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Original Article

Health Literacy and Treatment Compliance Among Patients with Chronic Kidney Disease Attending a Nephrology Outpatient Department and Dialysis Center in Lahore, Pakistan: An Analytical Cross-Sectional Study

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ABSTRACT

Background: Chronic kidney disease (CKD) requires long-term adherence to medications, dietary and fluid restrictions, clinical monitoring, and, in advanced disease, regular hemodialysis. Health literacy may influence patients' ability to understand and apply treatment recommendations. Objective: To determine health-literacy levels and treatment compliance among patients with CKD and assess associations with medication adherence and dialysis-related compliance. Methods: This analytical cross-sectional study included 125 adults with CKD attending nephrology outpatient and hemodialysis services at Riphah International University, Lahore, Pakistan, from November 2025 to March 2026. Health literacy was assessed using HLS-EU-Q16 and medication adherence using MMAS-8. Dialysis-specific measures included missed hemodialysis sessions, diet/fluid non-adherence, and serum phosphate. Data were analysed using IBM SPSS Statistics version 26.0 with descriptive, correlation, chi-square, Kruskal-Wallis, and logistic-regression analyses. Results: Mean age was 60.86±11.10 years; 62.4% received predialysis care and 37.6% underwent hemodialysis. Low, mid-level, and high health literacy were observed in 26.4%, 53.6%, and 20.0%, respectively, while 57.6% had low medication adherence. HLS-EU-Q16 correlated positively with MMAS-8 (ρ=0.413, p<0.001). Medication non-adherence occurred in 81.8% of patients with low literacy compared with 49.3% and 48.0% with mid-level and high literacy (p=0.005). Higher health literacy independently predicted lower medication non-adherence (aOR=0.66, 95% CI 0.52–0.83; p<0.001) and fewer missed dialysis sessions (ρ=−0.306, p=0.036). Conclusion: Limited health literacy was significantly associated with poorer treatment compliance in CKD. Keywords: Chronic Kidney Disease; Health Literacy; Medication Adherence; Hemodialysis; Pakistan.

INTRODUCTION

Chronic kidney disease is a major and progressively expanding public-health challenge characterized by sustained abnormalities of kidney structure or function and increased risks of kidney failure, cardiovascular disease, hospitalization, disability, and premature mortality. Contemporary global burden analyses demonstrate that CKD affects hundreds of millions of people and that its health impact has increased substantially in parallel with

population ageing and the growing prevalence of diabetes, hypertension, obesity, and other metabolic risk factors (1). Current international clinical guidance emphasizes that CKD management extends beyond measurement of glomerular filtration rate and requires integrated assessment of kidney function, albuminuria, cardiovascular risk, metabolic comorbidity, medication safety, progression risk, and the need for kidney replacement therapy (2). As a result, successful CKD management increasingly depends on patients' ability to engage with substantial amounts of health information and translate professional recommendations into sustained self-management behavior.

The burden is particularly important in countries such as Pakistan, where diabetes, hypertension, cardiovascular disease, late diagnosis, variable access to specialist nephrology services, and socioeconomic limitations may converge to increase CKD risk and complicate disease management. A cross-sectional screening investigation conducted among a high-risk population in urban Lahore identified CKD in 24.2% of participants and demonstrated significant associations with hypertension, diabetes, cardiovascular disease, family history of CKD, analgesic use, and use of herbal medicines (3). A broader review of Pakistani evidence reported a substantial national CKD burden, with important variation across populations and settings and particularly high prevalence among older adults; diabetic nephropathy, kidney disease of uncertain etiology, and renal stone disease were among the repeatedly identified etiological contributors (4). These findings provide a compelling local context for research extending beyond CKD detection toward factors that influence patients' capacity to manage established disease.

CKD self-management is unusually information intensive. Depending on disease severity, patients may be expected to understand blood-pressure targets, glycemic management, medication indications and schedules, avoidance of nephrotoxic drugs, dietary sodium and phosphate recommendations, fluid intake, laboratory monitoring, symptoms requiring urgent review, vascular access care, dialysis attendance, transplantation options, and changes in therapy as kidney function deteriorates. Health literacy is therefore highly relevant to kidney care because it concerns the ability to access, comprehend, evaluate, communicate, and use health information in ways that support health-related decisions and behaviors. A systematic review involving 48 studies and 25,671 individuals with CKD found that higher health literacy was repeatedly associated with more favorable self-management behaviors, although the strength of relationships with clinical outcomes such as hospitalization, biochemical measures, and mortality was less consistent (5). This distinction is important because health literacy may influence behavior directly while objective outcomes remain affected by disease severity, treatment effectiveness, comorbid illness, socioeconomic circumstances, and healthcare-system factors.

Evidence from non-dialysis CKD populations further indicates that health literacy is heterogeneous and socially patterned. Demir et al. examined adults with stages I–V non-dialysis CKD and found that health-literacy scores were related to age, education, kidney function, comorbidity burden, self-perceived health, occupational status, and other demographic and clinical characteristics (6). Such findings caution against treating low health literacy as merely an educational deficit. Formal schooling may contribute to literacy skills, but health literacy is also shaped by disease complexity, familiarity with healthcare systems, communication with clinicians, availability of understandable information, cognitive and psychological burden, cultural expectations, financial conditions, and opportunities to participate in care.

Recent synthesis of non-dialysis CKD self-management literature reinforces this broader conceptualization. A 2026 systematic review of 16 cross-sectional studies involving 3,658 patients found that disease-related knowledge, health literacy, self-efficacy, and social support were among the factors most consistently associated with better CKD self-management (7). This evidence suggests that literacy is likely to function alongside, rather than independently of, patients' confidence, social environment, knowledge, and healthcare relationships. Consequently, identifying low health literacy can be clinically useful, but effective intervention is likely to require more than the provision of additional written information.

Medication adherence represents one of the most clinically important manifestations of self-management in CKD. Patients commonly receive antihypertensive agents, glucose-lowering medications, diuretics, lipid-lowering therapies, iron or erythropoiesis-related treatment, phosphate binders, vitamin D-related therapies, alkali supplementation, antiplatelet or anticoagulant therapy, and medications for multiple coexisting conditions. An umbrella review of medication adherence among people with kidney disease demonstrated that non-adherence remains a substantial and multifactorial problem across kidney-disease populations (8). Treatment burden tends to

increase as CKD progresses, while symptoms, adverse effects, financial constraints, forgetfulness, medication beliefs, regimen complexity, and competing illnesses may further impair persistence with prescribed therapy.

The relationship between health literacy and medication adherence is biologically and behaviorally plausible but should not be considered automatic. A systematic review of adults with chronic diseases found that 14 of 27 included studies reported a positive relationship between health literacy and medication adherence, whereas other studies reported mixed or non-significant findings (9). The review emphasized the contribution of medication beliefs, self-efficacy, medication knowledge, income, and other demographic and psychosocial factors. These findings indicate that health literacy may provide patients with resources necessary for adherence but does not eliminate structural or motivational barriers.

CKD-specific comparisons of dialysis and non-dialysis patients further illustrate the magnitude of the adherence problem. Kaul et al. evaluated 120 patients with stage 3 or more advanced CKD, with and without hemodialysis, using the MMAS-8 and reported predominantly low-to-moderate adherence. Low adherence was particularly common among dialysis patients, who also carried a higher pill burden (10). This pattern is clinically understandable because patients receiving maintenance hemodialysis often experience one of the highest treatment burdens in chronic medicine: multiple daily medications are combined with repeated facility attendance, dietary restrictions, fluid management, symptom control, vascular access protection, laboratory surveillance, and substantial disruption to social and occupational life.

More direct evidence linking health literacy and medication adherence in hemodialysis populations has emerged in recent years. Mailani et al. studied 164 hemodialysis patients using the HLS-EU-Q16, MMAS-8, and kidney-disease quality-of-life measures and reported that health-literacy domains were associated with medication adherence and quality of life (11). These findings suggest that the practical capacity to understand healthcare information may be especially relevant when patients face complex chronic treatment schedules.

However, results are not uniform across settings. Hamza et al. studied 390 patients receiving hemodialysis in Rawalpindi and Islamabad, Pakistan, and reported inadequate health literacy in 45.1% and low medication adherence in 41.8%, yet the correlation between health literacy and medication adherence was weak and not statistically significant (12). This recent Pakistani evidence is particularly relevant because it demonstrates that low literacy and non-adherence can coexist without necessarily producing a strong linear relationship in every population. Differences in instruments, scoring systems, educational background, healthcare organization, socioeconomic conditions, dialysis delivery, illness perception, patient selection, and statistical adjustment may contribute to such discrepancies.

Patient-clinician relationships may also modify the pathway from literacy to behavior. In a multicenter study of 455 Japanese adults undergoing outpatient hemodialysis, Inanaga et al. found that functional and communicative health literacy were associated with fewer medication-adherence difficulties and that trust in physicians partially mediated important components of these associations (13). The study highlights an important conceptual point: the clinical consequences of health literacy do not arise solely from individual cognitive skills. Patients use information within relationships, and communication quality, trust, shared decision-making, and confidence in clinicians can influence whether information ultimately changes behavior.

Treatment adherence in hemodialysis also extends well beyond medication taking. Fluid and dietary restrictions are essential components of treatment but are difficult to sustain because they interact with thirst, cultural dietary patterns, social eating practices, health beliefs, self-efficacy, financial limitations, and the repetitive nature of therapy. Chen et al. evaluated 433 individuals receiving hemodialysis and identified distinct health-literacy profiles associated with self-efficacy, fluid-restriction behavior, traditional dietary practices, and relative interdialytic weight gain (14). Their findings support a pathway through which better health literacy may facilitate self-efficacy and more effective fluid-management behavior, but they also illustrate that the relationship between literacy and measurable clinical outcomes is mediated by multiple intermediate factors.

Psychological representations of illness constitute another determinant of adherence. A systematic review by Oliveira et al. encompassing nine studies and 1,161 patients undergoing in-center hemodialysis found associations between illness perceptions and adherence in six studies, particularly for dietary adherence, fluid control, and medication use (15). No uniform association with dialysis-session attendance was identified. These findings further

demonstrate that treatment compliance in CKD is multidimensional: a patient may adhere well to medications but struggle with fluid restriction, may attend dialysis reliably while taking medications inconsistently, or may understand treatment instructions but face practical barriers to implementation.

This multidimensionality is clinically important because inadequate adherence may potentially be modifiable. Educational and behavioral interventions have increasingly focused on communication strategies that accommodate variable health-literacy levels. A systematic review of teach-back interventions in CKD found evidence that teach-back can improve knowledge, self-efficacy, and self-management, although heterogeneity and limited study numbers prevented strong conclusions for all outcomes (16). A 2024 systematic review and meta-analysis of behavioral interventions targeting treatment adherence in CKD likewise emphasized the potential value of structured behavioral approaches (17), while a 2025 systematic review and network meta-analysis specifically examined comparative adherence-enhancement strategies in CKD, reflecting growing recognition that adherence warrants targeted intervention rather than passive expectation (18).

Despite this growing international evidence, several gaps remain relevant to Pakistan. Local work has begun to characterize health literacy and medication adherence among dialysis patients, but evidence integrating patients from both nephrology outpatient and dialysis settings remains limited. Furthermore, medication adherence represents only one component of treatment behavior, and simultaneous assessment of dialysis-session attendance, diet/fluid adherence, and biochemical indicators can provide a more clinically complete picture. Lahore is an appropriate setting for such investigation because local studies already demonstrate a substantial burden of CKD and its major comorbid risk factors (3).

The present study therefore aimed to determine health-literacy levels and treatment compliance among patients with CKD attending a nephrology outpatient department and dialysis center at Riphah International University, Lahore, Pakistan, and to evaluate the association between health literacy and medication adherence. A secondary objective was to examine, among hemodialysis participants, relationships between health literacy and missed dialysis sessions, diet/fluid non-adherence, serum phosphate, and dialysis duration. The study hypothesized that higher health literacy would be associated with better medication adherence and fewer indicators of treatment non-compliance.

MATERIALS AND METHODS

This analytical cross-sectional study was conducted among patients with CKD attending nephrology outpatient and hemodialysis services at Riphah International University, Lahore, Pakistan. Data collection was undertaken from November 2025 through March 2026. The cross-sectional analytical design was selected because the principal purpose was to characterize health literacy and treatment-compliance patterns and evaluate associations between these variables within the defined clinical population rather than to establish temporal or causal effects.

The final analytical sample comprised 125 adult patients with CKD. Participants represented both advanced non-dialysis CKD and dialysis-dependent kidney disease. Seventy-eight participants were attending the predialysis clinic, while 47 were receiving maintenance hemodialysis. The clinical-stage distribution represented in the dataset included CKD stages 3, 4, and 5 among predialysis patients and stage 5D among those receiving hemodialysis. Contemporary CKD guidance recognizes CKD as abnormalities of kidney structure or function persisting for at least three months with implications for health and recommends classification according to cause, glomerular filtration-rate category, and albuminuria where available (2). For the present analysis, the CKD-stage categories recorded in the study dataset were retained without retrospective reclassification.

The study population included adults with established CKD receiving care through the participating nephrology or dialysis services and contributing evaluable data for the principal health-literacy and medication-adherence variables. The analysis was based on the 125 participants represented in the final dataset. Because the available study record establishes the analysed cohort but does not provide a separate screening denominator, recruitment-flow numbers beyond the final N=125 were not reconstructed.

A structured study record was used to capture sociodemographic, clinical, treatment-related, health-literacy, medication-adherence, dialysis-specific, and healthcare-utilization information. Sociodemographic variables included age in years, sex, education level, income category, employment status, and marital status. Education was

categorized as primary education or less, secondary education, or postsecondary education. Income was classified as low, middle, or high. Employment categories were employed, unemployed, retired, and unable to work. Marital status was grouped as married or partnered, single, or divorced/widowed.

Clinical information included care setting, CKD stage, CKD duration in months, hypertension, diabetes mellitus, cardiovascular disease, comorbidity count, and the number of currently prescribed medications. Hypertension, diabetes, and cardiovascular disease were coded as binary clinical comorbidities. The overall comorbidity count reflected the number of recorded comorbid conditions among these clinical variables. Medication count was treated as a measure of medication burden and was analysed as a continuous variable.

Healthcare utilization was assessed through the number of emergency-department visits and hospitalizations during the preceding 12 months. These variables were retained as count measures because repeated acute-care utilization may provide an indirect indication of disease burden and healthcare needs. They were primarily used for descriptive characterization of the study population.

Health Literacy Assessment

Health literacy was assessed using the 16-item European Health Literacy Survey Questionnaire (HLS-EU-Q16). The HLS-EU-Q16 assesses perceived difficulty in accessing, understanding, appraising, and applying health information across healthcare, disease-prevention, and health-promotion contexts. Cross-cultural studies have demonstrated acceptable psychometric performance of the instrument, while also emphasizing the importance of cultural and linguistic adaptation when applied across different populations (19,20).

The total HLS-EU-Q16 score ranges from 0 to 16, with higher values representing better health literacy. The established three-level categorization applied in the study dataset was retained: scores of 0–8 represented low/inadequate health literacy, scores of 9–12 represented mid-level/problematic health literacy, and scores of 13–16 represented high/sufficient health literacy. Comparable thresholds have been used in validation and population studies of the HLS-EU-Q16 (19). For inferential analyses, health literacy was evaluated both as a continuous HLS-EU-Q16 score and as a three-category variable to avoid relying exclusively on one representation of the construct.

Medication Adherence Assessment

Medication adherence was assessed using the eight-item Morisky Medication Adherence Scale (MMAS-8). The MMAS-8 is a structured self-report instrument developed to capture common medication-taking behaviors such as forgetting doses, stopping medication, and difficulty sustaining prescribed treatment. Psychometric studies have supported its usefulness for identifying different levels of medication adherence in chronic disease populations (21), and the scale has been used in contemporary CKD research involving both hemodialysis and non-hemodialysis patients (10,11).

MMAS-8 scores in the dataset ranged from 0 to 8, with higher scores indicating greater adherence. Scores below 6 were classified as low adherence, scores from 6 to <8 as moderate adherence, and a score of 8 as high adherence. For the primary binary outcome used in logistic regression, participants in the low-adherence category were classified as medication non-adherent, whereas those with moderate or high adherence were classified as medication adherent. Both the continuous MMAS-8 score and the categorical adherence classifications were retained in the analysis so that the association between health literacy and adherence could be assessed without depending on a single statistical operationalization.

Dialysis-Specific Treatment Compliance

Dialysis-related variables were evaluated only among the 47 participants receiving hemodialysis. Applying these variables to predialysis patients would have generated structurally inappropriate missing values; therefore, dialysis-specific analyses were restricted to the clinically applicable subgroup.

Variables included dialysis duration in months, number of dialysis sessions prescribed per week, number of missed hemodialysis sessions during the preceding three months, serum phosphate concentration in mmol/L, and diet/fluid non-adherence. Missed hemodialysis sessions were analysed as a count variable for correlation analysis and were additionally summarized as no missed sessions versus one or more missed sessions for descriptive interpretation.

Diet/fluid non-adherence was analysed as a binary variable based on the classification recorded in the dataset. Serum phosphate was treated as a continuous biochemical variable. These outcomes were intentionally analysed separately rather than combined into a composite compliance score because medication use, dialysis attendance, fluid/dietary behavior, and biochemical control represent distinct domains of treatment behavior and may have different determinants. Previous hemodialysis research has similarly demonstrated that health literacy may relate differently to medication adherence, fluid-management behavior, and other components of self-care (13–15).

Analytical Variables and Potential Confounding

The primary exposure was health literacy measured by HLS-EU-Q16 score. The principal outcome was medication non-adherence based on the binary transformation of MMAS-8 categories. Secondary outcomes included the continuous MMAS-8 score and, among hemodialysis patients, missed dialysis sessions, diet/fluid non-adherence, serum phosphate, and dialysis duration.

Potential confounding variables were selected from clinically relevant demographic, socioeconomic, and treatment-related variables available within the participant-level dataset. These included age, sex, education level, income category, care setting, comorbidity count, medication count, and CKD duration. Including these variables in the multivariable model allowed evaluation of the health-literacy association while accounting for potential differences in socioeconomic resources, disease complexity, medication burden, and treatment setting.

Age, HLS-EU-Q16 score, comorbidity count, medication count, and CKD duration were entered as continuous predictors. Sex was analysed as male versus female. Education and income were entered as categorical predictors, with postsecondary education and high income used as the respective reference categories in the reported logistic model. Care setting was represented as predialysis versus hemodialysis.

Statistical Analysis

Data were analysed using IBM SPSS Statistics version 26.0. Statistical analysis was organized according to the measurement level and distributional characteristics of each variable. Categorical data were summarized as frequencies and percentages. Continuous variables were summarized using mean±standard deviation where informative, while median and interquartile range were additionally reported for variables with potentially non-normal or count-like distributions.

The relationship between continuous HLS-EU-Q16 and MMAS-8 scores was examined using Spearman rank correlation as the primary non-parametric correlation analysis. Pearson correlation was additionally calculated to quantify the linear relationship between the two continuous scores. Because health literacy was also categorized into low, mid-level, and high groups, differences in MMAS-8 scores across these three categories were tested using the Kruskal-Wallis test.

Associations between categorical health-literacy levels and binary medication non-adherence were assessed using the Pearson chi-square test. A separate chi-square analysis evaluated the association between health-literacy category and the three-level medication-adherence classification. The relationship between care setting and medication non-adherence was likewise evaluated using a chi-square test.

Dialysis-specific analyses were restricted to the 47 hemodialysis participants. Spearman correlation was used to evaluate the relationship of HLS-EU-Q16 score with the number of missed hemodialysis sessions during the preceding three months, serum phosphate, and dialysis duration. The association between categorical health-literacy status and diet/fluid non-adherence was examined using a chi-square test.

Binary logistic regression was used to quantify associations with medication non-adherence. Univariable models produced crude odds ratios with 95% confidence intervals. A multivariable model simultaneously included HLS-EU-Q16 score, age, sex, education, income, care setting, comorbidity count, medication count, and CKD duration. Adjusted odds ratios with 95% confidence intervals and p-values were reported. Statistical significance was defined as a two-sided p-value <0.05.

No imputation was required for the principal health-literacy and medication-adherence analyses represented in the final analytical dataset. Dialysis-specific variables that were not applicable to predialysis participants were treated

as structurally non-applicable and were excluded from the denominators of the dialysis-specific analyses rather than interpreted as missing observations.

Ethical Considerations

Ethical approval for the study was obtained from the Institutional Review Board of Riphah International University, Lahore, Pakistan. Informed consent was obtained from all study participants before participation and data collection. Participation was voluntary, and participant information was handled confidentially for research purposes.

RESULTS

A total of 125 patients with CKD were included in the final analysis. The participants had a mean age of 60.86±11.10 years and a median age of 62 years (IQR 54–69). Women represented 64 (51.2%) participants and men 61 (48.8%). Secondary education was the most common educational category, reported by 65 participants (52.0%), followed by primary education or less in 44 (35.2%) and postsecondary education in 16 (12.8%). More than two-fifths of participants belonged to the middle-income category, while almost half were retired.

Seventy-eight participants (62.4%) attended the predialysis clinic and 47 (37.6%) received hemodialysis. CKD stages 3, 4, non-dialysis stage 5, and stage 5D accounted for 22.4%, 28.0%, 12.0%, and 37.6% of the cohort, respectively. Mean CKD duration was 52.73±27.46 months. Hypertension was the most common recorded comorbidity, affecting 102 participants (81.6%), while diabetes mellitus and cardiovascular disease were present in 52 (41.6%) and 29 (23.2%), respectively. Mean medication count was 6.16±1.70, demonstrating substantial pharmacological treatment burden within the study population.

Table 1. Sociodemographic and Clinical Characteristics of Participants (N=125)

Characteristic	Category/Summary	n (%) or Summary
Age, years	Mean ± SD	60.86 ± 11.10
Sex	Female	64 (51.2)
	Male	61 (48.8)
Education	Primary or less	44 (35.2)
	Secondary	65 (52.0)
	Postsecondary	16 (12.8)
Income category	Low	45 (36.0)
	Middle	54 (43.2)
	High	26 (20.8)
Employment status	Employed	13 (10.4)
	Unemployed	29 (23.2)
	Retired	62 (49.6)
	Unable to work	21 (16.8)
Marital status	Married/partnered	78 (62.4)
	Single	26 (20.8)
	Divorced/widowed	21 (16.8)
Care setting	Predialysis clinic	78 (62.4)
	Hemodialysis unit	47 (37.6)
CKD stage	Stage 3	28 (22.4)
	Stage 4	35 (28.0)
	Stage 5, non-dialysis	15 (12.0)
	Stage 5D	47 (37.6)
CKD duration, months	Mean ± SD	52.73 ± 27.46
	Median (IQR)	49.0 (34.0–63.0)
Hypertension	Yes	102 (81.6)
Diabetes mellitus	Yes	52 (41.6)
Cardiovascular disease	Yes	29 (23.2)
Comorbidity count	Mean ± SD	1.46 ± 0.75
Medication count	Mean ± SD	6.16 ± 1.70
	Median (IQR)	6.0 (5.0–7.0)
Emergency visits, previous 12 months	Median (IQR)	1.0 (0–1)
Hospitalizations, previous 12 months	Median (IQR)	0 (0–1)

SD: standard deviation; IQR: interquartile range; CKD: chronic kidney disease.

The mean HLS-EU-Q16 score was 10.22±2.52, with a median of 10.0 (IQR 8.0–12.0). Low health literacy was identified in 33 participants (26.4%), mid-level health literacy in 67 (53.6%), and high health literacy in 25 (20.0%). Consequently, almost four-fifths of the cohort fell below the high/sufficient health-literacy category.

The mean MMAS-8 score was 5.86±1.25 and the median score was 5.8 (IQR 5.0–6.9). Low medication adherence was identified in 72 participants (57.6%), moderate adherence in 43 (34.4%), and high adherence in only 10 (8.0%). When low adherence was treated as medication non-adherence for binary analysis, 72 participants (57.6%) were classified as non-adherent and 53 (42.4%) as adherent.

A clinically relevant difference was observed between treatment settings. Among predialysis participants, 39 of 78 (50.0%) were medication non-adherent, whereas 33 of 47 hemodialysis patients (70.2%) were non-adherent. High medication adherence was observed in 10.3% of the predialysis group but only 4.3% of the hemodialysis group.

Among the 47 patients receiving hemodialysis, the median dialysis duration was 68.0 months (IQR 42.5–90.5). Fifteen patients (31.9%) received two dialysis sessions per week and 32 (68.1%) received three sessions per week. Twenty-six patients (55.3%) had missed at least one hemodialysis session during the preceding three months. Sixteen (34.0%) were classified as non-adherent to diet/fluid recommendations. Mean serum phosphate was 1.50±0.29 mmol/L.

Table 2. Health Literacy and Treatment-Compliance Characteristics

Variable	Category/Measure	Overall N=125	Predialysis n=78	Hemodialysis n=47
HLS-EU-Q16 score	Mean ± SD	10.22 ± 2.52	—	—
	Median (IQR)	10.0 (8.0–12.0)	—	—
Health literacy	Low	33 (26.4)	18 (23.1)	15 (31.9)
	Mid-level	67 (53.6)	44 (56.4)	23 (48.9)
	High	25 (20.0)	16 (20.5)	9 (19.1)
MMAS-8 score	Mean ± SD	5.86 ± 1.25	—	—
	Median (IQR)	5.8 (5.0–6.9)	—	—
Medication adherence	Low	72 (57.6)	39 (50.0)	33 (70.2)
	Moderate	43 (34.4)	31 (39.7)	12 (25.5)
	High	10 (8.0)	8 (10.3)	2 (4.3)
Medication non-adherence	Yes	72 (57.6)	39 (50.0)	33 (70.2)
Dialysis duration, months*	Mean ± SD			73.74 ± 42.33
	Median (IQR)			68.0 (42.5–90.5)
Dialysis sessions/week*	2			15 (31.9)
	3			32 (68.1)
Missed HD sessions, previous 3 months*	None			21 (44.7)
	≥1 session			26 (55.3)
Serum phosphate, mmol/L*	Mean ± SD			1.50 ± 0.29
Diet/fluid non-adherence*	Yes			16 (34.0)
	No			31 (66.0)

Dialysis-specific variables were evaluated only among the 47 hemodialysis participants. HD: hemodialysis; HLS-EU-Q16: 16-item European Health Literacy Survey Questionnaire; MMAS-8: eight-item Morisky Medication Adherence Scale.

Health literacy demonstrated a statistically significant relationship with medication adherence. The continuous HLS-EU-Q16 score was positively correlated with MMAS-8 score using Spearman analysis (ρ=0.413, p<0.001). Pearson analysis similarly demonstrated a positive linear association (r=0.472, p<0.001), supporting the robustness of the relationship across two correlation approaches.

Medication-adherence scores differed significantly across the three health-literacy categories (Kruskal-Wallis H=16.47, p<0.001). Mean MMAS-8 score was 5.06±1.16 among participants with low health literacy, 6.10±1.13 among those with mid-level health literacy, and 6.29±1.20 among those with high health literacy. Thus, the largest adherence difference occurred between the low-literacy group and the two higher-literacy groups.

Categorical analysis provided a similar pattern. Among the 33 participants with low health literacy, 27 (81.8%) were medication non-adherent and only six (18.2%) were adherent. Among participants with mid-level literacy, 33 of 67 (49.3%) were non-adherent, while 12 of 25 (48.0%) participants with high health literacy were non-adherent. The association between three-level health-literacy category and binary medication non-adherence was statistically significant (χ^2=10.78, p=0.005).

When medication adherence was retained as low, moderate, and high rather than dichotomized, the relationship with health-literacy category also remained statistically significant (χ^2=11.64, p=0.020). Care setting was independently associated with binary medication non-adherence in unadjusted categorical analysis, with greater non-adherence among hemodialysis than predialysis participants (70.2% vs 50.0%; χ^2=4.11, p=0.043).

Among hemodialysis patients, higher HLS-EU-Q16 scores were significantly associated with fewer missed hemodialysis sessions during the preceding three months (Spearman ρ=−0.306, p=0.036). This finding extended the observed relationship between health literacy and medication behavior to a separate domain of treatment engagement.

In contrast, HLS-EU-Q16 score was not significantly correlated with serum phosphate (ρ=−0.155, p=0.299) or dialysis duration (ρ=0.178, p=0.232). Health-literacy category was also not significantly associated with diet/fluid non-adherence (χ^2=1.76, p=0.415). These null findings indicate that the association between health literacy and compliance was not uniform across all treatment-related measures.

Table 3. Association of Health Literacy With Medication and Dialysis-Related Treatment Compliance

Analysis	Outcome/Comparison	Statistic	p-value
HLS-EU-Q16 vs MMAS-8	Continuous scores	Spearman ρ=0.413	<0.001
HLS-EU-Q16 vs MMAS-8	Continuous scores	Pearson r=0.472	<0.001
MMAS-8 across health-literacy categories	Low vs mid-level vs high HL	Kruskal-Wallis H=16.47	<0.001
Health literacy vs medication non-adherence	3×2 association	χ^2=10.78	0.005
Health literacy vs 3-level medication adherence	3×3 association	χ^2=11.64	0.020
Care setting vs medication non-adherence	Predialysis vs hemodialysis	χ^2=4.11	0.043
HLS-EU-Q16 vs missed HD sessions*	Number missed in previous 3 months	Spearman ρ=−0.306	0.036
HLS-EU-Q16 vs serum phosphate*	mmol/L	Spearman ρ=−0.155	0.299
Health literacy vs diet/fluid non-adherence*	Categorical association	χ^2=1.76	0.415
HLS-EU-Q16 vs dialysis duration*	Months	Spearman ρ=0.178	0.232

Hemodialysis subgroup only (n=47). HL: health literacy; HD: hemodialysis.

In univariable logistic regression, each one-point increase in HLS-EU-Q16 score was associated with a 27% reduction in the odds of medication non-adherence (OR=0.73, 95% CI 0.62–0.86; p<0.001). Predialysis treatment setting was associated with lower crude odds of medication non-adherence compared with hemodialysis care (OR=0.42, 95% CI 0.20–0.91; p=0.028). CKD duration also demonstrated a small crude association with medication non-adherence (OR=1.02 per month, 95% CI 1.00–1.03; p=0.040).

The multivariable model demonstrated that health literacy remained independently associated with medication non-adherence after adjustment for age, sex, education, income, care setting, comorbidity count, medication count, and CKD duration. Each one-point increase in HLS-EU-Q16 score was associated with approximately 34% lower adjusted odds of medication non-adherence (aOR=0.66, 95% CI 0.52–0.83; p<0.001).

The crude difference between predialysis and hemodialysis settings was attenuated after adjustment and was no longer statistically significant (aOR=0.73, 95% CI 0.29–1.86; p=0.514). This suggests that the higher unadjusted prevalence of medication non-adherence among dialysis participants may partly reflect differences in other demographic or clinical characteristics rather than dialysis setting itself.

Medication count showed a borderline positive association with non-adherence in the adjusted model (aOR=1.29 per additional medication, 95% CI 0.99–1.69; p=0.061), while increasing comorbidity count showed a borderline inverse association (aOR=0.54, 95% CI 0.29–1.00; p=0.051). CKD duration was no longer statistically significant after adjustment (aOR=1.02, p=0.081).

Secondary education, compared with postsecondary education, was associated with lower adjusted odds of medication non-adherence (aOR=0.22, 95% CI 0.05–0.96; p=0.044). However, given the relatively small postsecondary group and absence of a consistent dose-response educational gradient, this isolated categorical association warrants cautious interpretation.

The overall multivariable model was statistically significant (likelihood-ratio p<0.001) and had a McFadden pseudo-R^2 of approximately 0.22, indicating that the included predictors explained a meaningful but incomplete proportion of variability in medication non-adherence.

Table 4. Logistic Regression Analysis of Factors Associated With Medication Non-Adherence (N=125)

Predictor	Crude OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
HLS-EU-Q16 score, per 1-point increase	0.73 (0.62–0.86)	<0.001	0.66 (0.52–0.83)	<0.001
Age, per year	0.99 (0.96–1.03)	0.645	0.98 (0.93–1.02)	0.256
Male vs female	0.76 (0.37–1.54)	0.440	0.54 (0.22–1.30)	0.167
Primary or less vs postsecondary education	1.21 (0.35–4.22)	0.763	0.43 (0.08–2.28)	0.323
Secondary vs postsecondary education	0.37 (0.11–1.17)	0.091	0.22 (0.05–0.96)	0.044
Low vs high income	1.33 (0.49–3.57)	0.573	0.58 (0.17–1.99)	0.383
Middle vs high income	0.79 (0.31–2.03)	0.624	0.56 (0.18–1.73)	0.316
Predialysis vs hemodialysis setting	0.42 (0.20–0.91)	0.028	0.73 (0.29–1.86)	0.514
Comorbidity count, per condition	0.82 (0.50–1.32)	0.408	0.54 (0.29–1.00)	0.051
Medication count, per medication	1.21 (0.98–1.51)	0.081	1.29 (0.99–1.69)	0.061
CKD duration, per month	1.02 (1.00–1.03)	0.040	1.02 (1.00–1.03)	0.081

Outcome: medication non-adherence, coded as 1 for low MMAS-8 adherence and 0 for moderate/high adherence. The adjusted model included all predictors displayed. OR: odds ratio; CI: confidence interval.

DISCUSSION

The present study provides a multidimensional assessment of health literacy and treatment compliance among patients with CKD receiving predialysis and hemodialysis care in Lahore. The principal finding was a consistent association between lower health literacy and poorer medication adherence. This relationship was evident when both variables were analysed as continuous scores, when health literacy and adherence were categorized, and after adjustment for demographic, socioeconomic, and clinical characteristics in multivariable logistic regression. The association was not restricted to medication behavior: among patients receiving hemodialysis, higher health literacy was also associated with fewer missed dialysis sessions. At the same time, health literacy was not significantly related to serum phosphate or diet/fluid non-adherence. The overall pattern therefore supports health literacy as an important correlate of treatment engagement while demonstrating that compliance in CKD cannot be reduced to a single behavior or explanatory factor.

The observed level of limited health literacy is clinically important. Only 20.0% of participants were classified in the high-literacy category, whereas 26.4% had low literacy and 53.6% had mid-level literacy. This distribution is consistent with the broader CKD literature showing that substantial proportions of patients experience difficulty navigating health information, particularly when illness is advanced or accompanied by comorbidities. Billany et al. reviewed evidence from more than 25,000 people with CKD and concluded that higher literacy was generally associated with more favorable self-management behaviors, although the evidence base was heterogeneous with respect to measurement instruments and clinical outcomes (5). The present findings extend that evidence within a Pakistani nephrology population and are especially relevant because the participants faced considerable clinical complexity: more than four-fifths had hypertension, more than two-fifths had diabetes, and the mean medication count exceeded six drugs.

The demographic and disease profile of the present cohort is also consistent with the broader burden of CKD in Pakistan. Hypertension affected 81.6% of participants and diabetes 41.6%, emphasizing the close intersection between kidney disease and cardiometabolic conditions. Lahore-based screening research has similarly identified hypertension, diabetes, and cardiovascular conditions as major correlates of CKD (3), while national evidence emphasizes diabetes and other chronic conditions as substantial contributors to kidney disease (4). These comorbidities are not merely etiological factors; they increase therapeutic complexity because patients must manage kidney-specific recommendations alongside blood-pressure treatment, glycemic care, cardiovascular prevention, and other chronic therapies. Health literacy therefore becomes important not only for understanding CKD but for integrating multiple disease-specific instructions into one sustainable treatment routine.

The positive correlation between HLS-EU-Q16 and MMAS-8 scores was moderate in magnitude (Spearman ρ=0.413; Pearson r=0.472) and highly statistically significant. The categorical gradient was also clinically striking: medication non-adherence affected 81.8% of participants with low health literacy but approximately half of those with mid-level or high literacy. This pattern supports the concept that the greatest adherence disadvantage may be concentrated among patients with the lowest ability to obtain, process, and use healthcare information, rather than adherence increasing uniformly across every increment of literacy category.

The regression analysis strengthened this interpretation. Each one-point increase in HLS-EU-Q16 score was associated with a 34% reduction in adjusted odds of medication non-adherence after accounting for age, sex, education, income, care setting, comorbidity count, medication burden, and CKD duration. The persistence of this relationship after adjustment is important because formal education and socioeconomic position are frequently treated as proxies for health literacy. The present findings suggest that health literacy itself captured relevant variation beyond these characteristics. Demir et al. also demonstrated that literacy in CKD is influenced by, but not interchangeable with, age, education, disease burden, kidney function, and social characteristics (6).

Recent systematic-review evidence supports this interpretation. Muxunov et al. found that health literacy, disease-specific knowledge, self-efficacy, and social support were among the most consistent determinants of self-management in non-dialysis CKD (7). This framework helps explain why the present adjusted association remained substantial while other demographic variables were weaker. The HLS-EU-Q16 does not merely record years of education; it captures perceived ability to manage health-related information in real-world healthcare contexts.

Medication non-adherence affected 57.6% of the overall study population, demonstrating a substantial treatment-management challenge. This is compatible with the 2024 umbrella review by Tesfaye et al., which identified medication adherence as an important and persistent problem across kidney-disease populations (8). The high proportion is also consistent with CKD's considerable therapeutic burden. As disease progresses, patients frequently require more medications, more frequent monitoring, and more complicated timing instructions. Some treatments must be coordinated with meals, dialysis schedules, laboratory results, or symptoms, creating opportunities for both intentional and unintentional non-adherence.

The present comparison between predialysis and dialysis care offers further clinical insight. Medication non-adherence was present in 50.0% of predialysis patients and 70.2% of hemodialysis patients. Kaul et al. similarly reported poorer adherence and greater pill burden among hemodialysis patients compared with non-dialysis CKD patients (10). Dialysis dependence can increase treatment burden substantially because medications must be managed alongside fixed dialysis schedules, vascular-access care, dietary and fluid restrictions, transportation, fatigue, post-dialysis symptoms, employment disruption, and recurrent clinical appointments.

However, the current regression findings indicate that dialysis status should not be interpreted as an independent cause of poor medication adherence. The crude association between treatment setting and non-adherence was significant, but it disappeared after multivariable adjustment. This attenuation suggests that differences in medication burden, duration of disease, demographic characteristics, health literacy, or other clinical factors may explain part of the apparent dialysis effect. Such findings emphasize the importance of adjusted analysis when interpreting adherence differences between clinically dissimilar patient populations.

The magnitude and direction of the current health-literacy association are broadly consistent with the findings of Mailani et al. (11). Their 2024 cross-sectional study of hemodialysis patients also used HLS-EU-Q16 and MMAS-8 and found that aspects of health literacy contributed to medication adherence. This methodological similarity strengthens the comparison because differences arising purely from the use of different measurement instruments are reduced. Both studies suggest that healthcare-related literacy—understanding and using treatment information—may be particularly relevant to daily medication behavior.

Nevertheless, the present findings should not be portrayed as universally reproduced. Hamza et al. recently evaluated 390 hemodialysis patients in Rawalpindi and Islamabad and identified substantial inadequate health literacy and low medication adherence, but the correlation between the two variables was weak and statistically non-significant (12). The discrepancy with the present study is scientifically informative. Health literacy can operate differently across healthcare environments, and its behavioral influence may depend on the availability of family assistance, prescribing complexity, medication cost, healthcare-provider communication, local educational practices, treatment beliefs, illness perceptions, and the specific instrument used to measure literacy and adherence.

Differences in statistical approach may also contribute. The present study evaluated health literacy and medication adherence in several complementary ways, including continuous correlations, categorical analyses, and multivariable logistic regression. A weak linear correlation in one sample does not exclude clinically important threshold effects or confounding-adjusted relationships. Conversely, the current results should not be interpreted

as evidence that improving literacy alone will necessarily normalize adherence, because observational associations do not establish intervention effects.

The work of Inanaga et al. provides a useful explanatory framework for these differences (13). Their multicenter hemodialysis study demonstrated that trust in physicians partially mediated relationships between functional or communicative health literacy and medication adherence. This suggests that patients may possess the cognitive ability to understand information yet remain poorly adherent when trust, therapeutic alliance, or communication quality is inadequate. Conversely, patients with limited formal literacy may adhere successfully when information is explained effectively and treatment decisions are supported by trusted clinicians or family members. Health literacy should therefore be conceptualized as a patient-system interaction rather than simply a fixed individual deficit.

The high frequency of missed dialysis sessions in the present hemodialysis subgroup provides another clinically important finding. More than half of hemodialysis patients had missed at least one session during the preceding three months. Higher HLS-EU-Q16 scores were associated with fewer missed sessions, with a Spearman correlation of −0.306. Although modest, this association is meaningful because dialysis attendance constitutes a behavioral domain distinct from medication taking. The fact that literacy related to both medication adherence and dialysis attendance increases confidence that the observed relationship is not entirely dependent on one questionnaire.

The mechanisms behind dialysis attendance are nevertheless complex. Attendance requires patients to understand the importance of treatment but also to overcome transportation difficulties, competing employment or family obligations, financial constraints, treatment fatigue, symptom burden, weather or travel problems, and perceptions about the immediate consequences of missing a session. The current study did not measure these potential mediators directly. Consequently, the observed association should be interpreted as evidence of correlation, not as proof that low literacy caused missed dialysis.

The lack of a statistically significant association between literacy and diet/fluid non-adherence is equally important and should not be treated as a negative result of lesser value. Chen et al. demonstrated that relationships between health-literacy profiles and fluid management may operate indirectly through self-efficacy, traditional dietary practices, and adherence behavior (14). Their work suggests that a simple direct relationship may be difficult to detect when important mediating mechanisms are not included in the analysis. Cultural eating practices are particularly relevant because patients may clearly understand fluid or dietary recommendations while finding them difficult to implement in the context of family meals, climate, thirst, social expectations, or limited access to appropriate foods.

The findings of Oliveira et al. further support this multidimensional interpretation (15). Their systematic review found that illness perceptions were associated with dietary adherence, fluid control, and medication-taking behavior in many hemodialysis studies, but relationships varied across adherence domains. This helps explain why a patient with high health literacy may still be non-adherent to diet or fluid restrictions. Knowledge and comprehension are necessary resources, but behavior also depends on beliefs about illness severity, perceived benefits of treatment, perceived consequences of non-adherence, emotional responses, treatment burden, and confidence in the ability to follow recommendations.

Serum phosphate was likewise not significantly related to HLS-EU-Q16 score. This finding should not be interpreted as evidence that health literacy has no relevance to phosphate management. Serum phosphate is influenced by multiple factors beyond dietary behavior, including dietary phosphate bioavailability, use and timing of phosphate binders, dialysis adequacy, residual kidney function, nutritional status, and other physiological determinants. A single biochemical value is therefore an imperfect surrogate for adherence. The null correlation may indicate that the pathway from literacy to phosphate control is too indirect or multifactorial to be captured within this sample.

Dialysis duration was also not significantly associated with health literacy. Longer exposure to dialysis might theoretically increase knowledge through repeated contact with healthcare professionals, but it could also produce treatment fatigue without improving information-processing skills. Demir et al. observed that more frequent healthcare contact does not necessarily translate into higher health literacy, particularly when greater contact is driven by multimorbidity and disease burden (6). Repeated exposure to services therefore should not be assumed

to produce effective learning unless communication is structured, understandable, and responsive to patient needs.

The findings regarding education deserve careful interpretation. Secondary education was associated with lower adjusted odds of medication non-adherence compared with postsecondary education, but primary education or less was not significantly different from the postsecondary reference group. This is not a conventional dose-response relationship and may partly reflect the relatively small number of participants with postsecondary education. Formal education should therefore not be interpreted as having a protective or adverse effect based on this isolated coefficient. Health literacy is more proximal to actual healthcare tasks than educational attainment alone, and the strong independent HLS-EU-Q16 association supports measuring literacy directly where feasible.

Medication count approached statistical significance in the adjusted model. Each additional medication was associated with an estimated 29% increase in the odds of non-adherence, although the 95% CI included unity. The direction of the association is clinically plausible and consistent with literature emphasizing treatment complexity in CKD (8,10). Greater medication burden increases the number of dosing decisions patients must make each day, increases the likelihood of adverse effects or drug-related concerns, and may increase direct financial cost. The present sample may have lacked sufficient statistical power to demonstrate this association definitively after simultaneous adjustment for multiple covariates.

The borderline relationship between comorbidity count and non-adherence was in the opposite direction and should not be overinterpreted. Patients with more comorbidities may have more complex treatment regimens, but they may also interact with healthcare professionals more frequently, receive greater family assistance, or perceive stronger need for medication. The finding illustrates why adherence determinants are rarely linear and why multivariable results should be interpreted within the clinical context rather than through p-values alone.

From a clinical perspective, the results support the use of health-literacy-responsive communication within nephrology care. This does not necessarily require formal testing of every patient. Universal precautions for health literacy can include using plain language, limiting the amount of new information delivered at one time, prioritizing actionable instructions, linking medication purpose to timing, using visual aids where appropriate, and confirming understanding rather than asking patients simply whether they understood.

Teach-back is particularly relevant because it requires patients to explain information in their own words, allowing clinicians to identify misunderstandings immediately. Jagodage et al. systematically reviewed teach-back interventions in CKD and found evidence suggesting improvements in knowledge, self-efficacy, and self-management, although methodological heterogeneity limited the strength of conclusions for some outcomes (16). The method is particularly suited to CKD because instructions are repetitive, treatment regimens change over time, and patients are regularly exposed to nephrologists, nurses, pharmacists, dialysis staff, and dietitians.

Intervention evidence also suggests that adherence should be addressed behaviorally rather than by education alone. Ekholm et al. examined behavioral interventions targeting treatment adherence in CKD and highlighted the role of structured behavior-change strategies (17). A more recent systematic review and network meta-analysis by Ma et al. further evaluated comparative adherence-enhancement approaches in CKD (18). Together, these studies reinforce that improving adherence may require combinations of education, behavioral support, medication simplification, reminders, motivational strategies, self-monitoring, family engagement, clinician communication, and multidisciplinary follow-up.

The present findings have particular relevance for resource-constrained settings. Health-literacy-responsive care does not necessarily depend on expensive technology. Repeated verbal counseling, locally understandable educational materials, medication schedules, clear labeling, family-inclusive counseling, teach-back, and reinforcement during dialysis sessions may all be implementable within routine practice. Because dialysis patients have recurrent contact with healthcare professionals, the dialysis unit provides repeated opportunities to identify misconceptions and reinforce treatment behaviors.

At the same time, placing responsibility entirely on patients would be inappropriate. Health literacy is influenced by the demands healthcare systems place on individuals. Complex terminology, inconsistent instructions, fragmented prescriptions, short consultations, poorly designed written material, and inadequate coordination among professionals can create unnecessary literacy barriers. The finding that health literacy remained associated with

adherence after socioeconomic adjustment should therefore motivate improvements in communication systems rather than labeling patients as inherently non-compliant.

The study also has implications for future Pakistani research. The disagreement between the present results and the recent Rawalpindi/Islamabad study by Hamza et al. (12) indicates a need for multicenter investigation using consistent instruments and statistical frameworks. Larger studies could examine whether the literacy–adherence relationship varies according to dialysis status, education, sex, age, urban/rural residence, medication burden, socioeconomic status, family support, and healthcare-provider communication. Such work would help establish whether the current association is broadly reproducible or specific to particular kidney-care settings.

Longitudinal research is also required. The cross-sectional design used here establishes association but cannot determine whether limited health literacy precedes non-adherence, whether recurrent treatment difficulties influence perceived literacy, or whether both are shaped by unmeasured socioeconomic and psychological determinants. Prospective cohorts could evaluate whether baseline health-literacy level predicts future missed dialysis sessions, medication persistence, hospitalization, emergency attendance, phosphate control, CKD progression, or other clinically relevant outcomes.

Interventional studies would provide the strongest test of clinical utility. Patients identified as having limited literacy could receive structured literacy-responsive interventions incorporating teach-back, individualized medication schedules, family involvement, repeated dialysis-unit education, and adherence monitoring. Outcomes should extend beyond questionnaire scores to objectively measurable treatment behaviors and clinically meaningful events. Recent systematic reviews demonstrate growing interest in this intervention pathway but also indicate the need for more rigorous and context-specific evidence (16–18).

Several strengths of the present study deserve emphasis. First, the analysis included both predialysis and hemodialysis populations rather than restricting assessment to one disease stage. This allowed investigation of literacy and medication adherence across clinically different treatment settings. Second, the study assessed medication adherence using both continuous and categorical representations and confirmed the literacy association using multiple statistical approaches. Third, the use of multivariable logistic regression provided an adjusted estimate accounting for demographic, socioeconomic, and clinical factors. Fourth, dialysis-specific outcomes enabled assessment of treatment behavior beyond medication use. Fifth, both significant and non-significant findings were retained, avoiding an overly selective interpretation of health literacy as universally associated with every adherence measure.

Several limitations must also be considered. The analytical cross-sectional design prevents establishment of temporal sequence and causal inference. Higher literacy may support adherence, but the study cannot demonstrate that increasing literacy would necessarily produce improved adherence. Medication adherence was assessed through a self-reported scale and may therefore be influenced by recall error or social-desirability bias. The same concern applies to self-reported or behaviorally classified diet/fluid non-adherence.

The study was conducted within a single institutional setting in Lahore, limiting generalizability to other hospitals, provinces, rural communities, or healthcare systems. The total sample of 125 was adequate to identify the principal literacy–adherence relationship but restricted the precision of some subgroup and multivariable estimates. The hemodialysis subgroup contained 47 participants, reducing power for dialysis-specific associations, particularly diet/fluid adherence and biochemical measures.

Residual confounding remains possible. The available participant-level data did not include depression, anxiety, cognitive function, medication beliefs, illness perception, self-efficacy, social support, health-insurance status, medication cost, transportation barriers, dialysis adequacy, residual kidney function, detailed dietary intake, or clinician-patient trust. Existing literature demonstrates that several of these factors may independently influence treatment adherence or mediate its relationship with health literacy (9,13–15).

Serum phosphate was available as an objective biochemical measure but should not be regarded as a direct adherence test because it reflects multiple biological and treatment-related influences. Similarly, missed dialysis sessions measure one dimension of dialysis adherence but do not capture shortened treatments, late arrival, intradialytic behavior, or reasons for absence. Future studies would benefit from richer objective adherence metrics.

Despite these limitations, the study contributes locally relevant evidence that health literacy is associated with medication adherence in CKD and may also be relevant to dialysis attendance. The persistence of the association after adjustment, the magnitude of non-adherence among participants with low literacy, and the concordance between medication and dialysis-session findings collectively support greater attention to communication and comprehension within routine nephrology care.

The broader evidence base suggests that the appropriate response is not simply to give patients more information. Rather, kidney-care teams should reduce unnecessary informational complexity, communicate in accessible language, confirm understanding, address beliefs and practical barriers, and recognize the role of self-efficacy, trust, social support, and treatment burden. Such an approach is more consistent with contemporary evidence regarding health literacy and adherence than treating either construct as an isolated patient characteristic (5,7,9,13).

CONCLUSION

Health literacy was significantly associated with treatment compliance among patients with chronic kidney disease attending nephrology outpatient and hemodialysis services at Riphah International University, Lahore. More than half of the study population had low medication adherence, and medication non-adherence was especially frequent among participants with low health literacy. Higher HLS-EU-Q16 scores were associated with better MMAS-8 scores and independently lower odds of medication non-adherence after adjustment for demographic, socioeconomic, and clinical characteristics. Among hemodialysis patients, higher health literacy was additionally associated with fewer missed dialysis sessions, whereas associations with serum phosphate and diet/fluid non-adherence were not statistically significant. These findings demonstrate that health literacy is an important correlate of some, but not all, dimensions of treatment behavior in CKD. Integrating clear communication, assessment of understanding, individualized adherence support, and health-literacy-responsive patient education into routine nephrology and dialysis care may help address treatment-management difficulties while acknowledging the broader clinical, socioeconomic, psychological, and healthcare-system determinants of adherence.

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