FREQUENCY OF PATIENTS MEETING KIDNEY DISEASE OUTCOMES QUALITY INITIATIVE CRITERIA FOR SERUM CALCIUM, PHOSPHORUS, AND PARATHYROID HORMONE LEVELS ON MAINTENANCE HEMODIALYSIS PRESENTING AT CAPITAL DEVELOPMENT AUTHORITY HOSPITAL, ISLAMABAD

Original Research

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ABSTRACT

Background: Chronic kidney disease patients on maintenance hemodialysis are vulnerable to mineral and bone disorders, which significantly contribute to morbidity and mortality. Monitoring and achieving recommended biochemical targets for calcium, phosphorus, and parathyroid hormone (PTH) levels are vital in improving clinical outcomes. The Kidney Disease Outcomes Quality Initiative (KDOQI) provides standardized guidelines for mineral metabolism management. Evaluating patient adherence to these targets allows healthcare providers to identify care gaps and implement effective treatment strategies.

Objective: To assess the frequency of patients meeting KDOQI criteria for serum calcium, phosphorus, and PTH levels among those undergoing maintenance hemodialysis at Capital Development Authority Hospital, Islamabad.

Methods: A descriptive cross-sectional study was conducted over six months in the Nephrology Department at CDA Hospital, Islamabad. After obtaining ethical clearance, 190 patients aged 30–80 years on maintenance hemodialysis were recruited through non-probability consecutive sampling. Data on serum calcium, phosphorus, and intact PTH were collected and analyzed using standardized biochemical assays. Patients meeting the KDOQI targets were identified. SPSS Version 20 was used for statistical analysis. Mean and standard deviation were calculated for continuous variables, while categorical variables were presented as frequencies and percentages. Chi-square and Fisher's exact tests were applied, with a p-value ≤ 0.05 considered statistically significant.

Results: The mean age of participants was 58.2 ± 11.9 years; 57.9% (n=110) were male. Among the cohort, 63.2% (n=120) met calcium targets, 56.8% (n=108) achieved phosphorus targets, and only 28.4% (n=54) attained PTH goals. Hemodialysis adherence was significantly associated with calcium control (84.2% vs. 44.3%, p<0.05), as was vitamin D/calcium supplement use (85.8% vs. 64.3%, p<0.05). Thrice-weekly hemodialysis improved calcium (49.2%) and phosphorus (45.4%) target achievement compared to once-weekly sessions (3.3% and 9.3%, respectively). No significant associations were noted with PTH outcomes.

Conclusion: While a majority of patients achieved KDOQI objectives for calcium and phosphorus, PTH control remained inadequate. Improved dialysis adherence, supplement compliance, and higher dialysis frequency were associated with better calcium regulation. Focused interventions are needed to enhance PTH management.

Keywords: Calcium, Hemodialysis, Kidney Diseases, Parathyroid Hormone, Phosphorus, Renal Insufficiency, Treatment Outcome.

INTRODUCTION

Chronic kidney disease (CKD) remains a major global public health burden, affecting approximately 10% of the world's population and contributing to millions of deaths annually, largely due to limited access to affordable and timely treatment options (1). One of the most critical outcomes of CKD is its progression to end-stage renal disease (ESRD), which necessitates costly renal replacement therapies (RRT), such as dialysis or kidney transplantation. While high-income countries have witnessed stabilization in ESRD incidence due to improved awareness and early detection of CKD, this trend has not extended to lower-income nations or marginalized populations, where access to healthcare services remains insufficient (2). The financial strain imposed by ESRD on healthcare systems is substantial, with dialysis programs in developed nations growing at an annual rate of 6% to 12% over the past two decades (3). In middle-income regions, access to RRT has shown gradual improvement, yet significant barriers persist due to economic constraints and inadequate healthcare infrastructure (4). More than two million individuals worldwide depend on dialysis or kidney transplantation to survive; however, this represents only a fraction of those who actually require such interventions (5). Alarmingly, in over 112 countries with a combined population exceeding 600 million, the lack of access to dialysis or transplantation results in over one million preventable deaths annually due to untreated kidney failure (6). In response to these challenges, there has been a growing focus on the early diagnosis and management of CKD to delay disease progression and reduce the reliance on RRT. In countries like Pakistan, the prevalence of CKD is particularly high, and a large segment of the affected population relies on maintenance hemodialysis (MHD) as a life-sustaining therapy. A prior study involving 300 participants indicated that nearly one-quarter of them were diagnosed with CKD, underscoring the significant burden of the disease in the region (7). CKD and ESRD are associated with a host of systemic complications, including increased cardiovascular mortality, anemia, cognitive impairment, and bone mineral disorders, all of which contribute to reduced quality of life and heightened morbidity. Among these, mineral bone disorders (MBD) are particularly critical, as imbalances in serum calcium (Ca), phosphorus (P), and parathyroid hormone (PTH) levels can lead to serious musculoskeletal complications and cardiovascular events (8).

The Kidney Disease Outcomes Quality Initiative (KDOQI) guidelines provide evidence-based recommendations for the management of mineral metabolism in CKD and ESRD patients, especially those undergoing hemodialysis. These guidelines emphasize the importance of maintaining serum Ca, P, and PTH within defined target ranges to prevent complications associated with secondary hyperparathyroidism (9). Nevertheless, several studies suggest that many MHD patients—even within advanced healthcare systems—do not achieve these targets, pointing to gaps in clinical management and compliance with treatment protocols (10). Adherence to KDOQI benchmarks is not only indicative of the quality of healthcare services but also directly impacts patient outcomes and survival rates. Assessing how closely patients meet these targets helps in identifying deficiencies in care, guiding evidence-based interventions, and ultimately improving clinical outcomes (11). The current investigation was undertaken to assess the proportion of patients receiving maintenance hemodialysis at Capital Development Authority Hospital, Islamabad, who meet the KDOQI-recommended targets for serum calcium, phosphorus, and parathyroid hormone levels. Given the strong correlation between disordered mineral metabolism and adverse clinical outcomes in CKD and ESRD, understanding the level of biochemical control in this population is crucial. This study aims to bridge an important knowledge gap by evaluating current clinical practices against established guidelines, thereby supporting efforts to optimize patient management and enhance quality of care.

METHODS

This cross-sectional study was conducted in the Department of Nephrology at the Capital Development Authority (CDA) Hospital, Islamabad, with the objective of evaluating the proportion of maintenance hemodialysis (MHD) patients meeting the Kidney Disease Outcomes Quality Initiative (KDOQI) targets for serum calcium, phosphorus, and intact parathyroid hormone (iPTH) levels. Ethical approval was obtained from the institutional review board (IRB) of the hospital prior to data collection. All participants provided written informed consent after being informed about the study's purpose, procedures, and the voluntary nature of their participation, including the use of anonymized data for research purposes. Participants were recruited using a non-probability consecutive sampling technique. A total of 190 patients were enrolled over a four-month period, from 25th October 2024 to 20th February 2025. The sample size was calculated using the World Health Organization (WHO) sample size calculator, based on a reported frequency of serum PTH levels at

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38.7%, a 7% margin of error, and a 95% confidence interval. Inclusion criteria encompassed adult patients aged 30 to 80 years of either gender, undergoing maintenance hemodialysis. Patients were excluded if they had acute kidney injury, were on peritoneal dialysis, or had a prior history of parathyroidectomy. Additional exclusion criteria included comorbidities known to affect bone and mineral metabolism, such as hypo- or hyperthyroidism, malignancy, congestive heart failure, myocardial infarction, chronic liver disease, chronic obstructive pulmonary disease (COPD), stroke, or granulomatous diseases, to ensure the homogeneity and reliability of biochemical markers under investigation (3,12).

Demographic and clinical data were collected, including age, gender, residential status, and duration of hemodialysis, obtained through direct interviews and patient records. Blood samples (5 mL) were drawn pre-dialysis into lithium heparin tubes, and plasma was isolated through centrifugation. Biochemical analysis was conducted using validated methods: serum calcium was quantified using the NM-BAPTA technique, inorganic phosphate via the phospho-molybdate method, and albumin through the bromocresol green method. All these parameters were measured using the Roche Cobas c501 chemistry analyzer. For intact PTH assessment, the second-generation electrochemiluminescence (ECL) sandwich assay was used on the Cobas e411 immunoassay analyzer, ensuring precise and standardized measurement of mineral metabolism markers. Patients were evaluated against KDOQI guidelines to determine whether their serum calcium, phosphorus, and iPTH levels met the recommended targets. Data were analyzed using SPSS Version 20. Continuous variables such as age and dialysis duration were summarized using mean ± standard deviation (SD) for normally distributed data, and median with interquartile range (IQR) for non-normally distributed data. Categorical variables including gender, residence, and KDOQI goal attainment were presented as frequencies and percentages. Stratification was performed by age group, gender, residency status, and dialysis duration to identify potential effect modifiers. Post-stratification analyses were conducted using the chi-square test or Fisher's exact test, as appropriate. A p-value less than 0.05 was considered statistically significant.

RESULTS

The study evaluated 190 patients undergoing maintenance hemodialysis, with a mean age of 58.23 ± 11.85 years. Males constituted 57.9% (n=110) of the participants, while 46.8% (n=89) were over the age of 60. The average duration of hemodialysis was 6.11 ± 2.37 months, with more than half of the patients (54.2%, n=103) receiving dialysis for less than 6 months. Regarding treatment compliance, 69.5% (n=132) adhered to their hemodialysis schedules, and 77.9% (n=148) reported consistent use of vitamin D and calcium supplements. Most participants received dialysis either twice weekly (47.9%, n=91) or thrice weekly (44.2%, n=84), with a small proportion (7.9%, n=15) undergoing dialysis once weekly. In terms of achieving KDOQI-recommended biochemical targets, 63.2% (n=120) of patients met the criteria for serum calcium, 56.8% (n=108) for phosphorus, and only 28.4% (n=54) for intact PTH levels. A significantly higher proportion of patient's adherent to hemodialysis achieved calcium targets (84.2%) compared to non-adherent individuals (44.3%) (p < 0.05). Similarly, adherence to calcium and vitamin D supplementation was positively associated with calcium target attainment (85.8% vs. 64.3%, p < 0.05). Hemodialysis frequency was also influential; 49.2% of those undergoing thrice-weekly dialysis achieved calcium targets compared to only 3.3% of those on once-weekly dialysis (p < 0.05). No statistically significant associations were found between calcium target achievement and gender, residential status, age group, or duration of dialysis (p > 0.05). For phosphorus levels, 45.4% of thrice-weekly and 45.4% of twice-weekly dialysis recipients achieved targets, compared to only 9.3% in the once-weekly group; however, this trend did not reach statistical significance (p = 0.607). No significant differences were observed across gender, residential status, supplementation status, dialysis adherence, age, or dialysis duration (p > 0.05). Only 28.4% of participants achieved target PTH levels. There were no statistically significant differences in PTH target attainment across gender, age group, residency, dialysis frequency, supplementation adherence, or dialysis duration (p > 0.05). Although adherence to hemodialysis was associated with a higher rate of PTH control (75.9% in adherent vs. 66.9% in non-adherent), the difference was not statistically significant (p = 0.224).

Analysis of the combined achievement of all three biochemical targets—serum calcium, phosphorus, and PTH—revealed that only 20.0% of patients (n=38) simultaneously met the KDOQI-recommended levels for all parameters. This highlights a considerable gap in the comprehensive biochemical control among individuals receiving maintenance hemodialysis. While individual target achievement rates were 63.2% for calcium, 56.8% for phosphorus, and 28.4% for PTH, the overlap in control across all three markers was notably limited. Furthermore, significant associations were identified between calcium target attainment and several factors, including adherence to hemodialysis (p < 0.05), compliance with calcium and vitamin D supplementation (p < 0.05), and frequency of hemodialysis sessions (p < 0.05). These trends reinforce the importance of treatment adherence and regular dialysis frequency in achieving optimal mineral

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metabolism control. However, no statistically significant associations were observed for phosphorus or PTH targets in relation to these variables, and duration of dialysis did not demonstrate a meaningful trend with any of the three outcomes.

Table 1: Demographic and clinical details of the quantitative variables of the study participants (n=190)

Quantitative Variables	Minimum	Maximum	Mean	± SD
Age (Years)	30.00	80.00	58.23	11.85
Duration of hemodialysis (HD) (months)	4.00	12.00	6.11	2.37
Calcium Level (mg/dl)	6.20	10.90	8.97	.73
Phosphorus Level (mg/dl)	2.70	8.40	4.82	1.22
PTH Values (pg/ml)	109.00	925.00	393.07	208.65

Table 2: Clinical, demographic and comorbid details of study subjects (n=190)

Variables		Frequency	Percentage (%)
Gender	Male	110	57.9
	Female	80	42.1
Age Groups (Years)	<50	46	24.2
	50-60	55	28.9
	>60	89	46.8
Duration of HD (months)	<6	103	54.2
	≥6	87	45.8
Residential Status	Urban	102	53.7
	Rural	88	46.3
Adherence to HD	Yes	132	69.5
	No	58	30.5
Frequency of HD	1	15	7.9
	2	91	47.9
	3	84	44.2
Compliance to Vitamin-D Ca Supplements	Yes	148	77.9
	No	42	22.1

Table 3: Patients meeting the K/DOQI criteria for calcium (Stratification for various effect modifiers)

Variables		Meeting the K/DOQI criteria for Calcium		p-Value (x2-test)
		Yes	No	
Gender	Male	65 (54.2%)	45 (64.3%)	0.173
	Female	55 (45.8%)	25 (35.7%)	
Residential Status	Urban	64 (53.3%)	38 (54.3%)	0.899
	Rural	56 (46.7%)	32 (45.7%)	
Adherence to HD	Yes	101 (84.2%)	31 (44.3%)	0.000
	No	19 (15.8%)	39 (55.7%)	
Frequency of HD	1	4 (3.3%)	11 (15.7%)	0.006
	2	57 (47.5%)	34 (48.6%)	
	3	59 (49.2%)	25 (35.7%)	
Compliance to Calcium - Vit. D Supplements	Yes	103 (85.8%)	45 (64.3%)	0.001
	No	17 (14.2%)	25 (35.7%)	
Age Groups (Years)	<50 Years	24 (20.0%)	22 (31.4%)	0.103
	50-60 Years	40 (33.3%)	15 (21.4%)	

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Variables		Meeting the K/DOQI criteria for Calcium		p-Value
		Yes	**No**	**(x2-test)**
	>60 Years	56 (46.7%)	33 (47.1%)	
Duration of HD (months)	< 6	66 (55.0%)	37 (52.9%)	0.775
	≥ 6	54 (45.0%)	33 (47.1%)	

Table 4: Patients meeting the K/DOQI criteria for phosphorus (Stratification for various effect modifiers)

Variables		Meeting the K/DOQI criteria for Phosphorus		p-Value
		Yes	**No**	**(x2-test)**
Gender	Male	66 (61.1%)	44 (53.7%)	0.303
	Female	42 (38.9%)	38 (46.3%)	
Residential Status	Urban	56 (51.9%)	46 (56.1%)	0.561
	Rural	52 (48.1%)	36 (43.9%)	
Adherence to HD	Yes	76 (70.4%)	56 (68.3%)	0.758
	No	32 (29.6%)	26 (31.7%)	
Frequency of HD	1	10 (9.3%)	05 (6.1%)	0.607
	2	49 (45.4%)	42 (51.2%)	
	3	49 (45.4%)	35 (42.7%)	
Compliance to Calcium - Vit. D Supplements	Yes	86 (79.6%)	62 (75.6%)	0.508
	No	22 (20.4%)	20 (24.4%)	
Age Groups (Years)	<50 Years	29 (26.9%)	17 (20.7%)	0.596
	50-60 Years	31 (28.7%)	24 (29.3%)	
	>60 Years	48 (44.4%)	41 (50.0%)	
Duration of HD (months)	< 6	56 (51.9%)	47 (57.3%)	0.454
	≥ 6	52 (48.1%)	35 (42.7%)	

Table 5: Patients meeting the K/DOQI criteria for PTH (Stratification for various effect modifiers)

Variables		Meeting the K/DOQI criteria for PTH		p-Value
		Yes	**No**	**(x2-test)**
Gender	Male	28 (51.9%)	82 (60.3%)	0.288
	Female	26 (48.1%)	54 (39.7%)	
Residential Status	Urban	29 (53.7%)	73 (53.7%)	0.997
	Rural	25 (46.3%)	63 (46.3%)	
Adherence to HD	Yes	41 (75.9%)	91 (66.9%)	0.224
	No	13 (24.1%)	45 (33.1%)	
Frequency of HD	1	07 (13.0%)	08 (5.9%)	0.189
	2	22 (40.7%)	69 (50.7%)	
	3	25 (46.3%)	59 (43.4%)	
Compliance to Calcium - Vit. D Supplements	Yes	41 (75.9%)	107 (78.7%)	0.680
	No	13 (24.1%)	29 (21.3%)	
Age Groups (Years)	<50 Years	14 (25.9%)	32 (23.5%)	0.936
	50-60 Years	15 (27.8%)	40 (29.4%)	
	>60 Years	25 (46.3%)	64 (47.1%)	
Duration of HD (months)	< 6	30 (55.6%)	73 (53.7%)	0.815
	≥ 6	24 (44.4%)	63 (46.3%)	

Table 6: Significant Trends in Target Achievement

Variable	Target	p-Value	Statistical Significance
Adherence to HD	Calcium	< 0.05	Significant
Compliance to Vit D & Calcium	Calcium	< 0.05	Significant
Frequency of HD	Calcium	< 0.05	Significant

Table 7: Combined Achievement of Biochemical Targets

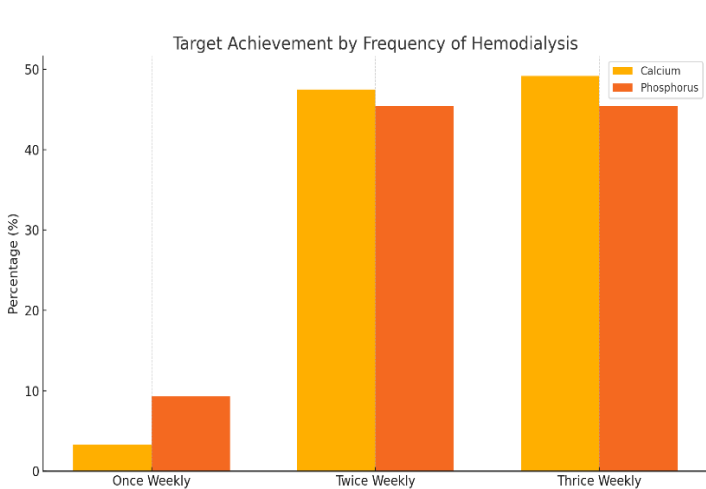| Achievement Category	Number of Patients	Percentage (%)
Calcium	120	63.2
Phosphorus	108	56.8
PTH	54	28.4
All Three	38	20

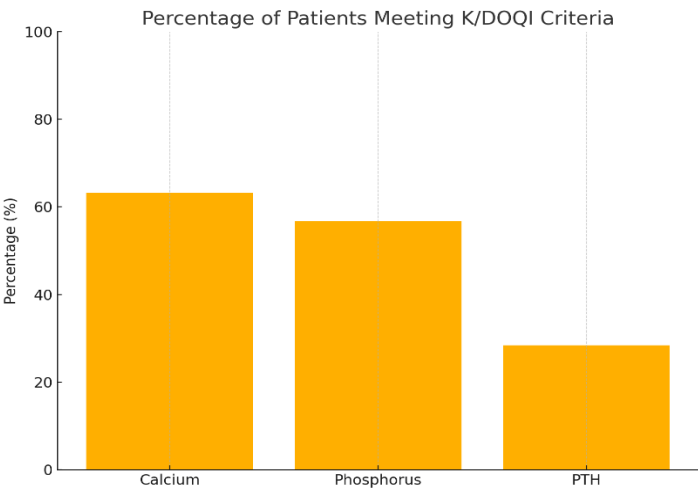*Figure 1 Target Achievement by Frequency of Hemodialysis*

Figure 2 Percentage of Patients Meeting K/DOQI Criteria

DISCUSSION

The clinical utility of the KDOQI guidelines in monitoring serum calcium, phosphorus, and parathyroid hormone (PTH) levels among patients on maintenance hemodialysis has been widely acknowledged across global nephrology practice. In this study, a local cohort was evaluated for adherence to these biochemical targets, revealing that 63.2% of patients achieved the recommended calcium range, and 56.8% met the phosphorus criteria. These findings are consistent with international data, such as the DOPPS report, which documented that approximately 50–60% of dialysis patients achieved similar control (13). Notably, phosphorus control in this study surpassed that of East African populations, where only 36.4% reached the target range. The variation is likely due to differences in dietary phosphorus intake, dialysis schedules, and adherence to phosphate binder regimens (14). Calcium regulation was significantly associated with adherence to dialysis and supplement use, reinforcing previous research that identified missed dialysis sessions and suboptimal calcium intake as key contributors to mineral metabolism disturbances. The beneficial impact of thrice-weekly dialysis on serum calcium levels observed in this study supports earlier clinical trials demonstrating improved biochemical control with increased dialysis frequency (15,16). Despite these gains, PTH regulation remained notably poor, with only 28.4% of patients meeting target levels, echoing the challenge reported in global data, where fewer than 30% of patients achieved KDOQI PTH objectives. Persistent

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failure to control PTH may be attributed to late diagnosis of secondary hyperparathyroidism, variable patient responses to vitamin D analogs and calcimimetics, and frequent medication nonadherence (17). This pattern remained unchanged across demographic and treatment-related variables, suggesting that additional non-measured factors—such as genetic variation, nutritional habits, or untracked pharmacologic influences—may contribute to PTH dysregulation (18,19).

A strength of the study lies in its comprehensive approach, which evaluated not only biochemical markers but also key demographic and clinical contributors to mineral metabolism outcomes. The inclusion of both urban and rural populations enhanced the generalizability of the findings, while standardized laboratory protocols improved the reliability of biochemical measurements. Furthermore, the study provides insight into local patterns of mineral metabolism control and identifies critical gaps in practice that warrant targeted intervention. However, several limitations must be acknowledged. The single-center cross-sectional design restricts the ability to infer causality and limits external validity. The relatively short dialysis vintage may have reduced the likelihood of observing more advanced stages of mineral bone disorders, which typically emerge over prolonged treatment durations. Additionally, the absence of data on dietary intake, medication adherence, and parathyroid imaging is a notable limitation, given the significant role these variables play in mineral metabolism. The unavailability of combined achievement rates in prior literature also restricts comparative interpretation of the study's holistic outcome indicator (20).

Given these limitations, future research should incorporate multicenter longitudinal designs to better understand the progression of mineral bone disease over time and evaluate the impact of evolving treatment strategies. Collecting data on dietary phosphate intake, detailed medication usage patterns, and imaging of the parathyroid glands would provide a more nuanced understanding of the underlying pathophysiology. Moreover, equitable access to phosphate binders, vitamin D analogs, and calcimimetics must be ensured through national policy reform, especially for socioeconomically disadvantaged patients who may face financial barriers to optimal care. Standardized implementation of evidence-based monitoring protocols, coupled with continuous patient education and individualized treatment planning, will be essential to achieving improved clinical outcomes in mineral and bone disorder management among patients receiving hemodialysis.

CONCLUSION

This study underscores significant gaps in the management of mineral metabolism among patients undergoing maintenance hemodialysis, particularly in the regulation of parathyroid hormone levels. While improved control of calcium and phosphorus was observed with consistent dialysis and supplement adherence, persistent challenges in achieving optimal PTH targets reflect the complexity of mineral bone disorder treatment. These findings emphasize the need for individualized, adherence-focused strategies and more robust clinical monitoring protocols. Strengthening patient education and ensuring access to comprehensive therapeutic options are vital steps toward enhancing treatment outcomes and aligning clinical practice with established care standards.

Author Contribution

Author	Contribution
Saira Ashraf*	Substantial Contribution to study design, analysis, acquisition of Data
	Manuscript Writing
	Has given Final Approval of the version to be published
Zulfiqar Ali	Substantial Contribution to study design, acquisition and interpretation of Data
	Critical Review and Manuscript Writing
	Has given Final Approval of the version to be published

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