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Assessment of Medications Adherence among Patients of Kidney Dialysis in an Iraqi Cohort in Erbil City

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ABSTRACT:

Background: Adherence to prescribed medications is an important aspect of effective treatment management for patients with ESRD who are typically taking multiple medications to manage the complications of ESRD such as anemia, hypertension, mineral and bone disorder, and cardiovascular diseases. Adherence may affect the effectiveness of treatment and result in adverse clinical outcomes if not adhered to. The challenges to adherence are frequent, however, and include complex medication regimens, burden of treatment, medication-related problems, and socioeconomic barriers.

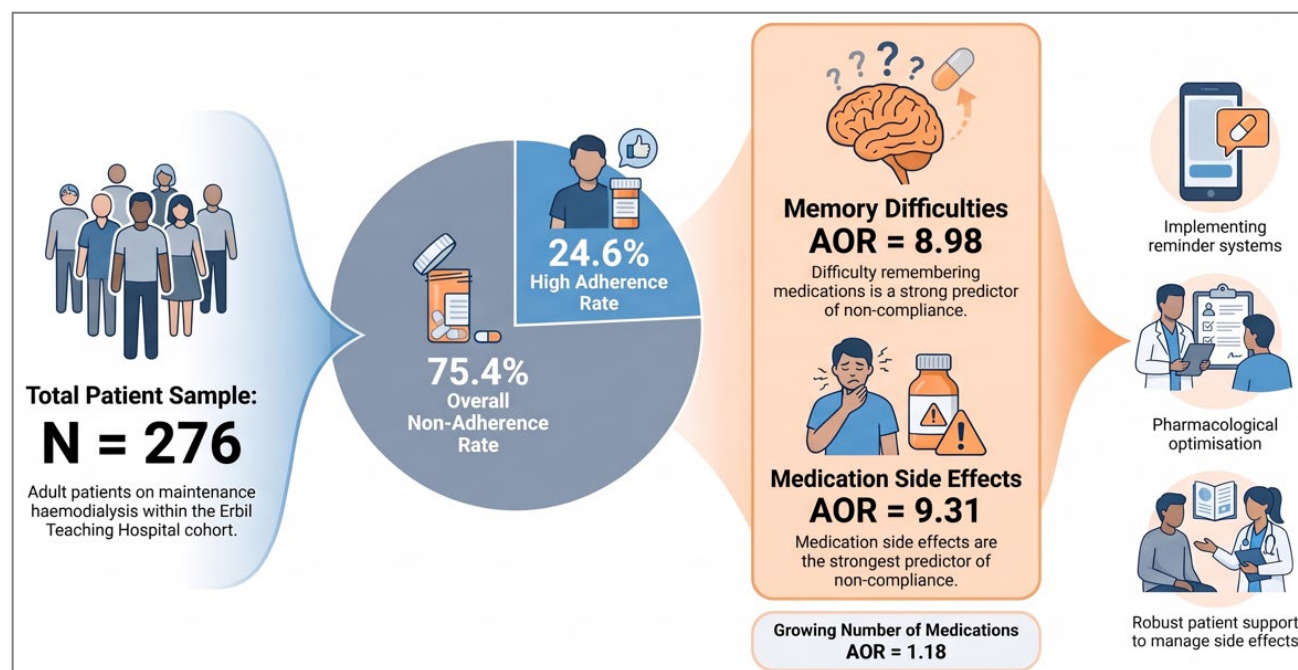
Objectives: This study sought to evaluate the rate of adherence to medication among people on hemodialysis in Erbil City, Iraq, and to determine the factors related to non-adherence to medication.

Methods: This study was a cross section of adult patients on maintenance hemodialysis from the Dialysis Center of Erbil Teaching Hospital. Convenience sampling was used to identify participants. The Morisky Medication Adherence Scale (MMAS-8) was used to measure adherence to medications. The participants were divided into two groups for analysis: high adherence and non-adherence. Descriptive analysis, comparative tests, and multivariable logistic regression were used to determine factors independently associated with non-adherence.

Results: Data from 276 patients were analyzed; only 24.6% had a high adherence rate, while 34.8% had a medium adherence rate and 40.6% had a low adherence rate. The overall non-adherence rate was 75.4%. The mean MMAS-8 score was 5.89 ± 2.06 . The most common adherence barrier was feeling burdened by treatment (67.8%), followed by not remembering the medications (43.5%) and careless medication taking (38.4%). Medication side effects (AOR=9.31, 95% CI: 2.13–40.63), difficulty remembering the medications (AOR=8.98, 95% CI: 1.11–72.82), and growing number of medications (AOR=1.18, 95% CI: 1.04–1.34) were independently associated with non-adherence.

Conclusions: Non-adherence to drugs is a significant problem in this Iraqi hemodialyzed population. Results show a high correlation between the difficulties of adherence and medication burden, complexity of treatment, memory problems, and side effects of medication. Pharmacological optimization and management of side effects, reminder systems, and patient support can be interventions that can help increase adherence among dialysis patients.

Visualized Abstract



INTRODUCTION

Chronic kidney disease (CKD) is a serious public health issue around the world that involves a progressive and irreversible loss of kidney function. Most patients eventually progress to end-stage kidney disease (ESKD) if kidney function decreases and will eventually need renal replacement therapies (RRT) like hemodialysis to improve their survival rate. Hemodialysis is a life-sustaining therapy, but the patient must be very active in the treatment, having to attend sessions regularly, change their diet, restrict their intake of water, and take a complex drug therapy (Kidney Disease: Improving Global Outcomes). The rising worldwide burden of CKD has significantly led to morbidity, mortality, and healthcare burden (1).

Multiple chronic complications and comorbid conditions are very common in patients undergoing maintenance hemodialysis, such as anemia, cardiovascular disease, diabetes mellitus, mineral and bone disorders, and hypertension. These patients often need several medications to manage kidney-related complications and associated diseases. These medications are necessary for clinical stability and prevention of complications; however, the number of medications taken and the complexity of therapeutic regimens can have a negative impact on patients' ability to maintain adherence to prescribed therapy (2).

Medication adherence is the extent to which patients comply with their medications as recommended and instructed by health care providers. For chronic diseases that are treated over a lifetime, sufficient adherence to treatment is a critical component to the success of treatment. Poor adherence to medication can result in substandard disease control, greater complications, more hospitalizations, diminished quality of life, and greater healthcare costs in patients on hemodialysis. Even though adherence is critical, it is difficult to maintain the correct behavior when taking medicines due to the ongoing need for dialysis treatment as well as due to the psychological and practical issues that can occur when managing a long-term condition (3).

A number of factors interact with each other to affect medication adherence in hemodialysis patients. These include sociodemographic factors (age, sex, education level, employment status, and socioeconomic status); clinical factors (dialysis duration, comorbidities, and medication burden); and patient factors (forgetfulness, side effects of medications, understanding of treatment instructions, and financial constraints). Adherence to HA has been shown to vary significantly across hemodialysis populations across different studies, in part, because of differences in study population, adherence measurement tools, and adherence definitions (4).

To successfully develop an intervention to improve outcomes for dialysis patients, it is crucial to identify the factors that contribute to medication non-adherence. Treatment complexity, medication burden, adverse effects, cognitive difficulties, and

socioeconomic factors have all been proposed as potential causes of adherence problems, as well as a single behavioral one, and there is evidence that all these factors contribute to adherence problems. It is therefore necessary to be aware of the patterns of medication adherence in certain health care contexts in order to develop strategies that reflect local context and address local barriers (5).

The general situation of medication adherence among patients undergoing maintenance hemodialysis has limited evidence in Iraq, especially in Erbil City. Local assessment is required as adherence behaviors could be affected by availability of health services, availability of medication, socioeconomic status, and patient characteristics. The current study was therefore aimed at evaluating the level of patients' adherence to their medications who are receiving kidney dialysis treatment in Erbil City in an Iraqi cohort, to identify the sociodemographic, clinical, treatment-related, and patient-related factors that influence the adherence and non-adherence of these patients.

MATERIALS AND METHODS

Study Design and Setting

A cross-sectional study was conducted at a hospital to evaluate medication adherence and factors associated with medication non-adherence among patients undergoing maintenance hemodialysis in Erbil City, Iraq. This study was carried out in the Dialysis Center of Erbil Teaching Hospital in Erbil City, Kurdistan Region, Iraq. The study period was from 1st May 2025 to 31st December 2025.

Study Population and Sampling Method

All adult patients requiring regular maintenance hemodialysis at the Dialysis Center of Erbil Teaching Hospital were included in the study. The participants were sampled using a non-probability convenience sampling technique in the course of the study. Patients were included in the study who met the eligibility criteria and gave informed consent.

Adult patients (age 18 or older), patients receiving regular hemodialysis, and patients who had been dialyzing for a minimum of one month were included. Patients currently taking prescribed medications, those who understood and could provide responses to the study questionnaire were included, and patients who gave informed consent for participation were included. Patients were excluded if they had severe psychiatric conditions that prevented their participation, severe cognitive impairment that prevented reliable questionnaire completion, critical illness, refusal to provide informed consent or to complete the questionnaire, or inability to provide information.

Data Collection and Study Variables

A structured questionnaire was used for data collection to gather information on sociodemographic factors, clinical characteristics, dialysis-related factors, medication-related factors, and medication adherence behaviors. Sociodemographic variables included age, sex, educational level, and employment status. Clinical and treatment-related variables consisted of dialysis-related variables, comorbidities, number of medications, medication burden, and barriers to medication use reported by the patient. The variables were chosen because of previously known factors that could predict adherence to medications in patients on hemodialysis.

Assessment of Medication Adherence

The Morisky Medication Adherence Scale (MMAS-8) was used to assess the medication-taking behavior of the study participants and this was used to determine medication adherence. The MMAS-8 is a widely used self-report tool for measuring adherence in patients with chronic illness. Participants were divided into two adherence groups for analysis based on their MMAS-8 score: high adherence (MMAS-8 score 8) and non-adherence (MMAS-8 score < 8, which included medium and low adherence). Overall adherence classification was completed in addition to a specific analysis of individual MMAS-8 items to determine specific behavioral barriers to adherence to medications. These encompassed forgetting doses, not taking medications as prescribed, discontinuing medications when symptoms were better or worse, forgetting medication when away from home, and feeling burdened by the treatment plan.

Statistical analysis

Data were analyzed statistically for the purpose of assessing adherence to medications and determining factors related to non-adherence in HD patients. All continuous variables were presented as mean $\pm$ standard deviation (SD), while all categorical variables were reported as frequencies and percentages. The 8-item Morisky Medication Adherence Scale (MMAS-8) was used to measure medication adherence. Adherence was defined as high adherence (MMAS-8 score = 8) or non-adherence (medium and low adherence; MMAS-8 score <8) for analytical purposes.

Descriptive statistics were first conducted to describe the study population and calculate the distribution of categorical adherence levels. Appropriate comparative tests were used to determine differences between patients with high adherence and those with non-adherence. Categorical variables were compared by the chi-square test or Fisher's exact test as appropriate and included sex, education level, employment status, comorbidities, dialysis frequency, medication-related barriers, and patient-reported barriers. The continuous variables such as age, number of medications, and hospital admissions were compared using a t-test with Welch correction, as there was the possibility of a difference in variance between the groups.

A multivariate logistic regression analysis was performed to find factors that were independently related to medication non-adherence. Non-adherence status (medium/low adherence based on the MMAS-8 versus high adherence) was the dependent variable. The regression model included variables that were clinically relevant and/or were found to be associated in the univariate analysis. All the following variables were included in the final model: age, number of medications, hospital admissions, difficulty remembering medications, medication side effects, financial burden, diabetes, and hypertension. Odds ratios (ORs) were adjusted for age and computed with 95% confidence intervals (CIs) for the estimation of the strength of the associations. An AOR >1 meant an increased likelihood of non-adherence, while AOR <1 meant a decreased likelihood of non-adherence. A two-sided P -value < 0.05 was set as the criterion of statistical significance.

Likelihood ratio testing, pseudo- R^2 according to McFadden, and the Akaike information criterion (AIC) were used to evaluate model performance. All 276 observations were used in the illustrative regression model, which had a significant overall fit (likelihood-ratio $p < 0.001$), a McFadden pseudo- R^2 of 0.211, and an AIC of 261.3. Due to the cross-sectional study design, all statistical analyses were interpreted as associations and not causal relationships.

Ethical Considerations

Ethical principles were maintained in accordance with the Kurdistan Higher Council of Medical Specialists (KHCMS) approval number (1558). Participation was voluntary, and informed consent was obtained from all participants before enrollment. The confidentiality and privacy of participant information were preserved throughout data collection, analysis, and reporting.

RESULTS AND DISCUSSION

This study showed that there is significant medication non-adherence in maintenance HD patients. Adherence to treatment was high in 24.6% of the 276 participants, medium adherence in 34.8%, and low adherence in 40.6%, corresponding to an overall non-adherence rate of 75.4% (MMAS-8 classification). Moreover, the mean MMAS-8 score was 5.89 ± 2.06 , further suggesting that adherence to medications is a challenge in this population (**Figure 1**). This is an important discovery because although many people with end-stage kidney disease (ESKD) have regular dialysis, it is still challenging to prevent them from taking their medications optimally.

The distribution of medication adherence categories showed that the studied hemodialysis population had a large percentage of suboptimal adherence. The 276 respondents included 68 (24.6%) high-adherence patients, defined as MMAS-8 scores of 4 to 8. Medium adherence was found in 96 patients (34.8%), while low adherence was found in 112 patients (40.6%). Overall, 208 patients were classified as non-adherent (75.4%), suggesting that poor medication adherence was very common among this group.

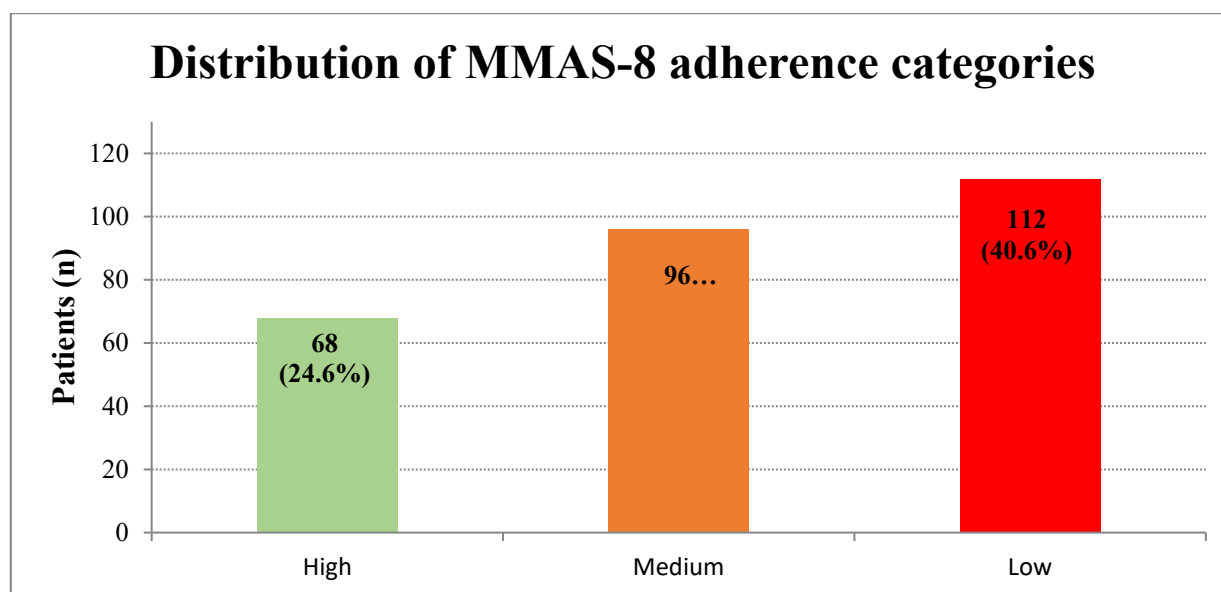


Figure 1: Distribution of MMAS-8 medication-adherence categories (N=276).

This discovery suggests that good medication adherence is still a significant problem among patients undergoing end-stage kidney disease (ESKD). The patient population is especially vulnerable since it is necessary for these patients to self-manage several medications, dialysis schedules, dietary restrictions, and several comorbid conditions throughout the day. Castellino et al. reported high rates of medication non-adherence among hemodialysis patients, although these estimates have been widely variable, depending on the method for determining adherence, the definition of adherence, and the characteristics of the patients studied (6).

The current study's findings on non-adherence might be attributed to the complexity and chronicity of dialysis treatment. The treatment burden for patients receiving hemodialysis is not the same as that of those receiving short-term medical therapy, as patients may become fatigued with treatment and experience problems with the need to take medications in a way that works for them. The literature has highlighted that there is often a high burden of medication for patients with ESKD, as they are likely to be on multiple treatments for anemia, mineral and bone disorders, hypertension, diabetes, and cardiovascular diseases. In a systematic review conducted by Liu et al., medication-related factors, including daily tablet count, overall pill burden, and regimen complexity, were identified as important factors associated with medication non-adherence among hemodialysis patients (7).

The present results also indicated that non-adherence might be due to treatment burden, rather than a deliberate decision to avoid treatment. Results from the MMAS-8 analysis showed that the most common barrier reported was feeling “hassled” about following the treatment plan (67.8%). Kvarnström et al. highlighted that there are psychological and practical obstacles to chronic dialysis care. Forgetfulness, side effects of medication, pill burden, complexity of regimens, and financial limitations are common obstacles to adherence among hemodialysis patients; interventions to improve adherence should focus on the patient's daily treatment experience, not just on increasing knowledge about the importance of taking the medication (8).

Moreover, the percentage of patients who were poorly adherent in this study is noteworthy in the clinical setting. Non-adherence to medications can pose a risk in managing dialysis-related issues and impact treatment outcomes among dialysis patients. The present data also revealed that there was a correlation between medication burden and adherence, with patients who were not adherent being on significantly more medications than those who were highly adherent (7.3 ± 3.2 vs. 5.4 ± 3.1 medications, $p < 0.001$). Recent studies suggest that an increased medication burden in dialysis patients is linked to increased risk of medication non-adherence and reduced patient-related outcomes, reinforcing the importance of ongoing medication review and optimization in dialysis (9).

Therefore, a multidisciplinary approach (involving nephrologists, pharmacists, nurses, and patient education programs) may be a feasible way to alleviate treatment burden and increase adherence. The demographic profile is provided in **Table 1**. The

association between employment status and adherence status was borderline ($p=0.051$) and was statistically significant ($p=0.003$) when the results were adjusted. In this illustrative analysis, there was no significant association between age and education grouping and the binary adherence outcome.

Table 1. Sociodemographic characteristics by high-adherence versus non-adherence status. Values are n (%) unless otherwise stated. P values are from chi-square tests for categorical variables and Welch's t-test for age.

Characteristic	Category	Overall (N=276)	High adherence (n=68)	Non-adherence (n=208)	P value
Sex	Female	136 (49.3)	41 (60.3)	95 (45.7)	0.051
	Male	140 (50.7)	27 (39.7)	113 (54.3)	
Education	No formal literacy	109 (39.5)	28 (41.2)	81 (38.9)	0.916
	Primary	68 (24.6)	17 (25.0)	51 (24.5)	
Employment	Secondary or higher	99 (35.9)	23 (33.8)	76 (36.5)	0.001
	Employed	24 (8.7)	9 (13.2)	15 (7.2)	
	Homemaker	122 (44.2)	31 (45.6)	91 (43.8)	
	Retired	42 (15.2)	14 (20.6)	28 (13.5)	
	Self-employed	23 (8.3)	2 (2.9)	21 (10.1)	
	Unemployed	62 (22.5)	9 (13.2)	53 (25.5)	
	Other	3 (1.1)	3 (4.4)	0 (0.0)	
Age, years	Mean $\pm$ SD	56.2 $\pm$ 15.8	57.9 $\pm$ 16.0	55.6 $\pm$ 15.7	0.291

CLINICAL, TREATMENT, AND PATIENT-REPORTED FACTORS

The mean number of medications that were used by non-adherent patients was higher than in highly adherent patients (7.3 ± 3.2 vs 5.4 ± 3.1 ; $p<0.001$). For bivariate comparisons, non-adherence was found to be related to diabetes, problems with recalling medications, side effects from medications, financial impact, and the frequency of dialysis. These were not statistically significant in unadjusted comparisons in the hospital admission category or the hypertension category, as expressed in **Table 2**.

Table 2: Clinical, treatment, and patient-reported factors by adherence status. Values are n (%) unless otherwise stated. P values are from chi-square tests for categorical variables and Welch's t-test for continuous variables.

Characteristic	Category	Overall (N=276)	High adherence (n=68)	Non-adherence (n=208)	P value
Dialysis frequency	1	12 (4.3)	7 (10.3)	5 (2.4)	0.045
	2	147 (53.3)	33 (48.5)	114 (54.8)	
	3	116 (42.0)	28 (41.2)	88 (42.3)	
	>3	1 (0.4)	0 (0.0)	1 (0.5)	
Hypertension	No	45 (16.3)	15 (22.1)	30 (14.4)	0.197
	Yes	231 (83.7)	53 (77.9)	178 (85.6)	
Diabetes	No	153 (55.4)	48 (70.6)	105 (50.5)	0.006
	Yes	123 (44.6)	20 (29.4)	103 (49.5)	

Cardiovascular disease	No	180 (65.2)	49 (72.1)	131 (63.0)	0.223
	Yes	96 (34.8)	19 (27.9)	77 (37.0)	
Difficulty remembering medications	No	234 (84.8)	67 (98.5)	167 (80.3)	<0.001
Medication side effects	Yes	42 (15.2)	1 (1.5)	41 (19.7)	
	No	202 (73.2)	66 (97.1)	136 (65.4)	<0.001
	Yes	74 (26.8)	2 (2.9)	72 (34.6)	
Financial burden	No	92 (33.3)	37 (54.4)	55 (26.4)	<0.001
	Yes	184 (66.7)	31 (45.6)	153 (73.6)	
Overall well-being	Poor	23 (8.3)	3 (4.4)	20 (9.6)	0.074
	Fair	57 (20.7)	19 (27.9)	38 (18.3)	
	Good	154 (55.8)	32 (47.1)	122 (58.7)	
	Very good	42 (15.2)	14 (20.6)	28 (13.5)	
Number of medications	Mean $\pm$ SD	6.8 $\pm$ 3.3	5.4 $\pm$ 3.1	7.3 $\pm$ 3.2	<0.001
Hospital admissions	Mean $\pm$ SD	1.1 $\pm$ 1.7	1.0 $\pm$ 1.4	1.2 $\pm$ 1.7	0.269

MMAS-8 item-level pattern

As shown in **Table 3**, the most common adherence-related problem was feeling “hassled” or burdened with the treatment plan (67.8%, N=187) when analyzed by individual MMAS-8 items. This was followed by poor recall of all medications (43.5%) and sometimes being careless about medications (38.4%). Other reported behaviors were stopping or decreasing medication if they felt unwell (25.4%), forgetting medication when travelling or away from home (21.7%), or stopping medication when they felt their condition was controlled (20.7%). Only 8 patients (2.9%) reported that they had not taken all their medications the day before.

Table 3: Item-level pattern of non-adherent responses on the Morisky Medication Adherence Scale (MMAS-8). Q5 is reverse-scored; Q8 is classified as non-adherent for any response above “Never/Rarely.”

MMAS-8 item	Medication-taking behavior assessed	Non-adherent response	n (%)
Q1	Forget to take medicines	Yes	47 (17.0)
Q2	Sometimes careless about taking medicines	Yes	106 (38.4)
Q3	Stop/ cut back when feeling worse	Yes	70 (25.4)
Q4	Forget medicines when travelling/leaving home	Yes	60 (21.7)
Q5*	Took all medicines yesterday (reverse-scored)	No (reverse-scored non-adherent response)	8 (2.9)
Q6	Stop medicines when condition controlled	Yes	57 (20.7)
Q7	Feel hassled by sticking to treatment plan	Yes	187 (67.8)
Q8*	Difficulty remembering all medicines	Any frequency above never/rarely	120 (43.5)

*Q5 is reverse-scored; Q8 is classified as non-adherent for any response above “Never/Rarely.”

The item-level analysis is useful to gain insight into the behavioral mechanisms underlying medication non-adherence among hemodialysis patients. The general level of non-adherence was high, but the most frequently cited issue was not the need to stop taking medication, but rather that the medication plan was overwhelming. Treatment burden was cited by 67.8% of

participants as an “adherence problem,” indicating that this may be one of the key factors underlying adherence challenges in the current study. Patients with hemodialysis often have complicated treatment needs, such as several medications daily, a special diet, fluid restrictions, and frequent dialysis appointments. All of this can make it challenging for patients to take medication consistently over time. These results are consistent with those of chronic kidney disease (CKD) patient groups, where increased treatment burden and treatment complexity resulted in lower medication adherence (10).

Difficulty remembering medications was the second most commonly reported barrier (43.5%). Loss of memory is a well-established behavioral factor of unintentional non-adherence, especially for long-term medications that need to be given every day. This may be exacerbated in dialysis patients with older age, cognitive deficits, fatigue, depression, and complex medication regimens. Previous studies have shown that forgetfulness is one of the most common reasons for missed doses of medication in patients with chronic kidney disease and dialysis-dependent renal failure. Thus, adherence interventions need to include strategies that work for the patient, including medication organizers, reminder systems, simplified dosing schedules, and caregiver involvement (11).

There is a high prevalence of reported non-adherence due to forgetfulness of taking medication (38.4%) and stopping or decreasing medication due to poor feeling (25.4%), which could be intentional or unintentional. Deliberate non-compliance can be due to side effects of medication, notions that medications are not necessary, symptom resolution, or poor attitudes about taking medications over time. For hemodialysis patients, the behaviors are clinically relevant because many of the medications can be given to prevent symptoms as opposed to treating them, and the need for these medications may not be evident to patients. Previous studies have focused on tackling patient beliefs, experiences with medication use, and provider-patient communication in addition to education about the seriousness of adherence problems (12).

The least common behavior was not taking all the medications the day before (2.9%), which suggests that most patients were not completely disclosing their medication habits. The pattern of adherence, however, seems to be more a sign of occasional problems, treatment boredom, and inconsistencies. This distinction is clinically significant as it may mean that patients who are only experiencing intermittent episodes might need more focused support interventions, rather than compliance ones. The findings of this study encourage the use of patient-centered adherence programs which have the ability to uncover individual barriers to adherence and propose solutions, especially in the context of minimizing treatment burden and self-management of treatment in hemodialysis patients (13).

Analysis of the individual MMAS-8 items identified that the top adherence barrier among the analysed patients was being burdened by the treatment regimen (**Figure 2**). Treatment burden was the most common response to non-adherence (67.8% of participants, Q7: “feel hassled by sticking to the treatment plan”). Q8, difficulty remembering all medications (38.4%), and Q2, carelessness about taking medications (43.5%), were the second most common barriers. Other reported behaviors were stopping or reducing medications when they feel worse (25.4%), forgetting medications when travelling or when out of the house (21.7%), and stopping medication when condition is controlled (20.7%). Failure to take all medications on the previous day (2.9%) was the least commonly reported non-adherent behavior.

The pattern seen in **Figure 2** offers valuable clues to the mechanisms responsible for medication non-adherence in hemodialysis. The majority of the burden, not total abandonment, of treatment indicates that problems of adherence are primarily related to the complexity of long-term disease management. The most common problem was being “hassled” by following treatment; about 2/3 reported this problem. This discovery suggests that dialysis patients might face challenges due to the constant demands on them, such as taking numerous medications, following a strict diet, limiting fluid intake, and visiting healthcare facilities regularly. Previous studies highlighted that treatment burden has been stressed as playing a significant role in medication adherence in chronic kidney disease, as it requires patients to adopt complex treatment regimens that they will be required to follow for the long term (12).

Unawareness of taking medications, as indicated by the high frequency of memory-related problems (43.5%), is a significant factor to consider in HD patients. Many medications require complex schedules and/or multiple pills; fatigue, advanced age, cognitive dysfunction, and psychological stress from chronic illness may all lead to forgetfulness. Based on existing evidence, some of the most prevalent barriers for adherence to medications reported by patients with chronic conditions, including kidney failure, are forgetfulness, medication organizers, reminder systems, simplified dosing, and caregiver support, as appropriate (14).

This study also included intentional non-adherence behaviors which are clinically relevant. There was a significant number of patients who indicated that they either discontinued or decreased medications when they felt worse (25.4%) or when they felt they were controlled (20.7%). The results indicate that for some patients, the decision to take a medication may be influenced more by how the symptoms are perceived than by medical advice. Many medications that are used for dialysis patients offer preventive benefits, and so patients may not realize the importance of these when symptoms improve. These same results have been seen in a study by Hagger and Orbell. In populations with chronic disease, the degree of adherence is influenced by the beliefs patients have about the necessity of the medication, the potential side effects of the medication, and the effectiveness of the treatment (15).

Interestingly, the smallest reported barrier was nonadherence to all medications the previous day (2.9%), which would indicate that treatment was not being discontinued but that patients had trouble adhering to the treatment over time. This distinction is meaningful because it suggests that specific behavioral strategies might prove to be more effective than just reinforcing medication directions. The results confirm prior studies indicating the need for patient-centered approaches to adherence that aim to decrease treatment burden, organize medications, address medication concerns, and enhance communication between the health system and the patient (16).

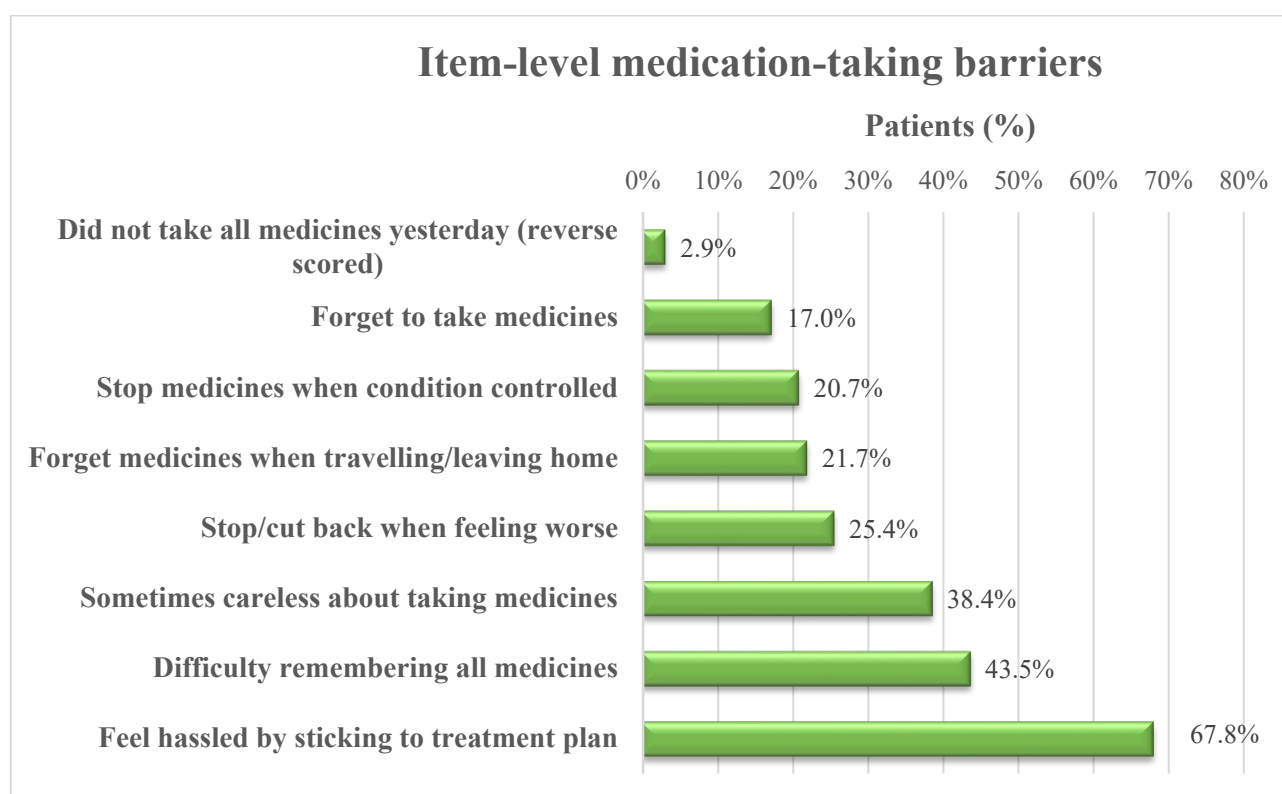


Figure 2. Item-level proportion of participants with a non-adherent MMAS-8 response.

Patient-reported barriers and non-adherence

The proportion of non-adherence was significantly greater among patients who indicated they had difficulty remembering medications (97.6% vs 71.4%), had side effects from their medications (97.3% vs 67.3%), and had financial difficulties with their medications (83.2% vs 59.8%). These are descriptive contrasts rather than causal effects, as they are not adjusted for other factors.

Medication non-adherence rates were significantly elevated across all domains of medication barriers among those who endorsed the barriers, irrespective of the specific medication barriers. There was a significant difference in the prevalence of non-adherence between patients with memory problems and without memory problems (97.6% vs 71.4%). Likewise, patients who reported side effects with the medication were less likely to take the drug as prescribed than those who did not report any

side effects (97.3% vs. 67.3%). In addition, patients who reported financial burden were more likely to be nonadherent than were those who did not report financial burden (83.2% vs. 59.8%). Barriers reported by patients are highly correlated with medication-taking problems among HD patients, as evidenced by these differences (17).

The results in **Figure 3** illustrate that patient-reported barriers are significant factors in non-adherence to hemodialysis treatment. Nearly all patients reporting memory problems with medications were non-adherent (97.6%). Patients with memory problems when taking medications were the most common group of non-adherent patients (97.6%). The study highlights the significance of the issue of unintentional non-adherence in dialysis patients, where the complexity of medication regimens and the high burden of treatment can make it difficult for patients to adhere to their medication regimens over the long term. Patients who are taking long-term treatments are at risk for missed doses due to cognitive difficulties, treatment fatigue, and the need for more than one daily dose. Forgetfulness is one of the most frequently reported causes of non-adherence to medications among hemodialysis patients in previous studies (18).

Similarly, medication-related side effects were strongly associated with non-adherence, as 97.3% of patients who reported side effects were deemed non-adherent, whereas 67.3% of patients who did not report any side effects were deemed non-adherent. This is important because it revealed the impact of medication experience on adherence behavior. Patients may self-manage their medications by reducing, stopping, or refusing to take them, particularly when the benefit for them seems to be outweighed by the harm. Multiple medications are usually prescribed to chronic kidney disease patients, making this an important problem, especially because patients are prone to experiencing adverse effects from the medicines and have decreased satisfaction with treatment. Adverse effects and medication concerns have been shown to be significant factors in predicting voluntary medication non-adherence in chronic disease populations in previous studies (19).

The impact of financial burden was also linked to non-adherence, but not as strongly as memory problems and side effects of medication. Of those who said they had financial burden, 83.2% were classified as non-adherent, while 59.8% of those who did not have financial burden were. This discovery could indicate that financial issues can affect the frequency with which patients can access their medicines, especially in healthcare systems where costs of health care and transport and availability of medicines are additional barriers. Medication non-adherence has been identified as a key challenge in healthcare, particularly for chronic conditions that require ongoing and expensive therapy, and socioeconomic factors have been established as key factors affecting medication adherence (16).

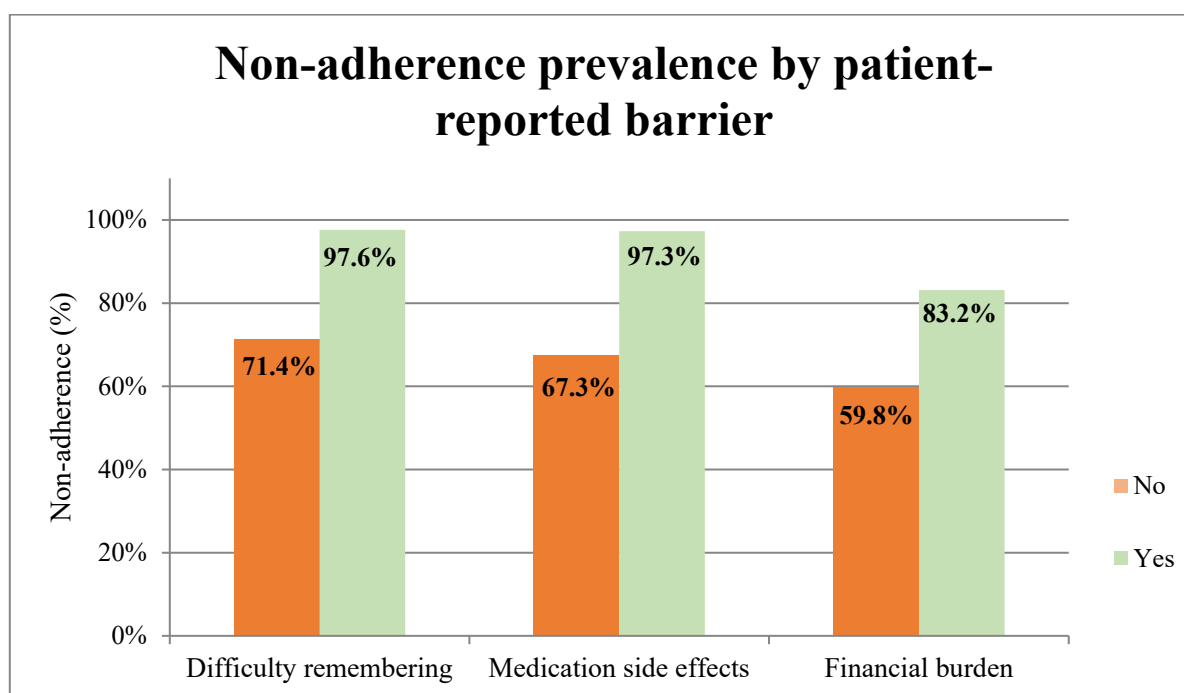


Figure 3: Unadjusted prevalence of non-adherence by selected patient-reported barriers.

The overall levels suggest that medication non-adherence among hemodialysis patients is multi-faceted, with cognitive, treatment, and socioeconomic factors all playing a role. Importantly, these results indicate that targeted interventions are needed in addition to general patient education to improve adherence. Reminder systems and strategies for organizing medication may prove helpful for those with memory problems, while assistance from health care providers to review and adjust medications may be necessary for individuals who are having side effects. Likewise, removing financial barriers through enhanced access to medicines and supportive healthcare policy may positively influence adherence results. Thus, the ability to recognize the barriers that are present in each patient should be an integral part of dialysis care (20).

Multivariable analysis of non-adherence

The odds of non-adherence (medium/low vs. high adherence) were estimated in a multivariable logistic regression model. Covariates included were age, number of medications, hospital admissions, difficulties of medication recall, side effects, financial impact, diabetes, and hypertension (**Table 4**). For the illustrative model, the 276 observations had a likelihood-ratio $P < 0.001$, a McFadden pseudo- R^2 of 0.211, and an AIC of 261.3.

The independent predictors of medication non-adherence (medium/low MMAS-8 adherence versus high adherence) were identified by a multivariable logistic regression model. Medication burden, difficulty remembering medications, and medication-related side effects were significant factors associated with non-adherence, after adjusting for age, number of medications, hospital admissions, difficulty remembering medications, medication side effects, financial burden, diabetes, and hypertension (20).

There were no significant interactions between the different medications. For every additional medication, there was an independent association with non-adherence (AOR = 1.18; 95% CI: 1.04–1.34; $P = 0.011$). Those patients who reported that they had difficulty remembering medications were at 8.98 times higher risk of not taking medications than patients who did not experience memory problems (95% CI: 1.11–72.82; $p = 0.040$). Likewise, increased odds of non-adherence were associated with reporting side effects of medication (AOR = 9.31; 95% CI: 2.13–40.63; $P = 0.003$). Other factors such as age, hospitalizations, financial strain, diabetes, and hypertension did not prove to be statistically significant factors after adjustment (6).

The multivariable regression analysis offers significant evidence of the independent predictors of medication adherence among hemodialysis patients, which are largely related to treatment complexity and adherence barriers related to the patient rather than demographic and comorbidity factors alone. Following adjustment for potential confounders, difficulty remembering medicines and side effects of medicines were the strongest predictors of non-adherence. These results suggest that dialysis patients have multiple problems with adherence, and that most of them are closely linked to the daily issues of complex medication management (21).

In this study, polypharmacy as a parameter of medication burden is associated with non-adherence, underscoring the importance of polypharmacy in dialysis care. For every additional medication, the risk of non-adherence doubled (AOR = 1.18, 95% CI: 1.04–1.34). This is clinically important because patients on hemodialysis frequently need a variety of drugs for anemia, mineral and bone disorders, cardiovascular disease, hypertension, diabetes, and other chronic kidney disease complications. The more medications, the more complexity in dosage, pill burden, and missed doses. The literature shows that polypharmacy is a significant issue associated with medication-related problems and non-adherence to medication among patients with chronic kidney disease (CKD) and dialysis dependence (15).

One of the most robust independent risk factors for non-adherence in the current analysis was difficulty remembering medications. Patients who complained of memory problems were almost 9 times more likely to be non-adherent than those who did not have this complaint (AOR = 8.98). This discovery implies that unintentional non-adherence plays a sizeable role in this population. The large confidence interval (1.11–72.82) suggests that the precision of this estimate is not high enough, possibly due to the relatively low number of patients experiencing memory impairments, and thus results should be interpreted with caution. However, forgetfulness has been cited as one of the most common challenges to drug adherence in chronic disease patients, including those with HD (16).

Medication-related side effects had the strongest statistical associations with non-adherence, with those who experienced the side effect being at over 9 times greater risk for non-adherence (AOR = 9.31; 95% CI: 2.13–40.63). This finding highlights the

need to consider patients' medication experiences as important factors for adherence behavior. Adverse effects can decrease patient confidence in dialysis, may lead to intentional dose reduction, or may lead to stopping dialysis without consulting a health care provider in dialysis patients. These studies have demonstrated that concerns about medicines, perceived harm, and intrusive treatment experiences have a strong impact on adherence behavior in patients on long-term treatment (17).

Table 4: Multivariable logistic regression for non-adherence (medium/low MMAS-8 category vs high adherence).

Variable	Adjusted OR*	95% CI*, lower	95% CI*, upper	P value
Age (per year)	0.98	0.96	1.01	0.156
Number of medications (per medication)	1.18	1.04	1.34	0.011
Hospital admissions (per admission)	0.97	0.78	1.20	0.751
Difficulty remembering (yes vs no)	8.98	1.11	72.82	0.040
Medication side effects (yes vs no)	9.31	2.13	40.63	0.003
Financial burden (yes vs no)	1.67	0.86	3.23	0.129
Diabetes (yes vs no)	1.61	0.82	3.18	0.170
Hypertension (yes vs no)	1.32	0.53	3.28	0.548

OR = odds ratio; CI = confidence interval. The model is illustrative, and associations are non-causal.

Interestingly, after adjustment, some clinical factors did not show an independent association with non-adherence, such as diabetes, hypertension, or hospitalizations. These findings indicate that the occurrence of comorbid conditions does not necessarily dictate medication-taking behavior, but rather the medically functional nature of dealing with medication may be more influential. Improvements in adherence of hemodialysis patients will be driven by interventions that address modifiable barriers such as medication simplification, pharmacist-led medication review, adverse-effect monitoring, and individualized adherence support (14).

After adjusting for potential confounders, the multivariable logistic regression model revealed that some factors were associated with medication non-adherence. The highest associations were found with medication conditions, as shown in **Figure 4**. Non-adherence was significantly associated with difficulty remembering medications, with a high AOR of 8.98 (95% CI: 1.11–72.82) values maintained above the null value. In the same way, those who reported side effects with their medications were significantly more likely to be non-adherent (AOR = 9.31; 95% CI: 2.13–40.63).

Medication burden was also significantly associated, as the ratio of one more medication was associated with greater odds of non-adherence (AOR = 1.18; 95% CI: 1.04–1.34). Age, hospital admissions, financial burden, diabetes, and hypertension, on the other hand, failed to show a statistically significant independent association, with confidence intervals crossing the reference value of 1.

As indicated in **Figure 4**, treatment-management challenges, and not just demographic factors or comorbidities, are the main drivers of non-adherence among hemodialysis patients. Difficulty of remembering medications and their side effects of medications was the strongest independent association, indicating that patients' experience with treatment is a significant factor in adherence behavior. The results confirm the notion that adherence depends on a complex behavior, which is shaped by the complexity of the medication regimen, its cognition, and perceived burden in patients with chronic kidney disease (6).

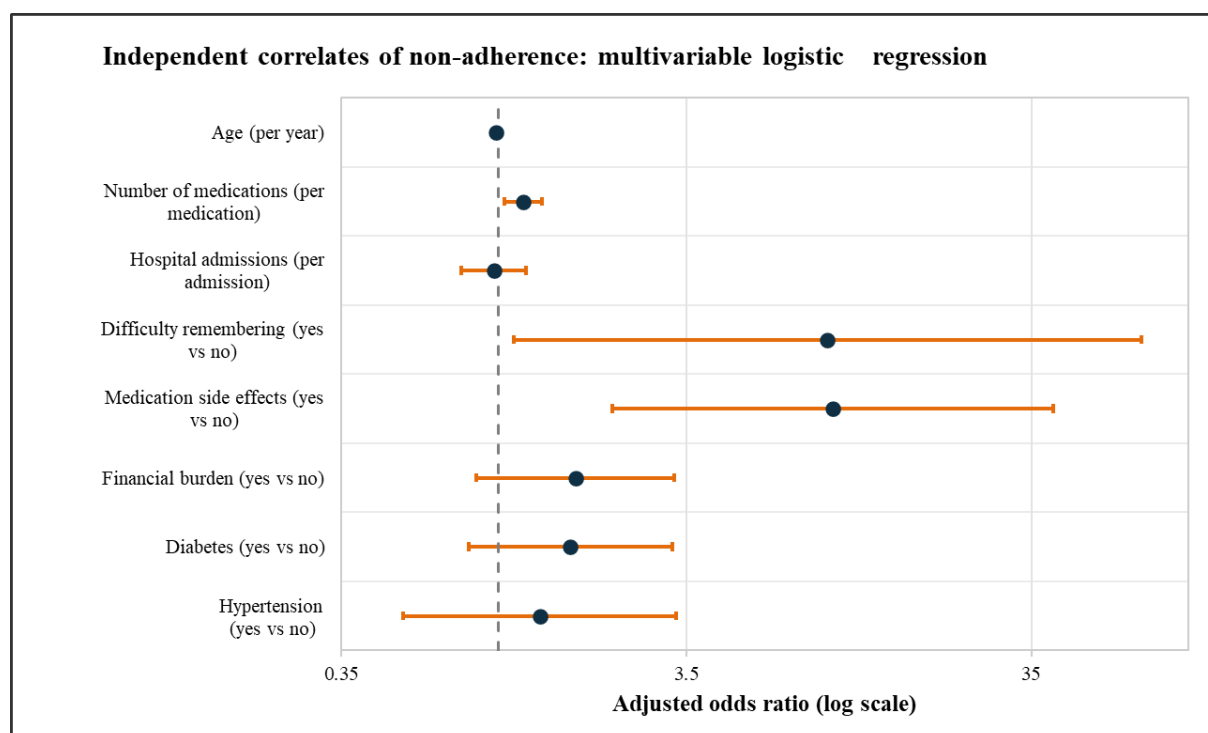


Figure 4: Adjusted odds ratios and 95% confidence intervals for non-adherence. Points to the right of 1 indicate higher estimated odds of non-adherence.

Difficulty remembering medications had almost 9 times the odds of non-adherence (AOR = 8.98). This finding suggests that non-adherence to medications may be due to unintentional non-adherence and is therefore an important factor to consider when understanding medication-taking difficulties in this population. Patients on hemodialysis frequently take several medications that require several doses a day, some that are taken with food, and extra medication for any complications. This complexity can make adherence to the medication schedule even more difficult, especially for older adults, for those who are fatigued, stressed or have less mental acuity. Forgetfulness is a common problem in adherence to the medication regimen among dialysis patients and one of the most commonly reported barriers to adherence found in previous studies (13).

In the model, medication side effects were shown to have the highest magnitude of association, with those affected having over 9-fold higher odds of non-adherence (AOR = 9.31). This discovery emphasizes the importance of tolerability of the medication in long-term adherence. Many of the people who have to have dialysis often take multiple medications, which can mean more side effects and possible negative perceptions about treatment. If a patient has unpleasant symptoms, he/she may change or stop a medicine without a physician's consent, especially when the medicine may not seem to be helping right away. Past adherence studies have shown that worry about side effects is a significant factor in non-adherence to medicines (19).

The association between medication number and lack of adherence further emphasizes the relevance of polypharmacy as an important medication-related treatment problem. For each additional medicine, the risk of non-adherence was about 18% higher. This association is clinically explainable, as an increase in the number of medications could lead to a greater pill burden, more pill complexity, and greater risk of medication errors. An increased medication burden is linked to an increase in treatment complexity and is a predictor of poor medication management among patients with chronic kidney disease; similar findings have been observed (18).

Interestingly, traditional clinical parameters like diabetes, hypertension, and a previous hospital admission were not independently associated with adherence following the adjustment. This implies it is not enough to have other medical conditions for adherence behavior to be influenced by them; rather, the practical aspects of implementing the treatment recommendations in daily life seem to be more influential. Hence, the interventions should focus on modifiable adherence barriers such as medication simplification, side-effect management, patient counseling, and personalized adherence support (7).

CONCLUSION

The present study showed that medication non-adherence is a significant problem among the patients who are receiving maintenance hemodialysis in Erbil City, Iraq. A significant percentage of patients had challenges in maintaining optimal medication-taking behaviors despite receiving regular dialysis care, signifying the complexity of long-term dialysis care. Results indicated that a small proportion of patients were found to be highly adherent to their medication, and the majority were deemed to be suboptimal in adherence based on the MMAS-8 assessment.

The study revealed that the factors affecting adherence to dialysis medications are not a single factor but a number of interrelated factors. All three factors medication burden, memory problems with medications, and medication side effects were independently associated with medication non-adherence. Furthermore, treatment burden was the most commonly reported adherence barrier, suggesting that the complexity of the medication regimen may play an important role in impacting a patient's overall ability to adhere to their medication regimen daily over time.

The results highlight the need to take a patient-centered perspective to enhance adherence to medications among dialysis patients. Medication Regimen Simplification, Medication Review, early identification and management of medication side effects, Reminder Systems, and individual patient education can be effective strategies for modifiable barriers to adherence. Multidisciplinary care, with nephrologists, pharmacists, nurses, and other health care professionals, may offer further assistance in optimizing medication management and treatment success.

Finally, enhancing medication adherence for hemodialysis patients involves acknowledging the real-world complexities of chronic dialysis care and designing interventions to tackle medication burden, cognitive hurdles, and medication-related concerns. Results from this Iraqi cohort may be useful for the local evidence base, which could help guide future interventions focusing on adherence in this cohort, as well as optimize dialysis care practices.

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