
(e.g. 500 mg)
Normal GFR ≈125 ml/min
Vd
Vd (e.g. 10 L)
Clr
Your kidney (filter) will clear a given volume of fluid per unit time "free of drug".
L/hr/kg, ml/min etc.

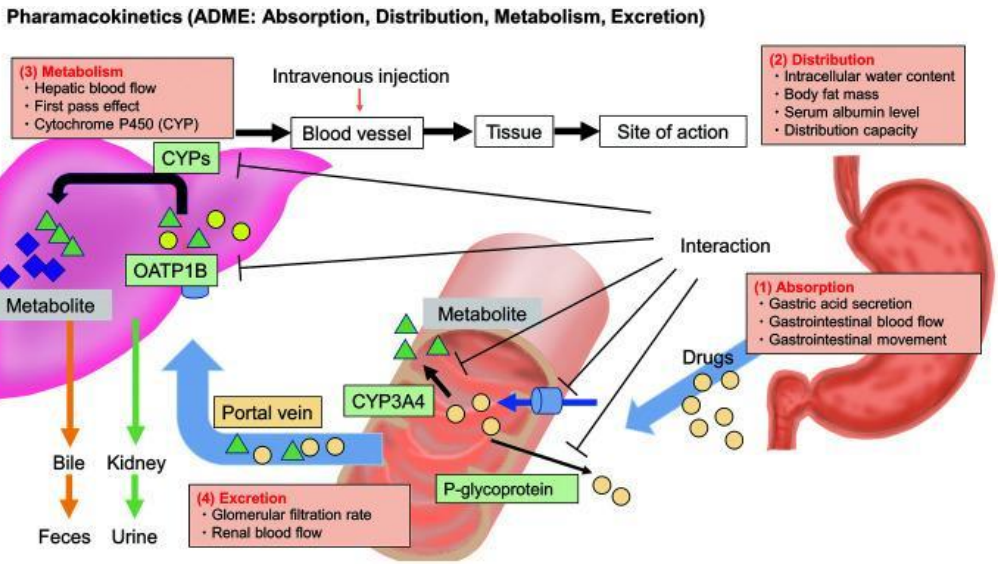
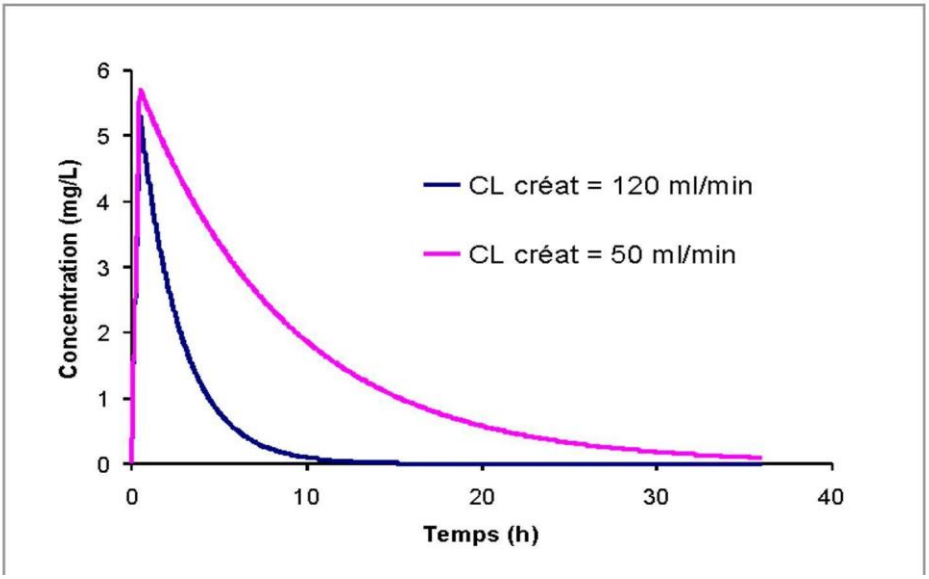

Pharamacokinetics (ADME: Absorption, Distribution, Metabolism, Excretion)
(3) Metabolism
· Hepatic blood flow
· First pass effect
· Cytochrome P450 (CYP)
Intravenous injection
Blood vessel
Tissue
Site of action
(2) Distribution
· Intracellular water content
· Body fat mass
· Serum albumin level
· Distribution capacity
CYPs
OATP1B
Metabolite
Interaction
(1) Absorption
· Gastric acid secretion
· Gastrointestinal blood flow
· Gastrointestinal movement
Metabolite
Drugs
CYP3A4
Portal vein
Bile
Kidney
Feces
Urine
(4) Excretion
· Glomerular filtration rate
· Renal blood flow
P-glycoprotein

Table 1: Mechanism of Renal Clearance.

Renal Clearance (ml/min)	*Renal Clearance Ratio*	*Mechanism of Renal Clearance*	*Example(s)*
0 (least value)	0	Drug filtered and Reabsorbed completely	Glucose
< 130	Above 0, Below 1	Drug filtered and Reabsorbed partially	Lipophilic drugs
130 (GFR)	1	Drug is filtered only	Creatinine, Inulin
> 130	> 1	Drug filtered as well as secreted actively	Polar, ionic drugs
650 (Highest value)	5	Clearance equal to renal plasma flow rate	Iodopyracet



Renal impairment affects all pharmacokinetic processes, including **absorption, distribution, metabolism, and excretion**. These changes can significantly alter drug response and increase the risk of toxicity. Drugs that are primarily eliminated through the kidneys are particularly affected by reduced renal function.[9,10]

Pharmacokinetic changes in renal impairment include:

- Decreased drug clearance
- Increased drug half-life
- Altered volume of distribution
- Reduced protein binding
- Accumulation of active metabolites

These changes necessitate **individualized dosing regimens and regular therapeutic monitoring** to ensure optimal drug therapy.[11,12]

Table 2: How To Use The Table For Renal Dosage Adjustment.

Parameter	Details
Estimation of Renal Function	Creatinine Clearance (CrCl) calculation using Cockcroft-Gault equation
Formula (Male)	CrCl (mL/min) = [(140 − age) × weight (kg)] / (72 × Serum Creatinine)
Formula (Female)	CrCl = 0.85 × Male CrCl
Weight to be Used	Ideal Body Weight (IBW) or Adjusted Body Weight (ABW) in obese patients
IBW (Male)	50 kg + 2.3 kg for each inch over 5 feet
IBW (Female)	45.5 kg + 2.3 kg for each inch over 5 feet
ABW Formula	IBW + 0.4 × (Actual Body Weight − IBW)
Dose Adjustment Basis	Based on severity of renal insufficiency
Renal Function Classification	30–49 mL/min: Mild renal insufficiency
	10–29 mL/min: Moderate renal insufficiency
	<10 mL/min: Severe renal insufficiency
Dialysis Consideration	Haemodialysis, Peritoneal Dialysis, Continuous Renal Replacement Therapy
Note	Dosage recommendations are based on Cockcroft-Gault CrCl, not GFR. Use clinical judgment along with pharmacokinetic data.

Table 3: Guidelines For Antibiotic Dosing.

Drug Class	Drug	Usual Dose	Mild (30–49 mL/min)	Moderate (10–29 mL/min)	Severe (<10 mL/min)	Haemodialysis	Peritoneal Dialysis
Penicillins	Amoxicillin (PO)	250–500 mg q8h	Same dose	Same dose	500 mg q24h or adjusted	500 mg q24h; post-dialysis dose	Usual dose
	Amoxicillin + Clavulanate	500/125 mg q8h	Usual dose	250/125 mg q12h	250/125 mg q24h	Adjust after dialysis	Usual dose
	Ampicillin (IV)	1–2 g q4–6h	Same dose	Same dose q8h	Reduced frequency	500–1000 mg q12h	Usual dose
	Cloxacillin / Penicillin V	1–2 g q4–6h	Same dose	75% of dose	No adjustment necessary	No adjustment	Usual dose
	Piperacillin + Tazobactam	4.5 g q6–8h	2.25–3.375 g q6h	2.25 g q8h	2.25 g q12h	Dose after dialysis	Adjusted
Carbapenems	Imipenem/Meropenem	Standard dose	Reduced dose	Further reduction	Significant reduction	Post-dialysis dosing	Adjusted

Table 4: Antihyperglycemic agents and kidney Function.

		DRUG CLASS						
		Metformin (max daily dose)	SGLT2i (Recommended daily dose*)	GLP1-RA	DPP4i (max daily dose)	All Insulins	Secretagogues	
							Glyburide	Others
eGFR (mL/min/1.73m²)	45 – 59	2 g	No dose change	No dose change	No dose change	No dose change	Avoid Glyburide	No dose change
	30 – 44	1 g	Canagliflozin 100 mg Dapagliflozin 10 mg Empagliflozin 10 or 25 mg		Linagliptin 5 mg Sitagliptin 50 mg (Saxagliptin 2.5 mg**)			Gliclazide or Repaglinide preferred Dose reduction may be needed
	15 – 29	500 mg			Linagliptin 5 mg Sitagliptin 25 mg	Dose reduction may be needed		
	<15 or on dialysis	Avoid	Stop on dialysis	Limited data available				
	Risk related to low GFR	Lactic acidosis	Cardiorenal protection preserved but less reduction in A1C with low GFR		Accumulation***	Accumulation and hypoglycemia	Prolonged and severe hypoglycemia	Hypoglycemia

*listed alphabetically, **increased risk for heart failure, ***except linagliptin

Table 5: Drug Class Requiring dosage adjustment in CKD.

	Drug Class	Adjust Dose	Avoid in Stages 4 and 5 of CKD
B	Beta Blockers	Acebutolol, atenolol, bisoprolol, nadolol, sotalol	Sotalol
A	ACE inhibitors /ARBs*	All ACE inhibitors	Olmesartan
N	NSAIDS**, Opioids	Codeine, morphine, oxycodone, tramadol	All NSAIDS, meperidine
D	Diuretics	Potassium sparing diuretics, thiazide diuretics	Potassium sparing diuretics, thiazide diuretics
D	Diabetic medications	Gliclazide, acarbose, insulin, gliptins	Glyburide, metformin, exanitide
C	Cholesterol medications	Pravastatin, rosuvastatin; fibrates	
A	Antimicrobials (Dose reductions are often delayed for 24-48 hours to allow for aggressive dosing/drug to reach steady state)	*Antibiotics:* Most antibiotics EXCEPT cloxacillin, clindamycin, metronidazole, erythromycin, azithromycin *Antifungals:* fluconazole, itraconazole *Antivirals:* acyclovir, famciclovir, valacyclovir	Nitrofurantoin
M	Miscellaneous	Allopurinol, colchicine, digoxin, H_2RAs***	New anticoagulants
P	Psychotropics	Lithium; gabapentin, pregabalin, topiramate, vigabatrin; bupropion, duloxetine, paroxetine, venlafaxine	

Table 6: Dosing Requirement in patients with chronic kidney disease.

Drug	Usual dosage	Dosage adjustment based on GFR		
		>50	10 to 50	<10
Allopurinol	300 mg daily	75%	50%	25%
Famotidine	20 to 40 mg at bedtime	50%	25%	10%
Metoclopramide	10 to 15 mg three times daily	100%	75%	50%
omeprazole	no adjustment needed	–	–	–
Ranitidine	150 to 300 mg at bedtime	75%	50%	25%

Medication	Usual Dose	Dose Adjustment in Renal Failure			Note	US FDA Pregnancy Category
		Mild (GFR 60 - 90 ml/min)	Moderate (GFR 30 - 59 ml/min)	Severe (GFR <30 ml/min)		
Dipeptidyl peptidase-4 (DPP-4) inhibitors						
Sitagliptin	100 mg OD	100%	30 - 50: 50%	25%	#	B
Vildagliptin	50 mg OD - BD	100%	50 - 59: 100% <50: limited data	(limited data)	#	-
Saxagliptin	2.5 - 5 mg OD	100%	2.5 mg OD	2.5 mg OD	#	B
Linagliptin	2.5 - 5 mg OD	No dosage adjustment necessary				B
Alogliptin	25 mg OD	No dosage adjustment necessary	12.5 mg OD	15 - 30: 6.25 mg OD	#	-
Sodium glucose co-transporter 2 (SGLT-2) inhibitors						
Dapagliflozin	5 - 10 mg OD	No dosage adjustment necessary	Avoid			C
Canagliflozin	100 - 300 mg OD	No dosage adjustment necessary	45 - 60: 100 mg OD <45: Avoid	Avoid		-
Empagliflozin	10 - 25 mg OD	No dosage adjustment necessary	<45: Avoid	Avoid		-
Insulin Doses should be adjusted based on frequent monitoring to balance goals of glycaemic control and avoidance of hypoglycaemia						
Antiamoebic						
Metronidazole	200 - 400 mg q8 - 12h	No dosage adjustment necessary			#	B
Antifungal						
Fluconazole	200 - 400 mg q8 - 12h	No dosage adjustment necessary	50%	50%		C (single dose for vaginal candidiasis) D (all other indications)

Dose adjustment is a critical component of medication management in patients with renal impairment. Failure to adjust medication doses can result in **drug toxicity, adverse effects, and therapeutic failure**. Various methods are used to determine dose adjustments, including **creatinine clearance, estimated glomerular filtration rate (eGFR), and therapeutic drug monitoring**.[13,14]

Healthcare professionals should consider:

- Severity of renal impairment
- Drug elimination pathway
- Patient-specific factors
- Drug toxicity profile
- Duration of therapy

Appropriate dose modification improves **patient safety, therapeutic outcomes, and quality of care**.[15,16]

CHALLENGES IN MEDICATION MANAGEMENT

Managing medications in patients with renal impairment presents several challenges. These include **polypharmacy, complex dosing regimens, lack of standardized guidelines, and limited monitoring facilities**. In addition, patients with renal impairment often experience **frequent hospitalizations, increased healthcare costs, and reduced quality of life**.

Healthcare providers must adopt **multidisciplinary approaches** involving physicians, pharmacists, and nurses to optimize medication management. Clinical pharmacists play a crucial role in identifying medication-related problems, recommending dose adjustments, and ensuring safe drug therapy.[17]

CLINICAL SIGNIFICANCE OF MEDICATION MANAGEMENT

Proper medication management in renal impairment is essential for:

- Preventing drug toxicity
- Improving therapeutic outcomes
- Reducing hospital admissions
- Enhancing patient safety
- Promoting rational drug use

Studies have demonstrated that **appropriate dose adjustment and monitoring significantly reduce adverse drug reactions and improve clinical outcomes**. Implementation of evidence-based guidelines and pharmacokinetic principles plays an important role in improving patient care.[18]

NEED FOR THE PRESENT STUDY

Despite the availability of guidelines, inappropriate medication use in patients with renal impairment remains common. This highlights the need for **evaluating medication management practices, dose adjustment patterns, and prescribing behaviours**. The present study aims to **assess medication management in patients with renal impairment and identify areas for improvement**.

This study will contribute to improving **patient safety, therapeutic outcomes, and rational drug use** in patients with renal impairment. Furthermore, it will help healthcare professionals adopt **evidence-based medication management strategies** to reduce complications and enhance patient care.

LITERATURE REVIEW

1. Aronoff GR (1999) presented one of the earliest comprehensive frameworks for drug prescribing in patients with renal impairment, emphasizing that **renal dysfunction significantly alters drug elimination and increases the risk of accumulation and toxicity**. The author highlighted the importance of individualized dosing strategies, particularly through **dose reduction or extension of dosing intervals**, depending on the degree of renal impairment. Creatinine clearance (CrCl) was identified as a fundamental parameter for guiding dosage adjustments, establishing a structured approach that continues to inform modern clinical practice.

URL: https://www.acponline.org

2. Nolin TD et al. (2008) elaborated on the **core principles of clinical pharmacokinetics in kidney disease**, demonstrating that renal impairment influences not only drug elimination but also absorption, distribution, metabolism, and protein binding. The study emphasized that **reduced renal function prolongs drug half-life and increases systemic exposure**, thereby elevating the likelihood of adverse drug reactions. The authors further stressed that pharmacokinetic changes are highly drug-specific and patient-dependent, necessitating individualized therapeutic decision-making rather than reliance on standard dosing alone.

DOI: https://doi.org/10.2215/CJN.01690408

3. Mushi L et al. (2019) evaluated dose adjustment practices in patients with renal impairment and reported that a **substantial proportion of prescriptions were not appropriately modified**, leading to increased risk of adverse drug events. The study identified key barriers such as lack of prescriber awareness, absence of standardized institutional protocols, and limited involvement of clinical pharmacists. The authors strongly recommended implementing **clinical decision-support systems and multidisciplinary interventions** to improve prescribing accuracy and patient safety.

DOI: https://doi.org/10.1186/s12882-019-1257-2

4. Nolin TD et al. (2007) examined challenges in drug dosing among patients with renal disease, emphasizing that reliance solely on serum creatinine is insufficient. The study advocated for the use of **estimated glomerular filtration rate (eGFR) or creatinine clearance (CrCl)** for more accurate assessment. Additionally, patient-specific factors such as **age, body weight, comorbidities, and concurrent medications** were identified as critical determinants in optimizing pharmacotherapy.

DOI: https://doi.org/10.2215/CJN.00950207

5. Naud J et al. (2012) explored pharmacokinetic alterations in renal disease, noting that uremic toxins can significantly modify **drug metabolism and protein binding**, thereby affecting drug efficacy and safety. The study highlighted that **standard dosing guidelines may not be universally applicable**, and emphasized the importance of **therapeutic drug monitoring (TDM)** and clinical judgment in achieving optimal outcomes.

DOI: https://doi.org/10.2165/11631930-000000000-00000

6. Thomas R et al. (2008) discussed the clinical implications of inappropriate drug dosing in chronic kidney disease (CKD), stating that **improper dose adjustment can result in toxicity, therapeutic failure, and increased healthcare burden**. The authors recommended routine renal function assessment and emphasized the importance of **interdisciplinary collaboration between physicians, pharmacists, and healthcare professionals** to enhance treatment outcomes.

URL: https://www.aafp.org

7. Brown EA et al. (2020) focused on prescribing practices in patients with renal impairment, particularly among elderly populations. The study highlighted the issue of **polypharmacy**, which increases the risk of drug interactions and adverse effects. The authors recommended a **patient-centered approach**, careful risk-benefit evaluation, and regular monitoring to ensure safe prescribing practices.

DOI: https://doi.org/10.1111/bcp.14209

8. Porrini E et al. (2019) investigated the pharmacokinetic implications of glomerular hyperfiltration, demonstrating that **increased renal function can also influence drug clearance**, potentially leading to subtherapeutic drug levels. The study emphasized the need for **dynamic and accurate assessment of renal function** to guide appropriate dosing strategies in both impaired and augmented renal states.

DOI: https://doi.org/10.2215/CJN.01680219

9. The U.S. Food and Drug Administration (2020) provided detailed regulatory guidance on pharmacokinetic studies in patients with impaired renal function, emphasizing the need for **standardized study designs, robust data analysis, and evidence-based labelling recommendations**. The document highlighted the growing role of **pharmacokinetic modelling and simulation techniques** in predicting drug behaviour and optimizing dosing regimens in renal impairment.

URL: https://www.fda.gov

10. The KDIGO Work Group (2021) issued globally recognized guidelines for drug dosing in acute and chronic kidney disease, emphasizing **standardization, patient safety, and individualized therapeutic approaches**. The guidelines advocate for continuous monitoring of renal function and integration of **evidence-based practices** into clinical decision-making processes.

URL: https://kdigo.org

11. Murray PT et al. (2019) discussed the principles of kidney pharmacotherapy, emphasizing the **complex interplay between pharmacokinetics and pharmacodynamics** in renal impairment. The study highlighted that altered drug handling requires **careful drug selection, dose adjustment, and close monitoring** to prevent toxicity and ensure therapeutic efficacy.

DOI: https://doi.org/10.1053/j.ajkd.2019.05.015

12. Zhang X et al. (2019) reviewed recent advancements in pharmacokinetic research, particularly focusing on **population pharmacokinetics and advanced modelling approaches**. The study emphasized that integrating these modern techniques into clinical practice can significantly improve **dose precision and individualized therapy** in patients with renal dysfunction.

DOI: https://doi.org/10.1002/cpt.1570

13. Carter BL and Ernst ME (2018) highlighted that **inappropriate medication dosing in CKD patients is a major contributor to adverse drug outcomes**. The authors recommended adherence to clinical guidelines, regular monitoring, and improved clinician education to enhance safe prescribing practices.

DOI: https://doi.org/10.1097/01.JAA.0000541478.52254.5c

14. Ali S et al. (2020) examined antimicrobial dosing in renal impairment and reported that **antibiotics are among the most frequently misused drugs due to improper dose adjustments**. The study emphasized that such misuse contributes to both toxicity and antimicrobial resistance, underscoring the need for **strict adherence to dosing guidelines and antimicrobial stewardship programs**.

URL: https://pharmaceutical-journal.com

15. Pottel H et al. (2021) discussed methods for estimating kidney function, highlighting that tools such as **eGFR and creatinine clearance equations are essential for accurate dose determination**. The study also noted variability among different estimation methods and emphasized the importance of selecting appropriate formulas based on patient characteristics.

DOI: https://doi.org/10.1111/bcp.14688

16. Patel K et al. (2021) explored the application of **physiologically based pharmacokinetic (PBPK) modelling** in patients with CKD. The study demonstrated that PBPK models can effectively simulate drug behaviour and support **personalized dosing strategies**, particularly in complex clinical scenarios involving multiple comorbidities.

DOI: https://doi.org/10.3389/fphar.2021.672658

17. Nolin TD et al. (2008) further reinforced the clinical importance of pharmacokinetic alterations in renal disease, emphasizing that **integration of scientific knowledge into routine clinical practice is essential for improving patient safety**. The authors also highlighted the need for continuous research and updated clinical guidelines to address evolving challenges in renal pharmacotherapy.

DOI: https://doi.org/10.2165/00003088-200847120-00001

SUMMARY OF LITERATURE REVIEW

*The collective evidence from the reviewed studies clearly indicates that **drug dosing in patients with renal impairment is a highly complex and clinically significant process** requiring careful consideration of pharmacokinetic and pharmacodynamic changes. Most studies consistently demonstrate that **failure to appropriately adjust drug doses can result in toxicity, therapeutic failure, prolonged hospitalization, and increased healthcare costs**. Key contributing factors to inappropriate dosing include **lack of awareness, insufficient use of renal function assessment tools, absence of standardized guidelines, and limited interdisciplinary collaboration**.*

*Furthermore, recent advancements in pharmacokinetic modelling, including **population-based and physiologically based approaches**, have enhanced the understanding of drug behaviour in renal disease. However, the translation of these advancements into routine clinical practice remains limited. Therefore, there is a critical need for **improved clinical training, implementation of evidence-based guidelines, integration of decision-support systems, and active***

involvement of clinical pharmacists. *Strengthening these measures will play a vital role in ensuring* ***safe, effective, and rational drug use in patients with renal impairment****, ultimately improving patient outcomes and reducing healthcare burden.*

AIM AND OBJECTIVES

AIM

The primary aim of the study titled **"Managing Medication in Patients with Renal Impairment"** is to comprehensively evaluate the principles, challenges, and clinical practices associated with medication management in patients with compromised renal function. This study seeks to assess how alterations in renal physiology influence drug pharmacokinetics and pharmacodynamics, thereby necessitating individualized dose modifications to ensure therapeutic efficacy and patient safety.[1,2]

In addition, the study aims to examine the extent to which current prescribing practices adhere to established clinical guidelines and evidence-based recommendations for dose adjustment in renal impairment. By identifying gaps in knowledge, prescribing behaviour, and implementation of dosing guidelines, the study intends to contribute toward improving rational drug use and minimizing adverse drug reactions in this vulnerable population.[4,6]

OBJECTIVES

1. **To evaluate prescribing patterns in patients with renal impairment**

This objective focuses on analysing current medication prescribing trends and determining whether appropriate dose adjustments are made based on renal function parameters such as creatinine clearance (CrCl) and estimated glomerular filtration rate (eGFR).[1,5]

2. **To assess the impact of renal impairment on drug pharmacokinetics and pharmacodynamics**

The study aims to understand how renal dysfunction alters drug absorption, distribution, metabolism, and excretion, and how these changes influence therapeutic outcomes and toxicity risks.[2,5]

3. **To identify commonly prescribed medications requiring dose adjustment**

This includes evaluating drug classes such as antimicrobials, cardiovascular drugs, and analgesics that are frequently used in renal patients and are highly dependent on renal elimination for clearance.[1,4]

4. **To determine the prevalence of inappropriate dosing in renal impairment**

The objective seeks to quantify the extent of incorrect dosing practices and associated risks, including adverse drug reactions, drug accumulation, and treatment failure.[3]

5. **To analyze factors contributing to irrational prescribing practices**

This involves identifying contributing factors such as lack of awareness, inadequate use of dosing guidelines, absence of clinical decision-support systems, and limited interdisciplinary collaboration among healthcare professionals.[6,7]

6. **To evaluate the role of clinical guidelines and regulatory recommendations**

The study examines the application of established guidelines, including those provided by regulatory authorities and international organizations, in optimizing drug therapy for patients with renal dysfunction.[9,10]

7. To assess the role of clinical pharmacists in medication management

This objective highlights the importance of pharmacist-led interventions in improving dose accuracy, preventing medication errors, and enhancing patient safety through medication review and monitoring.[11]

8. To propose strategies for optimizing medication management in renal impairment

Based on study findings, recommendations will be developed to improve prescribing practices, including clinician education, guideline implementation, use of pharmacokinetic modelling, and strengthening multidisciplinary collaboration.[12,16]

METHODOLOGY

STUDY DESIGN

The present study was designed as a **prospective observational and analytical study** aimed at evaluating medication management practices among patients with renal impairment. The study was conducted in a tertiary care hospital setting, where patients with varying stages of renal dysfunction receive continuous clinical care. A prospective approach was adopted to ensure **real-time data collection**, thereby improving the reliability and clinical relevance of the findings.

The study design allowed for the assessment of prescribing trends, dose adjustment practices, and associated clinical outcomes in accordance with established pharmacokinetic principles in renal disease.[1-4]

STUDY POPULATION

The study population comprised **patients diagnosed with renal impairment**, including both acute kidney injury (AKI) and chronic kidney disease (CKD), who were receiving pharmacological treatment during the study period. Patients were categorized based on severity of renal dysfunction using **estimated glomerular filtration rate (eGFR)** values, as recommended in clinical guidelines.[10,15]

Both male and female patients across different age groups were included to ensure **representative sampling**. The inclusion of diverse patient demographics enabled a comprehensive evaluation of medication use patterns and dosing practices.

INCLUSION AND EXCLUSION CRITERIA

INCLUSION CRITERIA

- Patients diagnosed with **renal impairment (CKD or AKI)**
- Patients receiving **one or more medications requiring dose adjustment**
- Patients with **complete clinical and laboratory data**
- Patients willing to participate in the study

EXCLUSION CRITERIA

- Patients with **incomplete medical records**
- Patients not receiving pharmacological treatment
- Pregnant or critically unstable patients (where data collection was not feasible)

DATA COLLECTION PROCEDURE

Data were collected using a **structured data collection form** designed to capture relevant clinical, laboratory, and medication-related information. The collected parameters included:

- **Demographic details** (age, gender)
- **Clinical diagnosis and comorbidities**
- **Laboratory parameters** (serum creatinine, eGFR, blood urea)
- **Medication details** (drug name, class, dose, frequency)
- **Dose adjustment practices** based on renal function

Renal function was assessed using standard equations such as **Cockcroft–Gault formula and eGFR calculations**, which are widely recommended for drug dosing decisions.[15]

The collected prescriptions were evaluated against **standard dosing guidelines** to determine appropriateness of dose adjustment.[1,6,13]

ASSESSMENT OF MEDICATION APPROPRIATENESS

The appropriateness of prescribed medications was assessed based on:

- **Renal dosing guidelines and standard references**[1,6]
- **Pharmacokinetic principles in renal impairment**[2,5]
- **Clinical recommendations and regulatory guidelines**[9,10]

Medications were categorized as:

- **Appropriately adjusted**
- **Inappropriately adjusted**
- **No adjustment required**

Special attention was given to drugs with **narrow therapeutic index and nephrotoxic potential**, as these require strict monitoring.[7,11]

OUTCOME MEASURES

The primary outcomes assessed in the study included:

- **Prevalence of appropriate and inappropriate dose adjustments**
- **Pattern of drug utilization in renal impairment**
- **Association between renal function and prescribing practices**
- **Identification of high-risk medications**

Secondary outcomes included evaluation of factors contributing to irrational dosing, such as lack of guideline adherence or inadequate monitoring.

STATISTICAL ANALYSIS

The collected data were systematically entered and analyzed using appropriate statistical software. The study employed the following statistical methods:

- **Descriptive Statistics:** Used to summarize demographic characteristics, clinical variables, and medication patterns. Data were presented as **mean, standard deviation, frequencies, and percentages**.
- **One-Way ANOVA (Analysis of Variance):** Applied to compare **mean laboratory values across different stages of CKD**, enabling assessment of variation in renal function parameters.
- **Chi-Square Test:** Used to evaluate **associations between categorical variables**, such as stage of renal disease and appropriateness of dose adjustment.
- **Cross-Tabulation (Crosstabs):** Used to present relationships between variables in a structured tabular format, facilitating interpretation of prescribing trends.

A **p-value < 0.05** was considered statistically significant, ensuring the reliability of the observed associations.

ETHICAL CONSIDERATIONS

The study was conducted in accordance with ethical standards and institutional guidelines. Patient confidentiality was strictly maintained, and all data were used solely for academic and research purposes. Ethical principles such as **respect for patient autonomy, privacy, and data protection** were strictly followed.

RATIONALE FOR METHODOLOGY

The chosen methodology provides a **systematic and evidence-based framework** to evaluate medication management in renal impairment. By integrating clinical data with pharmacokinetic principles and statistical analysis, the study ensures a comprehensive understanding of prescribing practices and their implications.

This approach aligns with global recommendations emphasizing the importance of **individualized therapy, continuous monitoring, and rational drug use in patients with compromised renal function.**[8,12,16]

RESULTS

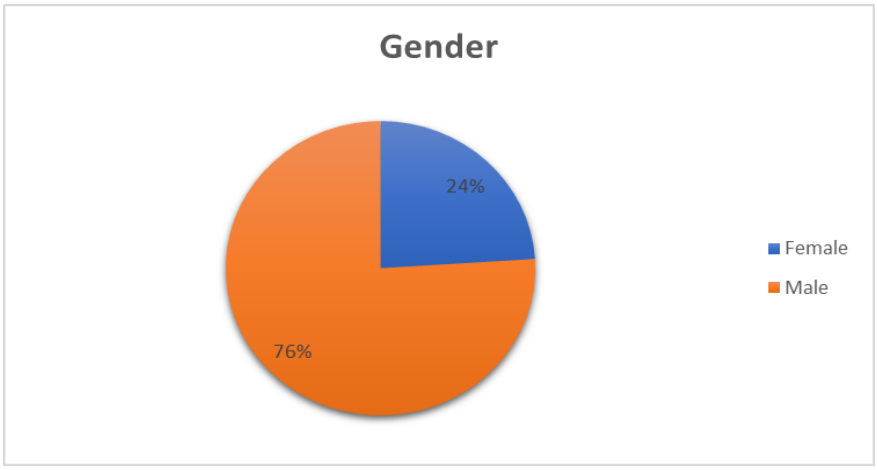
The present study evaluated **100 patients with renal impairment**, focusing on demographic characteristics, clinical profile, laboratory findings, and medication utilization patterns. The findings are presented systematically below.

1. DEMOGRAPHIC CHARACTERISTICS

The gender-wise distribution of the study population is presented in **Table 7**. The study population demonstrated a clear **male predominance**, with males constituting the majority of participants, while females represented a comparatively smaller proportion. This distribution may reflect gender-based differences in healthcare access, disease prevalence, or risk factor exposure.

Table 7: Gender Distribution of the Study Population (N = 100).

Gender	Frequency	Percentage (%)
Male	76	76%
Female	24	24%
Total	**100**	**100%**



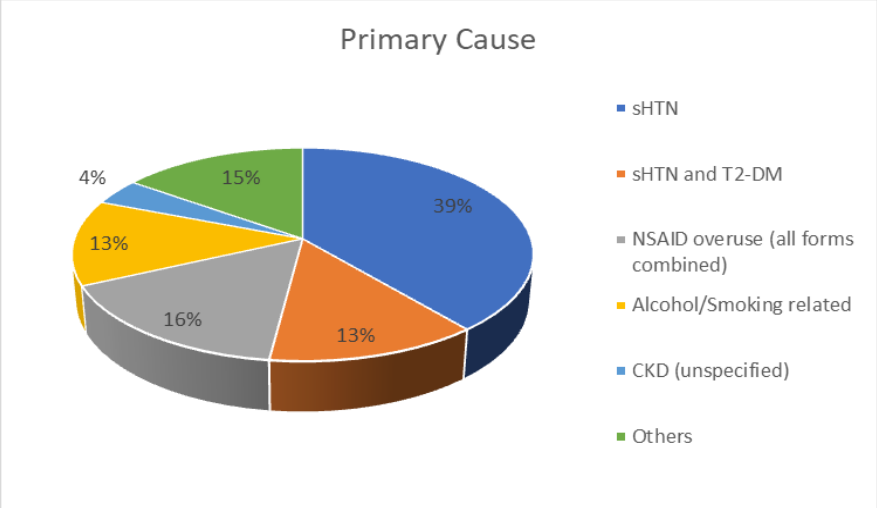
Among the 100 study participants, males constituted the majority (76%), while females accounted for 24%, indicating a male predominance in the study population.

2. ETIOLOGY OF CHRONIC KIDNEY DISEASE

The primary causes contributing to chronic kidney disease are summarized in **Table 8**. **Hypertension emerged as the leading etiological factor**, both as an isolated condition and in combination with diabetes mellitus. Additionally, **NSAID overuse and substance-related factors (alcohol/smoking)** were identified as significant contributors. These findings highlight the multifactorial nature of CKD and the role of both clinical and lifestyle-related determinants.

Table 8: **Primary Cause of CKD (N = 100).**

Cause	Frequency	Percentage (%)
sHTN	39	39%
sHTN and T2-DM	13	13%
NSAID overuse (all forms combined)	16	16%
Alcohol/Smoking related	13	13%
CKD (unspecified)	4	4%
Others	15	15%
Total	**100**	**100%**



Hypertension was the leading primary cause of CKD, either alone (39%) or in combination with diabetes (13%). NSAID overuse and substance abuse (alcohol/smoking) each contributed to 16% and 13% of cases, respectively.

3. COMORBID CONDITIONS

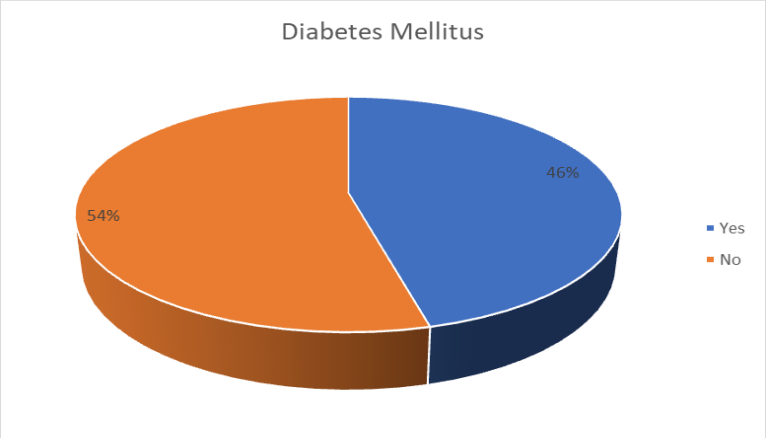
The prevalence of major comorbidities is presented in **Table 9 to Table 14**.

A substantial proportion of patients were diagnosed with **diabetes mellitus**, confirming its role as a major risk factor for CKD progression. However, **hypertension was the most prevalent comorbidity**, affecting the majority of the study population.

Conditions such as **anemia and electrolyte imbalance** were also observed, indicating complications commonly associated with declining renal function. The occurrence of additional conditions such as hyperlipidemia was relatively low, with most patients not reporting other significant comorbidities.

Table 9: **Diabetes Mellitus (N = 100).**

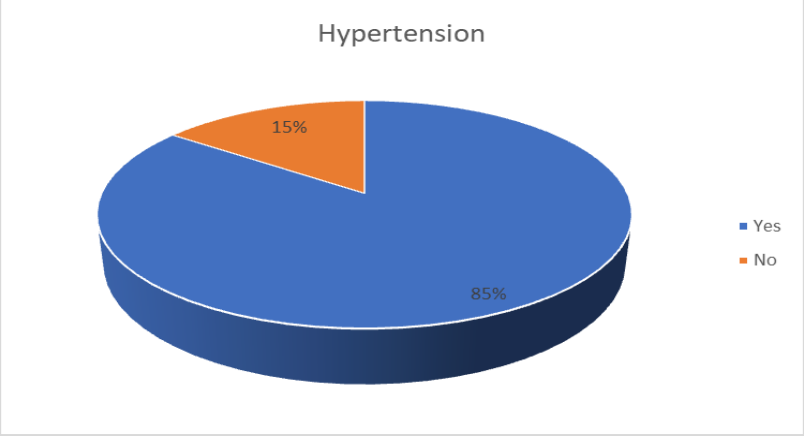
Category	Frequency	Percentage (%)
Yes	46	46%
No	54	54%
Total	**100**	**100%**



Diabetes mellitus was present in 46% of patients, indicating it as a major comorbidity in CKD.

Table 10: **Hypertension (N = 100).**

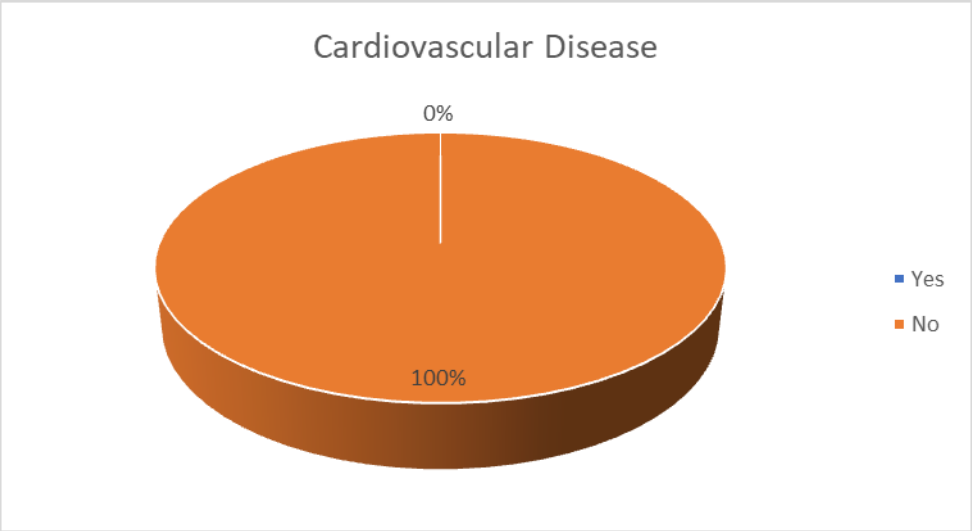
Category	Frequency	Percentage (%)
Yes	85	85%
No	15	15%
Total	**100**	**100%**



A majority of patients (85%) had hypertension, making it the most prevalent comorbidity.

Table 11: **Cardiovascular Disease (N = 100).**

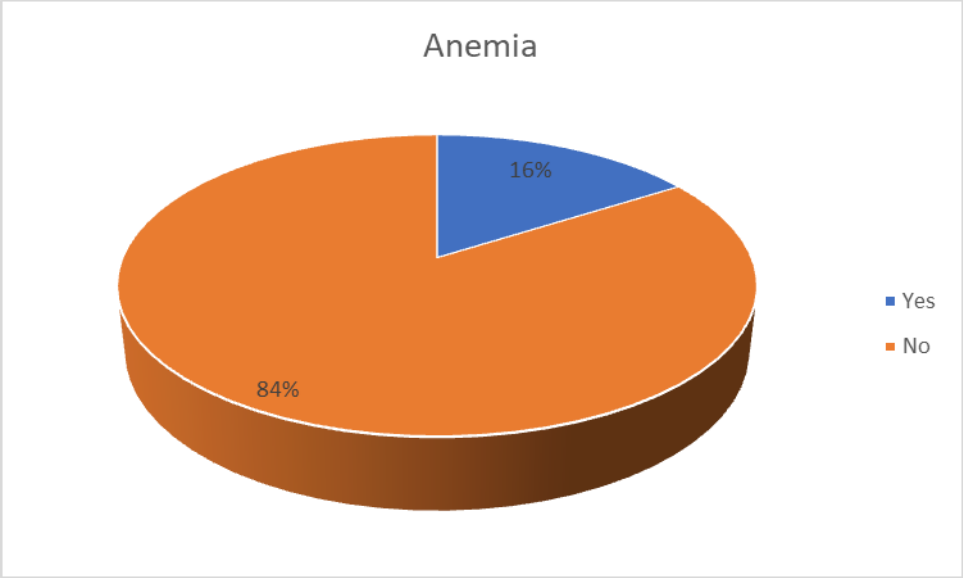
Category	Frequency	Percentage (%)
Yes	0	0%
No	100	100%



No patients in the study were reported to have cardiovascular disease.

Table 12: **Anemia (N = 100).**

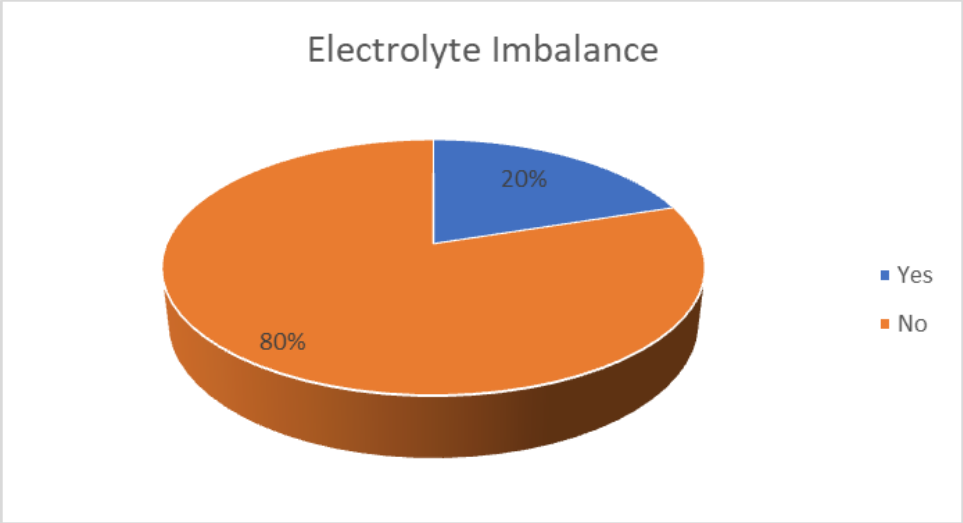
Category	Frequency	Percentage (%)
	16	16%
	84	84%
	100	**100%**



Anemia was observed in 16% of patients, indicating a common complication of CKD.

Table 13: Electrolyte Imbalance (N = 100)

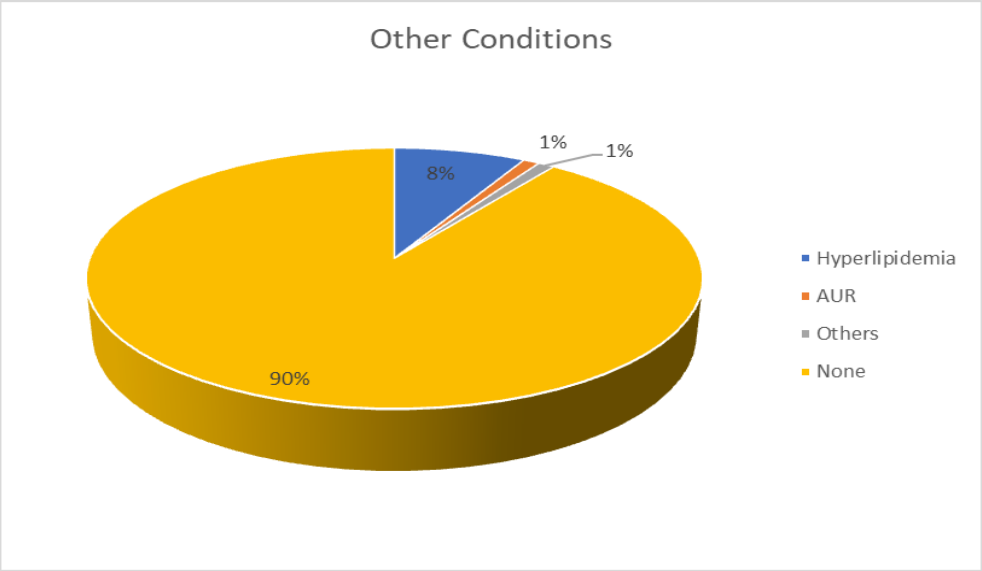
Category	Frequency	Percentage (%)
Yes	20	20%
No	80	80%
Total	**100**	**100%**



Electrolyte imbalance was present in 20% of patients.

Table 14: Other Conditions (N = 100).

Condition	Frequency	Percentage (%)
Hyperlipidemia	8	8%
AUR	1	1%
Others	1	1%
None	90	90%
Total	**100**	**100%**



Most patients (90%) had no additional conditions, while hyperlipidemia was the most common among those reported (8%).

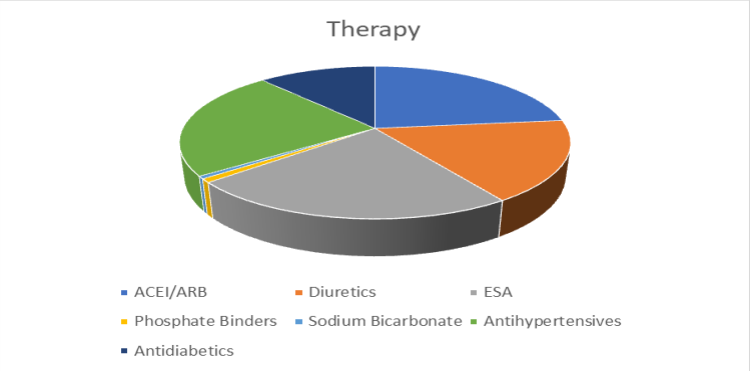
4. THERAPEUTIC MANAGEMENT OF CKD

The pattern of CKD-specific therapy is outlined in **Table 15**.

A large proportion of patients were receiving **ACE inhibitors/ARBs, erythropoiesis-stimulating agents (ESA), and antihypertensive therapy**, indicating adherence to standard CKD management protocols. However, the utilization of **phosphate binders and sodium bicarbonate** was minimal, suggesting possible underutilization of certain supportive therapies.

Table 15: CKD-Specific Therapy (N = 100).

Therapy	Yes (%)
ACEI/ARB	86%
Diuretics	64%
ESA	86%
Phosphate Binders	3%
Sodium Bicarbonate	2%
Antihypertensives	86%
Antidiabetics	43%



Most patients received ACEI/ARB, ESA, and antihypertensive therapy (86%). Use of phosphate binders and sodium bicarbonate was minimal.

5. DIETARY AND LIFESTYLE MODIFICATIONS

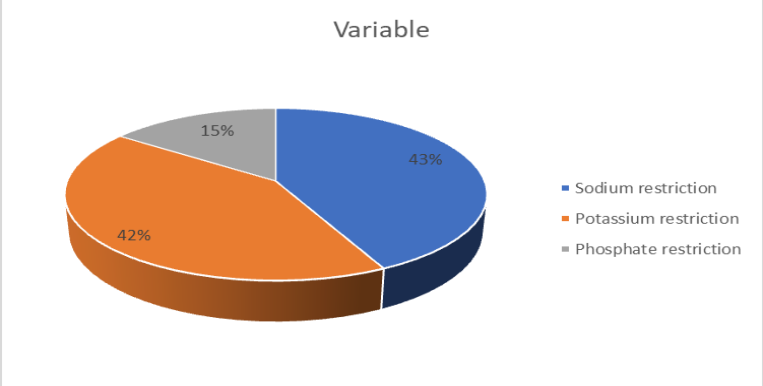
Patient adherence to dietary and lifestyle modifications is presented in **Table 16 and Table 17**.

A high level of compliance was observed for **sodium and potassium restriction**, reflecting effective dietary counselling in these areas. In contrast, **phosphate restriction showed relatively lower adherence**, indicating a potential gap in patient awareness or implementation.

Lifestyle modifications were notably poor. Only a small proportion of patients reported **avoidance of NSAIDs, smoking cessation, and regular follow-up**, highlighting a critical area requiring intervention.

Table 16: Dietary Modifications (N = 100).

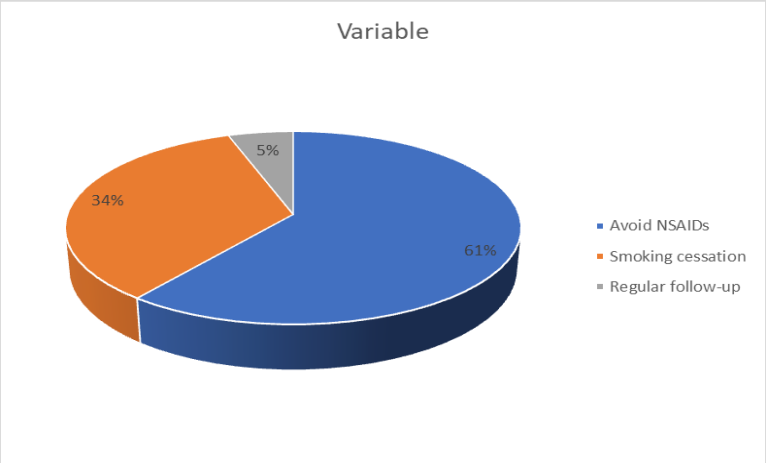
Variable	Yes (%)
Sodium restriction	93%
Potassium restriction	92%
Phosphate restriction	33%



High adherence was observed for sodium and potassium restriction, whereas phosphate restriction was followed by only 33% of patients.

Table 17: Lifestyle Modifications (N = 100).

Variable	Yes (%)
Avoid NSAIDs	23%
Smoking cessation	13%
Regular follow-up	2%



Lifestyle modification adherence was poor, with only 23% avoiding NSAIDs and 13% quitting smoking.

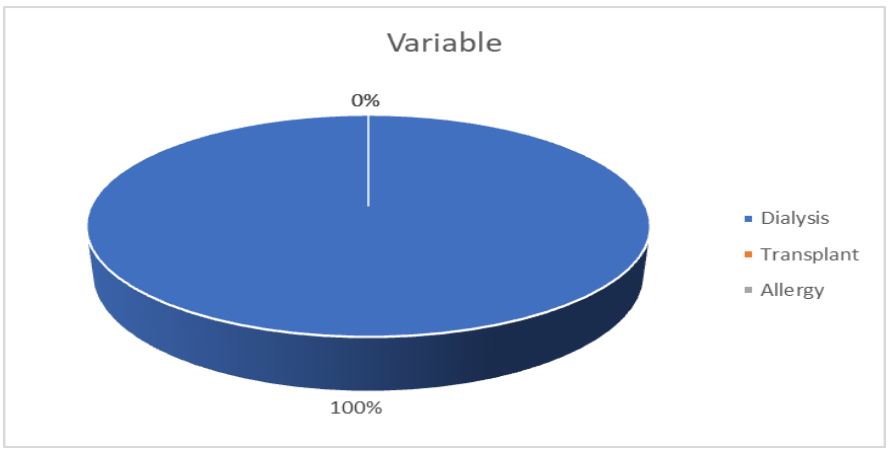
6. CLINICAL MANAGEMENT PRACTICES

Clinical management strategies are summarized in **Table 18**.

All patients included in the study were undergoing **dialysis**, indicating that the majority were in advanced stages of renal disease. Notably, none of the patients had undergone renal transplantation, and no drug allergies were reported.

Table 18: Clinical Management (N = 100).

Variable	Observation
Dialysis	100%
Transplant	0%
Allergy	0%



All patients were on dialysis, with no history of transplantation or drug allergies.

7. VITAL SIGNS AND ANTHROPOMETRIC PARAMETERS

The distribution of vital and anthropometric parameters is presented in **Table 19**.

The mean **systolic blood pressure was elevated**, suggesting suboptimal blood pressure control among the study population. Other parameters, including **pulse rate, respiratory rate, and body temperature**, were generally within near-normal ranges.

Although the average **body mass index (BMI)** was within the normal range, considerable variability was observed, indicating heterogeneity in nutritional and metabolic status.

Table 19: Vital Signs and Anthropometric Parameters (N = 100).

Variable	Mean ± SD	Minimum	Maximum
SBP (mmHg)	148.05 ± 18.07	110	190
DBP (mmHg)	74.79 ± 13.52	60	120
Pulse Rate (bpm)	87.59 ± 5.44	70	110
Respiratory Rate (per min)	21.88 ± 7.22	16	88
Temperature (°C)	37.44 ± 0.99	29.0	39.4
Weight (kg)	65.70 ± 8.46	40	86
Height (cm)	172.07 ± 12.40	130	190
BMI (kg/m²)	24.23 ± 19.66	12.3	216

The mean systolic blood pressure was elevated (148.05 mmHg), indicating poor blood pressure control. The average BMI was within the normal range, although a wide variation was observed. Other vital parameters such as pulse rate, respiratory rate, and temperature were within near-normal limits.

8. RENAL FUNCTION AND BIOCHEMICAL PROFILE

Renal and biochemical parameters are summarized in **Table 20 and Table 21**.

The findings clearly demonstrate **significant renal impairment**, as evidenced by elevated serum creatinine levels and reduced eGFR values.

Electrolyte abnormalities, particularly **hyperkalemia and elevated sodium levels**, were frequently observed. Additionally, **reduced hemoglobin levels** indicated the presence of anemia, while alterations in calcium and phosphate levels suggested disturbances in mineral metabolism.

The mean CKD stage indicated that **most patients were in advanced stages (Stage 4–5)**, reflecting late presentation and progression of disease.

Table 20: Renal Function and Biochemical Parameters (N = 100).

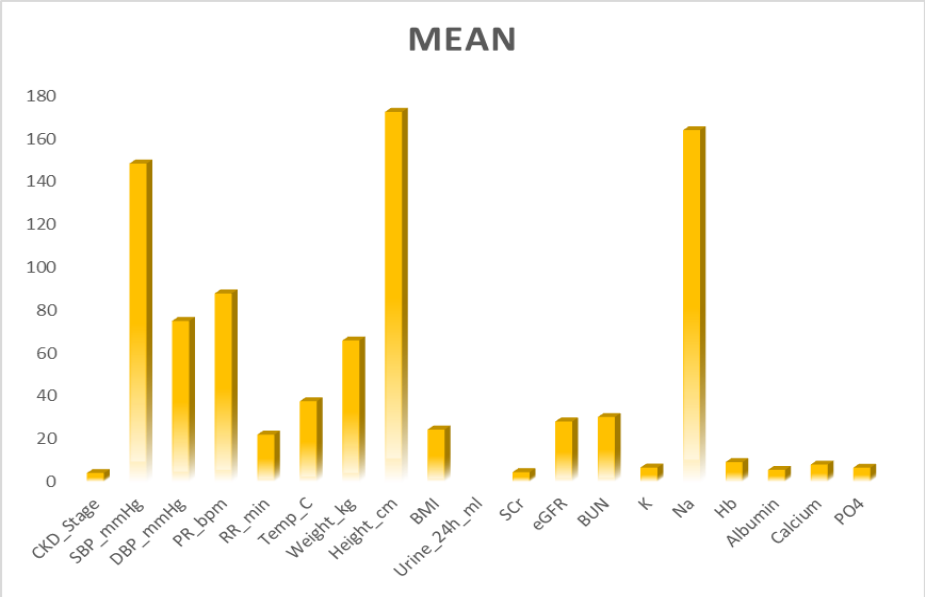
Variable	Mean ± SD	Minimum	Maximum
Serum Creatinine (mg/dL)	4.45 ± 2.71	1.4	13.0
eGFR (ml/min)	28.01 ± 4.98	12	54
BUN (mg/dL)	30.09 ± 6.53	3.5	45
Potassium (mEq/L)	6.55 ± 1.70	3.5	10.0
Sodium (mEq/L)	163.55 ± 10.12	140	185
Hemoglobin (g/dL)	9.07 ± 1.62	6.0	15.0
Albumin (g/dL)	5.49 ± 1.42	3.0	9.0
Calcium (mg/dL)	7.95 ± 1.21	5.0	11.0
Phosphate (mg/dL)	6.48 ± 6.56	3.0	66.0

Renal function parameters indicated significant impairment, with elevated serum creatinine (4.45 mg/dL) and reduced eGFR (28.01 ml/min). Electrolyte imbalance was evident, particularly hyperkalemia and elevated sodium levels. Hemoglobin levels were reduced, indicating anemia, while calcium levels were relatively low, suggesting mineral imbalance.

Table 21: CKD Stage Distribution (Continuous Form).

Variable	Mean ± SD	Minimum	Maximum
CKD Stage	4.03 ± 0.22	3	5

The mean CKD stage was 4.03, indicating that most patients were in advanced stages (Stage 4–5) of chronic kidney disease.



9. COMPARATIVE ANALYSIS ACROSS CKD STAGES

The comparison of laboratory parameters across CKD stages using ANOVA is presented in **Table 22**.

A **statistically significant difference** was observed in serum creatinine levels across different CKD stages (**$p < 0.05$**), confirming its strong association with disease severity.

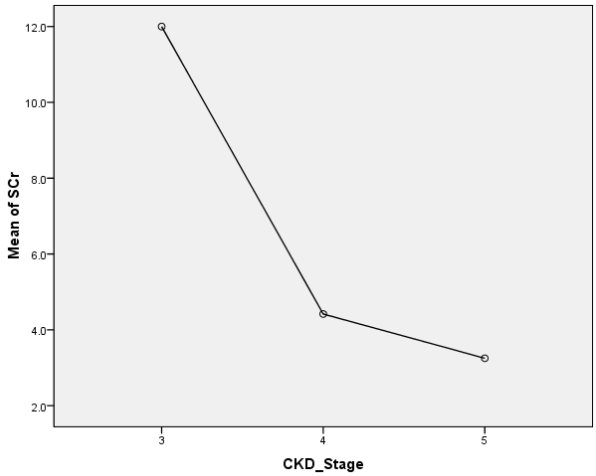
However, parameters such as **potassium and hemoglobin did not show statistically significant variation**, although clinically meaningful trends were observed. The lack of statistical significance may be attributed to **unequal sample distribution across stages**.

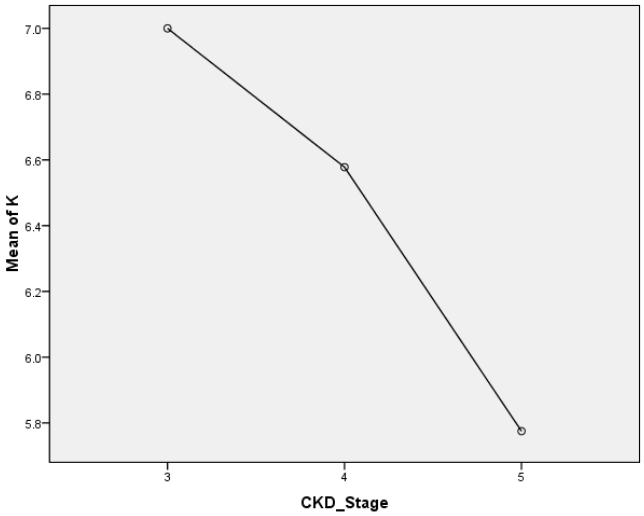
Table 22: Comparison of Laboratory Parameters Across CKD Stages (ANOVA Analysis).

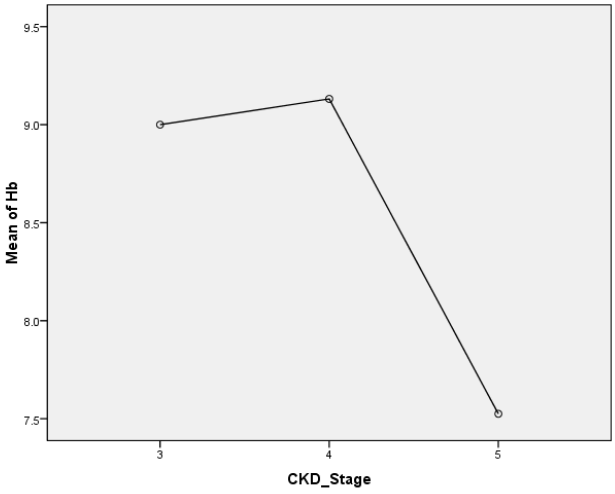
Parameter	CKD Stage 3 (Mean)	CKD Stage 4 (Mean ± SD)	CKD Stage 5 (Mean ± SD)	F-value	p-value
Serum Creatinine (mg/dL)	12.0	4.42 ± 2.65	3.25 ± 1.21	4.589	**0.012**
Potassium (mEq/L)	7.0	6.58 ± 1.72	5.78 ± 1.49	0.459	0.634
Hemoglobin (g/dL)	9.0	9.13 ± 1.61	7.53 ± 1.30	1.924	0.151

A one-way ANOVA was performed to compare laboratory parameters across CKD stages. A statistically significant difference was observed in serum creatinine levels among different CKD stages ($p = 0.012$), indicating its strong

association with disease severity. However, potassium (p = 0.634) and hemoglobin (p = 0.151) did not show statistically significant differences across CKD stages. Despite the lack of statistical significance, hemoglobin levels were lower in advanced CKD stages, suggesting clinical relevance. The small sample size in Stage 3 and Stage 5 groups may have influenced the statistical outcomes.







10. DRUG UTILIZATION PATTERN

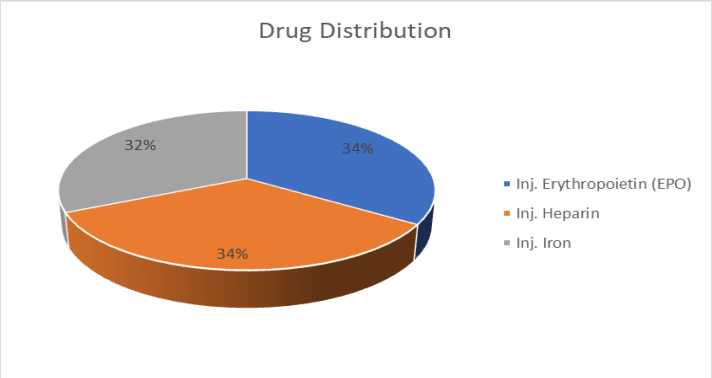
Drug distribution and prescribing patterns are presented in **Table 23 to Table 27**.

The most frequently administered medications included **erythropoietin, heparin, and iron preparations**, reflecting standard treatment for anemia and dialysis-related management.

All medications were administered via the **intravenous route**, indicating a hospital-based treatment setting. The dosing frequency varied, with **once-daily and thrice-weekly regimens** being most common.

Table 23: Drug Distribution.

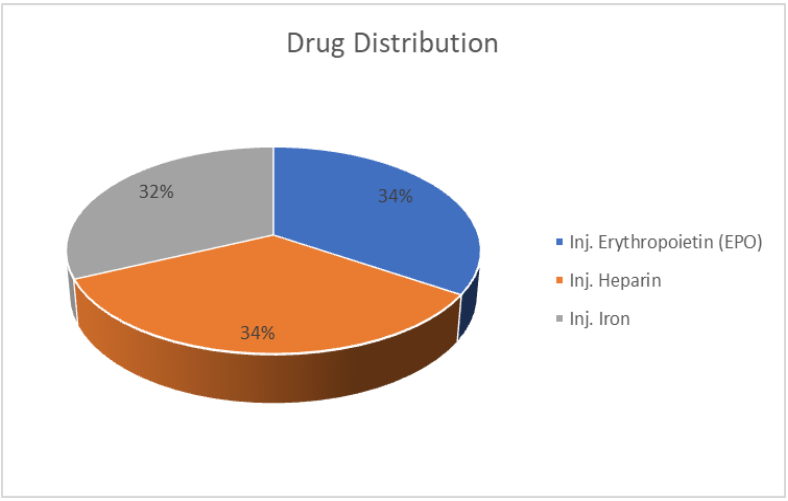
Drug	Frequency	Percentage (%)
Inj. Erythropoietin (EPO)	100	34.1%
Inj. Heparin	100	34.1%
Inj. Iron	93	31.7%
Total	**293**	**100%**



Erythropoietin and heparin were the most commonly prescribed drugs (34.1% each), followed by iron therapy (31.7%).

Table 24: Dose Distribution.

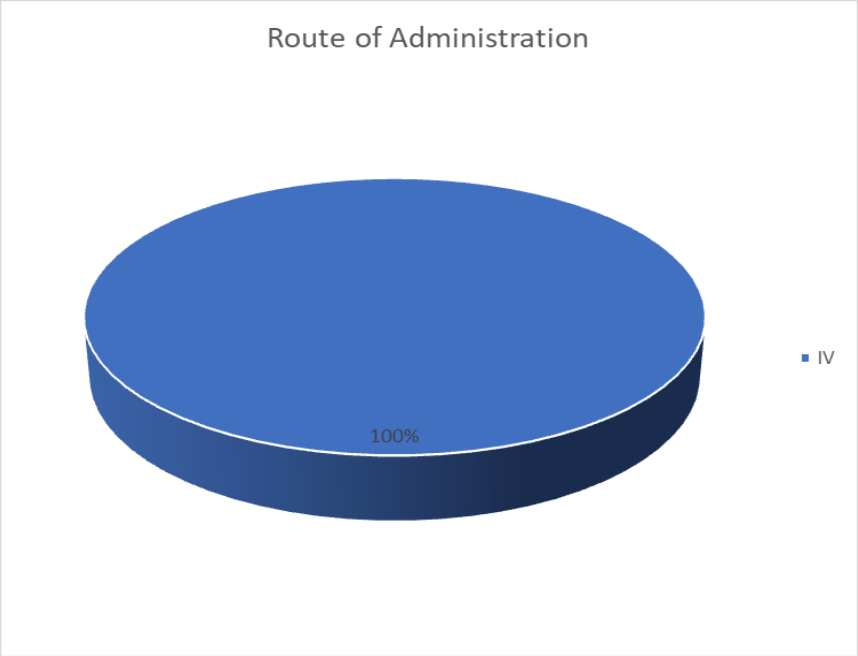
Dose	Frequency	Percentage (%)
4000 IU	100	34.1%
5 mL (loading dose)	100	34.1%
100 mg	93	31.7%
Total	**293**	**100%**



The most frequently used doses were 4000 IU and 5 mL loading dose (34.1% each), followed by 100 mg (31.7%).

Table 25: Route of Administration.

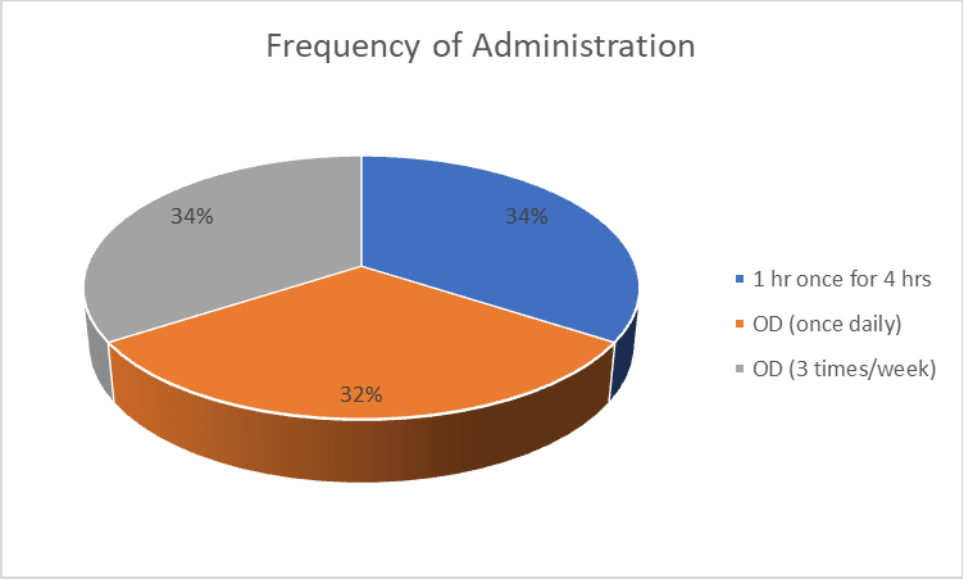
Route	Frequency	Percentage (%)
IV	293	100%



All medications were administered via the intravenous route.

Table 26: Frequency of Administration.

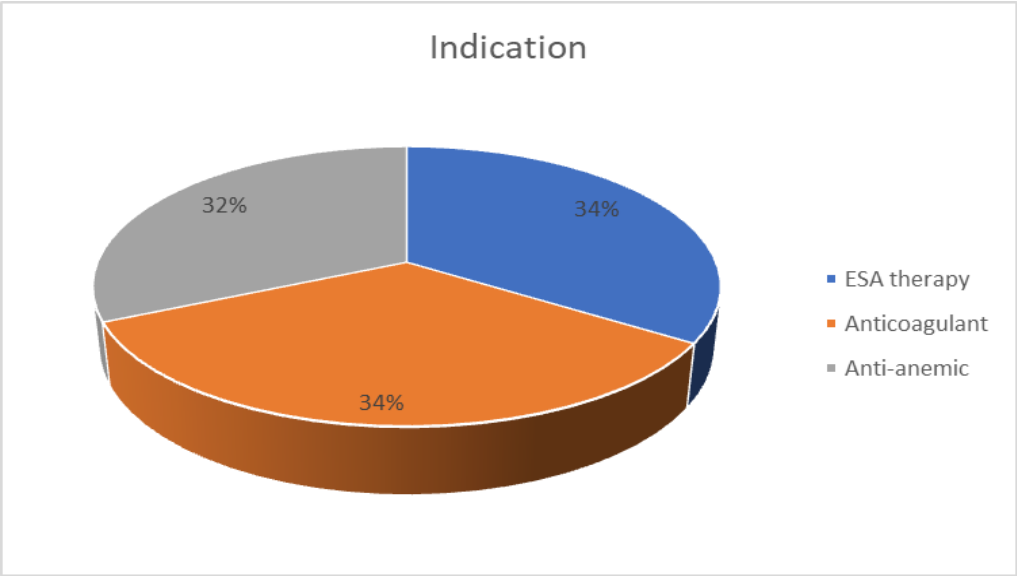
Frequency	Frequency	Percentage (%)
1 hr once for 4 hrs	100	34.1%
OD (once daily)	93	31.7%
OD (3 times/week)	100	34.1%
Total	**293**	**100%**



The most common administration patterns were once daily and thrice weekly dosing, each accounting for 34.1%.

Table 27: Indication.

Indication	Frequency	Percentage (%)
ESA therapy	100	34.1%
Anticoagulant	100	34.1%
Anti-anemic	93	31.7%
Total	**293**	**100%**



The primary indications were erythropoiesis-stimulating therapy and anticoagulation (34.1% each), followed by anemia management (31.7%).

11. CURRENT AND PAST MEDICATION PROFILE

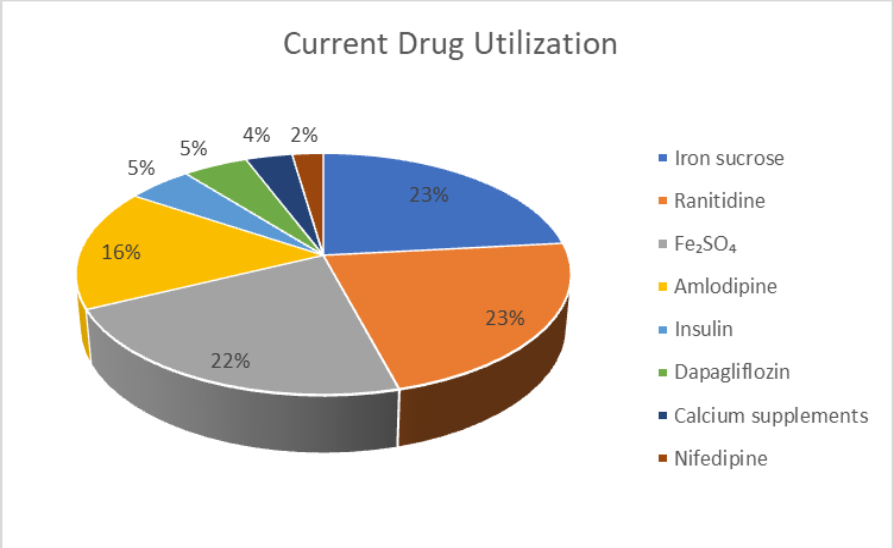
The current drug utilization pattern is shown in **Table 28**, while past medication history is presented in **Table 29**.

Iron supplements, **ranitidine, antihypertensives, and antidiabetic agents** were commonly prescribed. Past medication history revealed frequent use of **diuretics, beta-blockers, and oral hypoglycemic agents**.

Importantly, prior exposure to **NSAIDs and certain nephrotoxic drugs** was also observed, which may have contributed to disease progression.

Table 28: Current Drug Utilization.

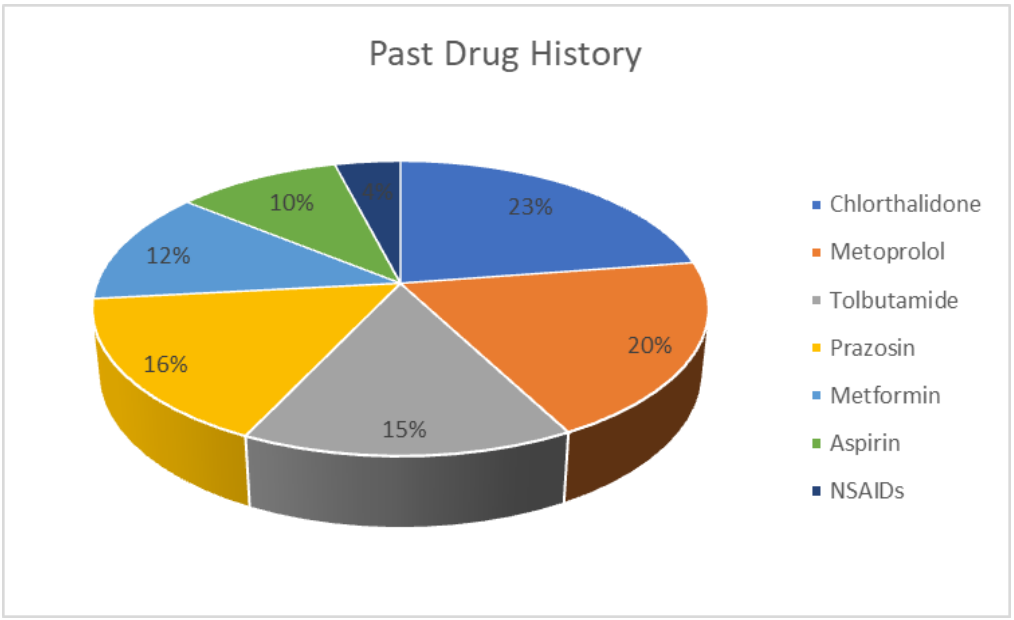
Drug	Frequency	Percentage (%)
Iron sucrose	99	21.7%
Ranitidine	95	20.8%
Fe_2SO_4	94	20.6%
Amlodipine	69	15.1%
Insulin	21	4.6%
Dapagliflozin	21	4.6%
Calcium supplements	15	3.3%
Nifedipine	10	2.2%
Others	Remaining	—
Total	**456**	**100%**



Iron preparations (iron sucrose and Fe_2SO_4) and ranitidine were the most commonly used drugs, followed by antihypertensives such as amlodipine. Antidiabetic agents were moderately prescribed.

Table 29: Past Drug History.

Drug	Frequency	Percentage (%)
Chlorthalidone	67	14.7%
Metoprolol	58	12.7%
Tolbutamide	44	9.6%
Prazosin	48	10.6%
Metformin	37	8.1%
Aspirin	30	6.6%
NSAIDs	12	2.6%
Others	Remaining	—
Total	**456**	**100%**



Diuretics and antihypertensives were commonly used in the past. Notably, NSAIDs and metformin were also reported, which may contribute to renal impairment.

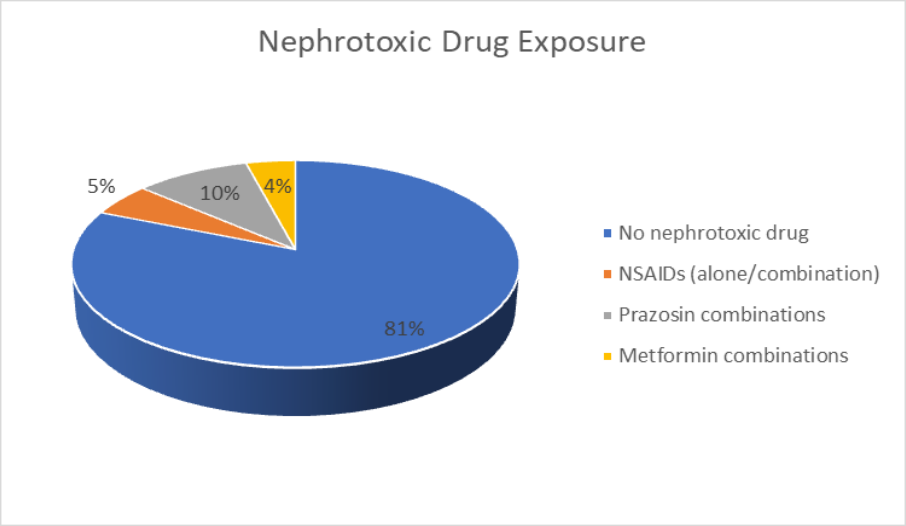
12. NEPHROTOXIC DRUG EXPOSURE

The distribution of nephrotoxic drug exposure is presented in **Table 30**.

Although the majority of patients had **no documented exposure**, a subset of patients reported use of **NSAIDs and combination therapies**, which are known risk factors for renal damage.

Table 30: Nephrotoxic Drug Exposure.

Category	Frequency	Percentage (%)
No nephrotoxic drug	360	78.9%
NSAIDs (alone/combination)	23	5.0%
Prazosin combinations	42	9.2%
Metformin combinations	18	3.9%
Others	Remaining	—
Total	**456**	**100%**



Most patients (78.9%) had no reported nephrotoxic drug exposure. Among those exposed, NSAIDs and combination therapies were the most common.

13. DURATION OF DRUG USE AND MEDICATION ADHERENCE

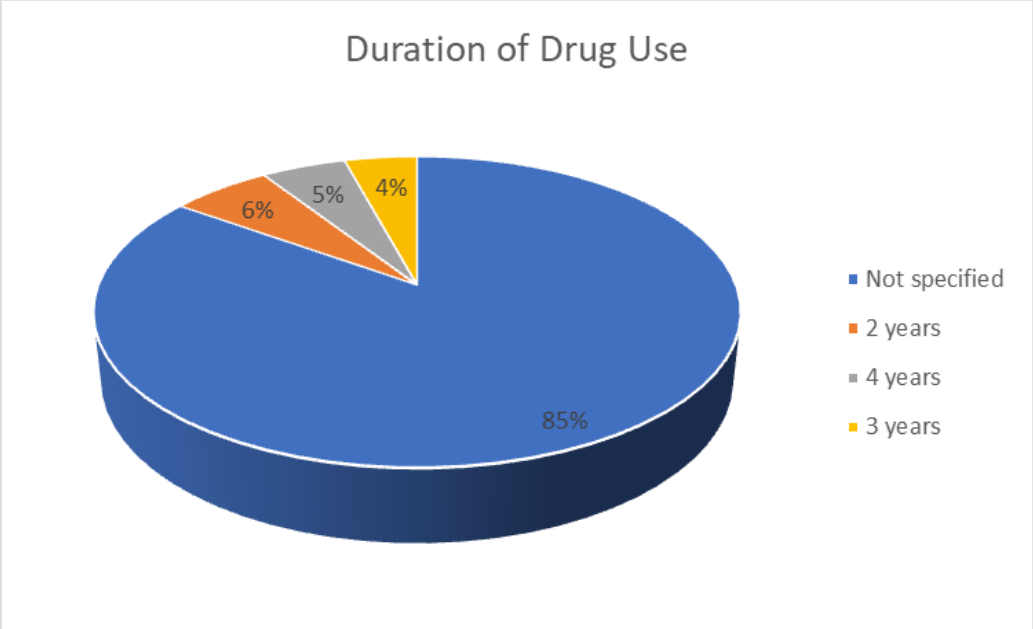
Drug usage duration and adherence patterns are shown in **Table 31 and Table 32**.

A significant proportion of records lacked documentation regarding **duration of drug use**, indicating limitations in data recording.

Medication adherence was found to be **suboptimal**, with only a small percentage of patients demonstrating good adherence, highlighting the need for improved patient education and follow-up.

Table 31: Duration of Drug Use.

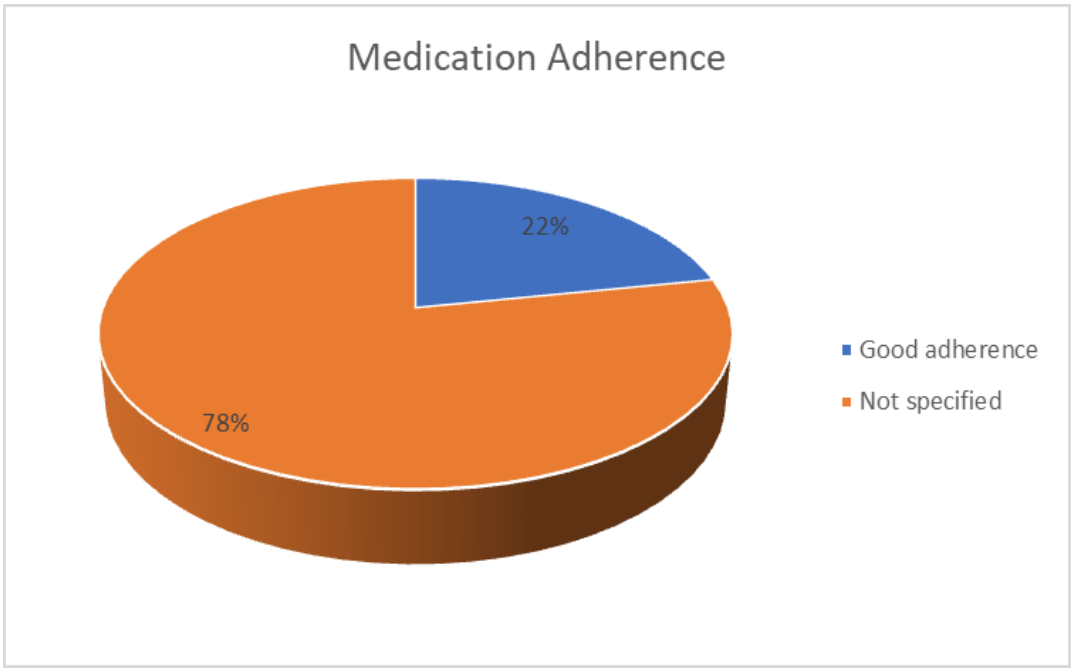
Duration	Frequency	Percentage (%)
Not specified	356	78.1%
2 years	25	5.5%
4 years	21	4.6%
3 years	18	3.9%
Others	Remaining	—
Total	**456**	**100%**



Drug duration was not specified in the majority of cases (78.1%). Among reported data, most patients had a drug history of 2–4 years.

Table 32: Medication Adherence.

Category	Frequency	Percentage (%)
Good adherence	100	21.9%
Not specified	356	78.1%
Total	**456**	**100%**



Only 21.9% of patients demonstrated good medication adherence, while adherence status was not documented for the majority.

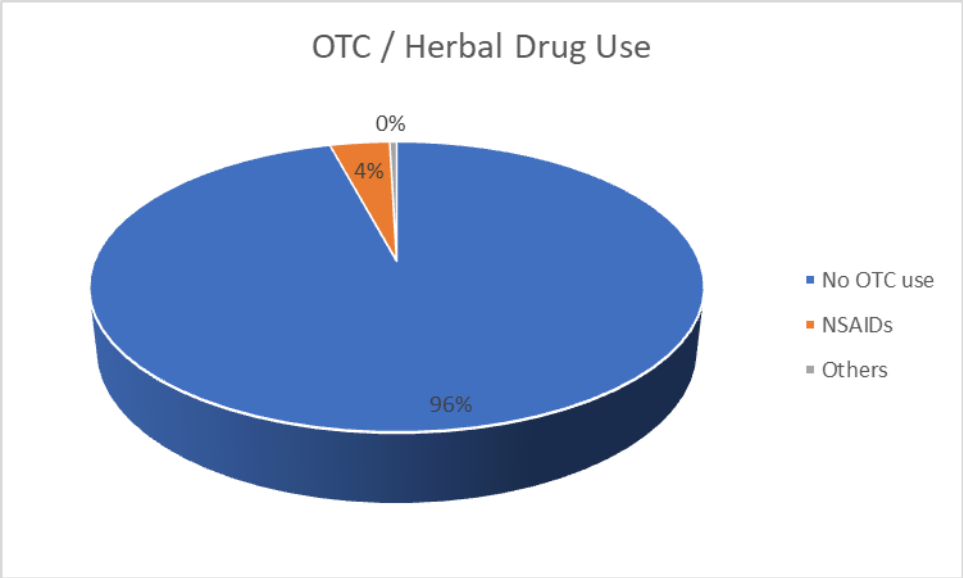
14. OTC AND HERBAL DRUG USE

The use of OTC and herbal medications is presented in **Table 33**.

Most patients reported **no use of OTC or herbal drugs**, while a small proportion reported NSAID use. Although the prevalence was low, such usage remains clinically significant due to its potential nephrotoxic effects.

Table 33: OTC / Herbal Drug Use.

Category	Frequency	Percentage (%)
No OTC use	437	95.8%
NSAIDs	17	3.7%
Others	2	0.5%
Total	**456**	**100%**



The majority of patients (95.8%) did not report OTC or herbal drug use. NSAIDs were the most commonly used OTC drugs among the remaining patients.

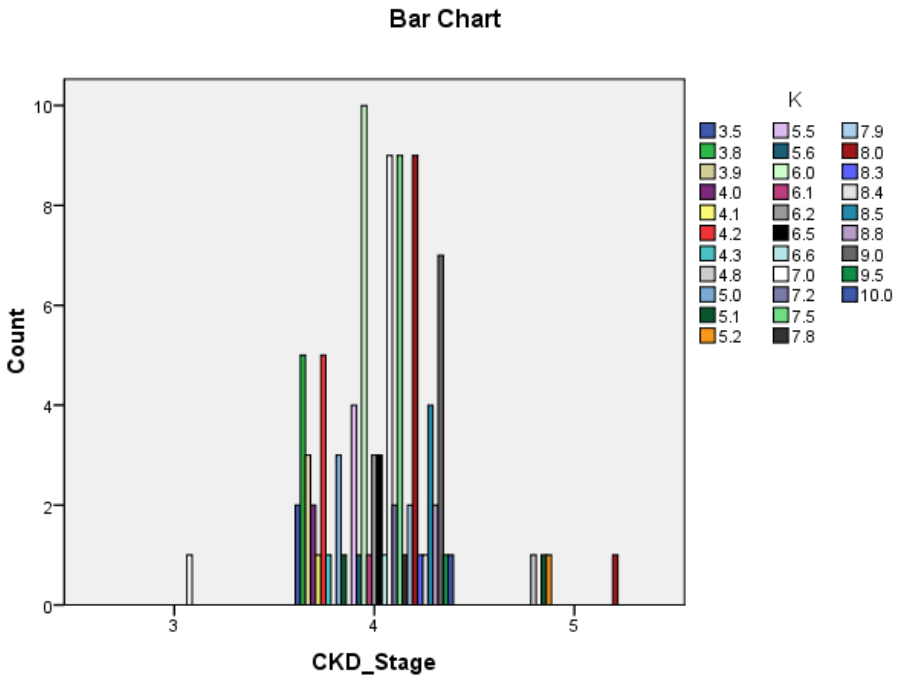
15. ASSOCIATION ANALYSIS

The association between CKD stage and biochemical parameters using Chi-square analysis is shown in **Table 34**.

No statistically significant association was observed (**p > 0.05**). However, the reliability of this analysis is limited due to a **high proportion of cells with low expected frequencies**, which violates Chi-square assumptions. Therefore, these findings should be interpreted with caution.

Table 34: Association Analysis using Chi-Square Test CKD_Stage * K (N = 100).

Test	Value	df	p-value
Pearson Chi-Square	72.579	60	0.128
Likelihood Ratio	28.931	60	1.000
Linear-by-Linear Association	0.888	1	0.346



The Chi-square test showed no statistically significant association between the variables ($p = 0.128$). Similarly, the likelihood ratio and linear-by-linear association were also not significant. However, a large proportion of cells (94.6%) had expected counts less than 5, which violates the assumptions of the Chi-square test and may affect the reliability of the results.

No significant association was observed between the variables ($p > 0.05$), and the results should be interpreted with caution due to low expected cell counts.

OVERALL INTERPRETATION

Overall, the results indicate that:

- ***Hypertension and diabetes are the primary contributors to CKD***
- *Majority of patients are in* ***advanced disease stages***
- ***Standard therapies are widely used****, but supportive measures are underutilized*
- ***Medication adherence and lifestyle modifications are inadequate***
- ***Nephrotoxic exposure and inappropriate practices still exist***

These findings collectively highlight the need for **improved clinical monitoring, rational prescribing, and patient-centered interventions**.

DISCUSSION AND CONCLUSION

DISCUSSION

The present study provides a comprehensive evaluation of **medication management practices in patients with renal impairment**, highlighting critical aspects of disease burden, prescribing patterns, and clinical outcomes. The findings

emphasize that chronic kidney disease (CKD) remains a **multifactorial and progressive condition**, requiring careful therapeutic planning and continuous monitoring.

A key observation in this study is the **high prevalence of hypertension and diabetes mellitus**, which were identified as the primary contributors to renal impairment. This finding is consistent with previous studies that have established these conditions as the leading etiological factors for CKD globally.[6,11] Hypertension, in particular, was observed in a substantial proportion of patients, suggesting its dual role as both a **cause and consequence of renal dysfunction**. The coexistence of diabetes further accelerates nephron damage through mechanisms such as glomerular hyperfiltration and microvascular injury.[5,17]

The study population predominantly consisted of patients in **advanced stages of CKD (Stage 4–5)**, indicating late diagnosis or delayed referral to specialized care. Similar observations have been reported in earlier studies, where patients often present at advanced stages due to lack of awareness and inadequate screening practices.[10,15] The elevated serum creatinine levels and reduced eGFR observed in this study further confirm **significant deterioration in renal function**, necessitating aggressive therapeutic interventions and dialysis support.

In terms of **drug utilization patterns**, the study demonstrated widespread use of erythropoiesis-stimulating agents (ESA), iron preparations, and anticoagulants, reflecting adherence to standard treatment protocols for anemia management and dialysis-related care. These findings align with established clinical guidelines that recommend correction of anemia and prevention of thrombotic complications in CKD patients.[13,14] However, the relatively lower use of phosphate binders and sodium bicarbonate suggests **potential underutilization of adjunct therapies**, which are essential for managing metabolic and mineral imbalances in advanced CKD.

Another important observation is the presence of **nephrotoxic drug exposure**, particularly NSAIDs, although reported in a smaller proportion of patients. Previous studies have highlighted NSAIDs as a significant risk factor for renal injury due to their inhibitory effects on renal prostaglandin synthesis.[4,14] Even limited exposure can contribute to disease progression, especially in patients with pre-existing renal impairment. Therefore, strict avoidance and patient education regarding nephrotoxic drugs are essential components of CKD management.

The study also revealed **suboptimal medication adherence and poor lifestyle modification practices**, which represent major barriers to effective disease management. Despite high adherence to dietary sodium and potassium restrictions, compliance with other lifestyle measures such as smoking cessation, avoidance of NSAIDs, and regular follow-up was notably low. Similar trends have been reported in previous studies, where behavioural factors significantly influence treatment outcomes.[6,12] These findings underscore the need for **structured patient counselling and multidisciplinary interventions** to improve adherence and long-term prognosis.

From a clinical perspective, the analysis of **laboratory parameters across CKD stages** demonstrated a statistically significant association between serum creatinine levels and disease severity. This reinforces the importance of serum creatinine as a **reliable marker for renal function assessment and dose adjustment**.[4,18] Although potassium and hemoglobin levels did not show statistically significant differences, clinically relevant trends were observed, particularly reduced hemoglobin levels in advanced stages, indicating worsening anemia. The lack of statistical significance may be attributed to sample size limitations and uneven distribution across CKD stages.

The findings related to **medication prescribing practices** highlight both strengths and gaps in clinical management. While the use of essential drugs was largely appropriate, issues such as incomplete documentation, inadequate dose adjustment, and insufficient monitoring were identified. These challenges are consistent with earlier reports indicating that inappropriate dosing remains a common issue in renal impairment due to lack of awareness and limited use of dosing guidelines.[2,3] The integration of clinical decision-support systems and pharmacist-led interventions has been recommended to address these gaps effectively.[7,11]

Additionally, the minimal use of OTC and herbal medications reported in this study may reflect increased awareness among patients undergoing dialysis. However, given the known risks associated with unsupervised drug use, continuous monitoring and education remain crucial. Studies have shown that even occasional use of OTC medications can lead to significant drug interactions and adverse effects in renal patients.[14]

The statistical analysis using Chi-square tests did not demonstrate significant associations between certain variables, which may be due to **limitations such as small sample size and low expected frequencies**. This highlights the importance of larger, multicentric studies to validate these findings and improve statistical power.

Overall, the present study underscores the **complex interplay between disease progression, pharmacotherapy, and patient-related factors** in renal impairment. The findings strongly support the need for **individualized drug therapy**, guided by renal function assessment and pharmacokinetic principles. Advances in pharmacokinetic modelling and evidence-based guidelines have significantly improved our understanding of drug behaviour in CKD patients, but their translation into routine clinical practice remains a challenge.[12,16]

CONCLUSION

The present study provides a detailed evaluation of medication management practices among patients with chronic kidney disease (CKD), highlighting the clinical and pharmacotherapeutic challenges associated with renal impairment. The findings clearly indicate that **patients with CKD are at a significantly higher risk of inappropriate medication use**, primarily due to the presence of multiple comorbid conditions, progression to advanced stages of disease, and the necessity for complex and long-term drug regimens.

The study observed that **commonly recommended therapies**, including *erythropoietin, iron supplementation, and antihypertensive agents*, were widely prescribed as part of standard CKD management. However, despite adherence to general treatment protocols, several critical gaps were identified in prescribing practices. These include **continued exposure to potentially nephrotoxic drugs, insufficient dose adjustment based on renal function, suboptimal lifestyle modifications, and poor patient adherence to prescribed therapy**. Such issues may contribute to disease progression, increased hospitalization, and adverse clinical outcomes.

Analysis of laboratory parameters further reinforced the clinical severity of renal impairment among the study population. A **statistically significant association between CKD stage and serum creatinine levels** was observed, emphasizing the importance of continuous monitoring of renal function. These findings strongly support the necessity of **individualized dose adjustment based on renal function indicators such as eGFR and creatinine clearance**, which are essential for minimizing drug toxicity and optimizing therapeutic efficacy.

Additionally, the study highlights the growing concern of **polypharmacy and its associated risks**, including drug–drug interactions and adverse drug reactions. This underscores the need for **regular medication review and multidisciplinary involvement**, particularly the inclusion of clinical pharmacists in patient care, to ensure rational prescribing and improved therapeutic outcomes.

The statistical analysis performed using *SPSS version 16.0* provided robust validation of the study findings, enabling accurate interpretation of relationships between clinical variables and medication use patterns. The application of **descriptive statistics, ANOVA, chi-square tests, and cross-tabulation techniques** strengthened the reliability and scientific rigor of the results.

Overall, this study emphasizes that **effective medication management in patients with renal impairment requires a patient-centered, evidence-based approach**, integrating rational drug selection, individualized dosing strategies, and continuous clinical monitoring. There is a critical need to **enhance awareness among healthcare professionals, implement strict prescribing guidelines, and promote patient education regarding medication adherence and lifestyle modifications**.

In conclusion, optimizing pharmacotherapy in CKD patients is essential to **reduce medication-related complications, slow disease progression, and improve quality of life**. The findings of this study provide valuable insights for clinicians and policymakers and highlight the urgent need for **systematic interventions aimed at ensuring safe, rational, and effective medication use in patients with renal impairment**.

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