

Effectiveness of Educational Program on Knowledge and Adherence to Treatment Among Hemodialysis Patients: A Quasi-Experimental Study

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ABSTRACT:

Background: Hemodialysis patients require comprehensive knowledge about disease and strict adherence to complex treatment regimens. Knowledge deficits and non-adherence contribute to poor clinical outcomes, increased complications, and reduced quality of life. Structured educational interventions are essential to bridge knowledge gaps and improve adherence behaviors.

Objective: To evaluate the effectiveness of a structured educational program on improving knowledge and adherence to treatment across multiple domains among hemodialysis patients.

Methods: A quasi-experimental study was conducted with 110 hemodialysis patients (55 study group, 55 control group) at hemodialysis centers. The study group received a comprehensive educational program. Knowledge was assessed using kidney disease knowledge questionnaire and another three validated questionnaires measuring fluid control knowledge (FCHPS knowledge subscale), dietary knowledge (SDKHP), and exercise perceptions (benefits and barriers). Adherence was measured using four validated instruments: Hemodialysis Adherence Scale (HAS), Morisky Medication Adherence Scale (MMAS), Fluid Control Habits- Scale (FCHPS) with behavior and attitude subscales, and Scale of Dietary Behavior in Hemodialysis Patients (SDBHP). All assessments were conducted at three time points: pre-test, post-test 1, and post-test 2. Data were analyzed using SPSS version 27.

Results: The educational program produced significant improvements in both knowledge and adherence domains. Knowledge outcomes showed substantial gains in the study group: kidney disease knowledge increased from 7.04 ± 2.40 to 17.22 ± 2.78 ($p < 0.001$), fluid control knowledge improved from 11.64 ± 3.41 to

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16.80±1.84 ($p<0.001$), dietary knowledge increased dramatically from 0.75±1.14 to 12.29±2.63 ($p<0.001$), perceived exercise benefits increased from 23.25±5.91 to 40.62±3.67 ($p<0.001$), and perceived exercise barriers decreased from 37.95±5.75 to 19.13±3.38 ($p<0.001$). Adherence outcomes demonstrated parallel improvements: hemodialysis treatment adherence (HAS) improved from 15.96±3.66 to 22.98±2.40 ($p<0.001$), medication adherence (MMAS) improved from 3.42±1.78 to 2.05±0.93 ($p<0.001$), fluid control behavior improved from 17.93±5.17 to 27.09±2.15 ($p<0.001$), fluid control attitudes improved from 13.27±4.44 to 7.85±2.57 ($p<0.001$), and dietary adherence improved from 36.00±6.21 to 50.65±4.46 ($p<0.001$). All improvements were sustained at follow-up assessment, while the control group showed no significant changes, confirming the effectiveness of the educational intervention.

Conclusion: The structured educational program was highly effective in enhancing both knowledge and adherence to treatment among hemodialysis patients across all critical domains. Significant improvements in knowledge domains translated into measurable adherence domains improvements. Integration of structured educational programs into routine hemodialysis care is strongly recommended to optimize patient outcomes.

Keywords: chronic kidney disease, hemodialysis, knowledge assessment, treatment adherence, educational intervention.

1. Introduction

Chronic kidney disease (CKD) is defined as an abnormality of kidney structure or function present for more than 3 months. This long decline in renal function ultimately results in ESRD (Wilson et al., 2021). Hemodialysis is the most prevalent form of renal replacement therapy for patients with end-stage renal disease (ESRD) and it requires ESRD patients to attend treatment sessions usually three times a week (Arad et al., 2021). The prevalence and incidence of CKD are difficult to estimate correctly, because mild to moderate CKD is generally asymptomatic. However, the World Health Organization (WHO) has reported 10-14% of all people worldwide are affected with CKD (Kovesdy, 2022), with projections indicating it will become the fifth leading cause of years of life lost worldwide by 2040 (Li et al., 2020). In the United States, about 37 million adults have CKD, with around 786,000 progressing to ESRD, requiring

dialysis (Johansen et al., 2024a). The Middle East region have varying prevalence rates. In Saudi Arabia, CKD affects approximately 4-5% of the population, with higher prevalence observed in older males and those with diabetes and hypertension (Alshehri et al., 2025). Jordan estimates CKD prevalence at 12.5%, with many patients progressing to end-stage renal disease (ESRD) (Al-Momany et al., 2024a). Regional disparities exist within Iraq, with significant variations in CKD prevalence across cities including Basrah province, 6.8% among patients at dialysis centers, Sulaimani governorate was 0.01% (Kamil et al., 2021a; Sharif et al., 2017). Additionally, CKD has emerged as the fourth leading cause of death, accounting for approximately 6.06% of fatalities (Kamil et al., 2021b). A recent multicenter study revealed that among 10,721 hemodialysis patients across Iraq, Baghdad had the highest patient population undergoing HD (27.0%), followed by Basra (10.5%), Karbala (8.1%), Erbil (6.4%), Dohuk

(3.2%), Salah-al-Din (2.0%), Anbar (4.4%), Diyala (4.5%), Wasit (3.6%), Najaf (2.8%), Maysan (3.2%), Al-Muthanna (2.3%), Nasiriyah (3.9%), Ninawa (6.2%), Kirkuk (3.8%), Babil (4.1%), and Diwaniyah (2.2%). Sulaymaniyah had the least number of patients undergoing HD (1.8%) (Ismael et al., 2025). However, successful hemodialysis outcomes depend not only on the technical aspects of treatment but critically on patient knowledge and adherence to complex therapeutic regimens (Murali et al., 2019). Adherence has been defined by WHO as the extent to which a patient's behavior corresponds with agreed recommendations from healthcare providers, including attending scheduled hemodialysis sessions, following prescribed medication regimens, adhering to dietary and fluid restrictions (Sorrell et al., 2023). Despite the critical importance of patient adherence, studies consistently demonstrate poor adherence rates among hemodialysis patients globally. Non-adherence to hemodialysis treatment regimens ranges from 30% to 60% across different populations (Ozen et al., 2019). Poor adherence correlates with limited patient knowledge. In the Iraqi context, the challenges are particularly pronounced due to limited healthcare resources, and the absence of comprehensive patient registry systems (Jassim et al., 2025). Recent evidence shows that hemodialysis patients in developing countries, including Iraq, often lack essential information about their disease, and treatment needs (Hussain et al., 2023). Consequently, inadequate knowledge is linked to missing dialysis sessions, greater intradialytic weight gain, vascular access complications, and lower quality of life (Tsai et al., 2021; Xu et al., 2024). Systematic reviews and meta-analyses have demonstrated that structured educational programs can significantly enhance patient knowledge, improve adherence and reduce complications (Chae et al., 2023). In Kurdistan Region of Iraq, preliminary studies have indicated significant knowledge gaps among hemodialysis patients. These knowledge deficits contribute to suboptimal adherence behaviors and adverse clinical outcomes. Given the growing burden of ESRD in Iraq and the critical role of patient knowledge and adherence in determining treatment success, there is an urgent need for evidence-based

educational interventions tailored to the local context. This study aims to evaluate the effectiveness of a structured health education program on improving knowledge and adherence to treatment among hemodialysis patients at Duhok dialysis center, Kurdistan region, Iraq.

2. Research Question

What is the effectiveness of the educational program in improving knowledge and adherence among hemodialysis patients.

3. Methods

3.1. Study Design, Setting, Period, and Sampling

This study employs a quasi-experimental design with pre-test, post-test to evaluate effectiveness of a structured health education program on improving knowledge and adherence to treatment among hemodialysis patients at Duhok dialysis center, Kurdistan region, Iraq. The study included two groups: a study group that received the educational intervention and a control group that received standard care. The entire study was conducted over an eight-month period from November 2024 to June 2025. A non-probability purposive sampling technique was employed to select participants who met the study inclusion criteria. To ensure group comparability and minimize selection bias, eligible patients were systematically allocated based on their pre-assigned shifts: those on afternoon/evening dialysis were assigned to the study group, and those on morning shifts to the control group, yielding balanced groups of 55 patients each.

3.2. Sample Size

Sample size was determined using G*Power (version 3.1) based on similar nursing educational intervention studies, and two independent groups (study group and control group). Parameters included significance level $\alpha = 0.05$, adequate statistical power = 0.80, and medium effect size (Cohen's $d = 0.54$), yielding 53.78 participants per group. Rounding up to 54 and applying a continuity correction factor of 1.02 adjusted this to 55 per group (total $n = 110$), ensuring 80% power to detect differences between the study group receiving the

nursing educational program and the control group receiving standard care.

3.3. Inclusion/exclusion

Participants were selected based on specific inclusion criteria including confirmed diagnosis of end-stage renal disease, regular hemodialysis treatment (three times per week), age 18 years or older, ability to communicate in Kurdish or Arabic, and willingness to participate in the study. Additionally, exclusion criteria included severe cognitive impairment, acute medical complications requiring hospitalization, positive hepatitis B surface antigen (HBsAg) and prepared for kidney transplant during the study period.

3.4. Study Tools and measures

The questionnaire was structured into five main parts. First part collected sociodemographic characteristics (age, gender, marital status, level of education, occupational status, smoking status and number of cigarettes per day). The second section obtained information related to clinical data this section documented duration since diagnosis with renal disease (months/years), family history of renal failure (yes/no), degree of family relationship to affected family member (first-degree, second-degree), co-morbidities (diabetes mellitus, hypertension, cardiovascular disease, others). The third section assessed hemodialysis data and anthropometric measurements (type of vascular access, length of time receiving hemodialysis (months), number of hemodialysis sessions per week, hours spent per hemodialysis session, pre-dialysis weight (kg), post-dialysis weight (kg), height (cm), pre-dialysis blood pressure (mmhg), post-dialysis blood pressure (mmhg), post-hemodialysis session complaints). The fourth section assessed knowledge outcomes using four instruments including chronic kidney disease knowledge (6 items). **Each item was scored as 1 for correct response and 0 for incorrect response. After collecting responses, the scores are summed for each patient's answers.** Second domain is fluid control hemodialysis patient scale (FCHPS) knowledge subscale assessing understanding of fluid management principles. It is validated instrument and contains three subdimensions, the first is knowledge subdimension consists of 7 items

rated on a three-point scale ("agree" = 3, "indecisive" = 2, "don't agree" = 1). Cronbach's alpha for the knowledge subdimension was 0.92 (Cosar and Pakyuz, 2016). Third domain standardized scale for assessing dietary knowledge in hemodialysis patients (SDKHP) developed and validated by Duzalan (2017). It consists of 18 items using a three-point response format (True = 1, False = 0, I don't know = 0). Total scores range from 0 to 18, with higher scores indicating better dietary knowledge. The scale demonstrated good reliability (Cronbach's alpha = 0.86). Fourth domain include a validated tool dialysis patient-perceived exercise benefits and barriers scale (DPEBBS) designed for hemodialysis (HD) patients and consists of 24 items divided into two subdimensions: Benefits of exercise: 12 items (items 1, 2, 3, 4, 6, 7, 10, 13, 16, 20, 22, 23), Barriers to exercise: 12 items (items 5, 8, 9, 11, 12, 14, 15, 17, 18, 19, 21, 24). Items are rated on a 4-point Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Agree, 4 = Strongly Agree). Barrier items are reverse-scored. Total scores range from 24 to 96, with higher scores indicating more perceived exercise benefits and fewer exercise barriers. Cronbach's alpha was 0.83 for the total scale, 0.87 for benefits, and 0.80 for barriers (Lightfoot et al., 2021a). Part five is adherence assessment that is also subdivided to five parts. First part, hemodialysis adherence scale (HAS). The HAS is a researcher-developed questionnaire comprises 14 items organized into several content areas: Items 1-2 assess session attendance frequency, items 3-9 evaluate confidence and awareness of consequences, and items 10-14 assess behaviors related to leaving sessions early and reasons for missed appointments. Items 1-10 utilize a 4-point Likert-type scale (never = 0, sometimes = 1, most of the time = 2, all of the time = 3). Items 11-14 use categorical response options (item 11: number of missed sessions (0, 1, 2, or 3+ sessions), item 12: binary yes/no response regarding early departure, item 13: duration of early departure (4 time intervals), item 14: primary reason for missed sessions (5 categorical options). Item 8 is reverse-scored. Higher total scores indicate better adherence. **Cronbach's alpha was 0.96.** Second subdivision is validated morisky medication

adherence scale (MMAS-7) (Kırman, 2020). Items 1-7 use yes/no responses and yes responses are scored 0 (indicating non-adherence), while no responses (indicating adherence) are scored 1. Cronbach's alpha was 0.83. Third subdivision assess fluid control behavior (11 items) and attitudes subdimensions (6 items) in fluid control hemodialysis patient (FCHPS) Scale. Item 18th (behavior subdimension) and all attitude items are reverse-scored. Cronbach's alpha was 0.80 for behavior and 0.67 for attitudes (Cosar and Pakyuz, 2016). Fourth part standardized scale for dietary behavior in hemodialysis patients (SDBHP) (13 items). The SDBHP uses a 5-point Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Not Sure, 4 = Agree, 5 = Strongly Agree) with no reverse-scored items. Total scores range from 13 to 65, with higher scores indicating better dietary behaviors. Cronbach's alpha was 0.73 (Duzalan, 2017). All adherence measures were combined to assess overall treatment adherence. Cronbach's alpha for total adherence domains was 99.99%, indicating excellent reliability.

3.5. Pilot Study

The study questionnaire was initially tested with a group of 27 hemodialysis patients between 1st of August to the 1st of September, 2024. The pilot study aimed to ensure the clarity, reliability, and validity of all questionnaire items. Internal consistency was evaluated using Cronbach's alpha (Taber, 2018). The findings demonstrate that most instruments achieved acceptable to excellent internal consistency reliability, supporting their suitability for use in a larger-scale study. Feedback from experts confirmed that the questionnaire was suitable, comprehensible, and culturally appropriate for the target population. The data from the pilot study were excluded from the final statistical analysis.

3.6. Educational Intervention

The study group received a comprehensive, structured educational program delivered over multiple sessions. The educational content covered six main domains: (1) kidney disease pathophysiology and progression to ESRD, (2) hemodialysis treatment principles and procedures, (3) medication management including purposes,

dosing, and adherence strategies, (4) fluid control strategies and consequences of fluid overload, (5) dietary guidelines including protein, phosphorus, potassium, and sodium restrictions, and (6) exercise recommendations and benefits for hemodialysis patients. The educational sessions were delivered by trained nephrology nurses and dietitians using multiple teaching methods including lectures, demonstrations, visual aids, printed materials, and interactive discussions. Each session lasted approximately 45-60 minutes, and participants received take-home educational materials for reinforcement. The control group received standard care without the structured educational intervention.

3.7. Data Collection

Data were collected at three time points: pre-test (baseline before intervention), post-test 1 (2 weeks following completion of the educational program), and post-test 2 (8 weeks after post-test 1 to evaluate sustainability of improvements). The researcher administered a structured questionnaire through face-to-face interviews with patients, documenting their responses directly on the questionnaire.

3.8. Ethical considerations

This study followed the Institutional Research Ethics Board and the Declaration of Helsinki guidelines. Ethical approval for the study was obtained from the College of Nursing Ethics Committee of Hawler Medical University, with the code 2470 granted on October 24th 2024. Verbal consent was obtained from all participants. The researcher kept the name, address, and phone number for confidentiality and anonymity.

3.9. Statistical Analysis

Data analysis was done with the Statistical Package for Social Sciences (SPSS) software, version 26. Descriptive statistics like frequency, percentage, mean, and standard deviation will be used to describe the sociodemographic and clinical characteristics of the study and control groups, their hemodialysis treatment characteristics, anthropometric measurements, and baseline scores. Independent Samples T-Tests were used to examine between-group differences at three time points (pre-test, post-test 1, and post-test 2) on all continuous

variables such as Standardized Kidney Disease Knowledge Scale (SDKS), Standardized Fluid Control Hemodialysis Patient Scale knowledge domain attitude domain behavior domain fluid control Standardized Dietary Knowledge in Hemodialysis Patients Scale (SDKHP), Dialysis Patient-Perceived Exercise Benefits and Barriers Scale (DPEBBS), Standardized Hemodialysis Adherence Scale (HAS), Standardized Modified Morisky Adherence Scale (MMAS), Standardized Scale for Dietary Behavior in Hemodialysis Patients SDBHP) plus clinical and anthropometric measurements body weight blood pressure total complaints score plus other continuous variables. Categorical variables such as type of vascular access and the number of hemodialysis sessions per week were analyzed using Chi-Square Tests while individual ordinal complaint items scored on a three-point scale were analyzed using Mann-Whitney U Tests.

To find out if certain sociodemographic characteristics were linked to total knowledge and adherence scores in both the study and control groups separately, One-Way Analysis of Variance (ANOVA) with Tukey's Post Hoc Test was used for factors having three or more categories—like age group, level of education, occupational status, and smoking status. Gender and marital status were also tested under the same method since they only have two categories as variables. Paired Samples T-Tests assessed changes within the study group over time to see how effective an educational program really was in enhancing knowledge and treatment adherence by comparing pre-test with post-test 1, pre-test with post-test 2, and post-test 1 with post-test 2 scores. Results showed highly significant improvements in total knowledge scores right after the intervention (mean difference = 25.382, $p < 0.001$) that continued fully at two months' follow-up (mean difference = 25.564, $p < 0.001$) without any significant decline between the two post-tests measurements ($p = 0.443$). This confirmed both

immediate and long-term effectiveness of the educational program. All statistical tests were two-tailed; a p -value of less than 0.05 was considered statistically significant and 95% confidence intervals reported for all inferential analyses.

4. Results

4.1. Demographic Characteristics of Respondents

Table 1 presents sociodemographic characteristics of the Study and Control groups. The largest age group in both is 50–64 years (Study: 43.6%, Control: 40%), followed by 65–79 years (Study: 32.7%, Control: 30.9%). Younger adults (20–34 years) are more common in the Control group (18.2% vs. 7.3%). Regarding gender distribution of males and females is fairly balanced, with males (Study 47.3%, Control 49.1%), Females (Study 52.7%, Control 50.9%). Most participants were married (Study: 83.6%, Control: 85.5%), while never married individuals are slightly higher in the Study group (16.4% vs. 12.7%). Additionally, the majority of participants cannot read and write (Study: 69.1%, Control: 67.3%), while higher education at level of institute or college is low (around 7.3% in both groups). Occupationally, homemakers dominate (Study: 45.5%, Control: 40%), followed by paid work and self-employment, which is slightly higher in Controls (20% vs. 16.4%). Retirees are more common in Controls (20% vs. 9.1%). Unemployment due to health reasons (Study: 5.5%, Control: 3.6%) and unemployment due to other reasons (Study: 5.5%, Control: 1.8%) remains low. Most participants are non-smokers (Study: 69.1%, Control: 69.1%). Ex-smokers are higher in the Study group (23.6% vs. 16.4%), while smokers are more frequent in Controls (14.5% vs. 7.3%). Nearly all report smoking zero cigarettes/day (Study: 92.7%, Control: 85.5%), with a small percentage smoking up to 20 daily (Study: 7.3%, Control 14.5%).

Table 1: Distribution of Sociodemographic Characteristics Among Study and Control Groups of Hemodialysis Patients

Sociodemographic Characteristics		Groups			
		Study		Control	
		F.	%	F.	%
Age group (Years old)	20-34	4	7.3	10	18.2
	35-49	9	16.4	6	10.9
	50-64	24	43.6	22	40
	65-79	18	32.7	17	30.9
Gender	Male	26	47.3	27	49.1
	Female	29	52.7	28	50.9
Marital status	Never married	9	16.4	7	12.7
	Married	46	83.6	47	85.5
	Separated	0	0	1	1.8
Level of Education	Cannot read and write	38	69.1	37	67.3
	Can read and write	0	0	2	3.6
	Primary school graduated	5	9.1	4	7.3
	Intermediate school graduated	5	9.1	4	7.3
	Secondary school graduate	3	5.5	4	7.3
	Institute and College graduated	4	7.3	4	7.3
Occupational status	Paid work	9	16.4	5	9.1
	Self-employed	9	16.4	11	20
	Student	1	1.8	3	5.5
	Keeping house/homemaker	25	45.5	22	40
	Retired	5	9.1	11	20
	Unemployed (Health reason)	3	5.5	2	3.6
	Unemployed (Other reason)	3	5.5	1	1.8
Smoking	Non-smoker	38	69.1	38	69.1
	Ex-smoker	13	23.6	9	16.4
	Smoker	4	7.3	8	14.5
No. of Cigarettes per 24 hours	0	51	92.7	47	85.5
	0-20	4	7.3	8	14.5

4.2. Clinical Characteristics and Comorbidities Among Hemodialysis Patients at Baseline

Table 2 compares clinical data of the Study and Control groups. Most participants were diagnosed with renal disease 1–5 months ago (Study: 43.6%, Control: 52.7%), followed by 6–10 months (Study: 27.3%, Control: 20%), with a smaller portion diagnosed for more than 10 months (Study: 14.5%, Control: 18.2%). More in the Study group reported a family history of renal failure (34.5% vs. 21.8%), mostly in first-degree relatives (Study: 30.9%,

Control: 20%). Those have no family history (Study: 65.5%, Control: 78.2%). Finally, when based on the presence of comorbidities, nearly all participants had at least one comorbidity (Study: 100%, Control: 98.2%), with only one person in the Control group having no comorbidities. Hypertension was highly prevalent (Study: 85.5%, Control: 81.8%). Nephritis affected about half (Study: 54.5%, Control: 50.9%), diabetes was common (Study: 49.1%, Control: 41.8%) and Heart disease was more common in Controls (54.5% vs. 29.1%), while hyperthyroidism and other comorbidities were rare.

Table 2: Distribution of Clinical Characteristics and Comorbidities Among Study and Control Groups of Hemodialysis Patients at Baseline

Clinical Data		Group			
		Study		Control	
		F.	%	F.	%
Durations Diagnosed with Renal Disease-months	< 1	8	14.5	5	9.1
	1-5	24	43.6	29	52.7
	6-10	15	27.3	11	20
	> 10	8	14.5	10	18.2
Family History of Renal Failure	No	36	65.5	43	78.2
	Yes	19	34.5	12	21.8
Degree of Family Relationship to Renal Failure	No family history	36	65.5	43	78.2
	1st degree relative	17	30.9	11	20
	2nd degree relative	2	3.6	1	1.8
Does the patient have any Co-morbidities?	No	0	0	1	1.8
	Yes	55	100	54	98.2
Nephritis	No	25	45.5	27	49.1
	Yes	30	54.5	28	50.9
Diabetes Mellitus	No	28	50.9	32	58.2
	Yes	27	49.1	23	41.8
Hypertension	No	8	14.5	10	18.2
	Yes	47	85.5	45	81.8
Heart Disease	No	39	70.9	25	45.5
	Yes	16	29.1	30	54.5
Hyperthyroidism	No	46	83.6	48	87.3
	Yes	9	16.4	7	12.7
Other comorbidity (specify)	No	54	98.2	53	96.4
	Yes	1	1.8	2	3.6

4.3. Comparison of All Knowledge Scale Scores Between Study and Control Groups (Pre-Test, Post-Test 1, and Post-Test 2)

Table 3 presents the between-group comparison of all knowledge scales across the three time points.

The control group scored significantly better than the study group on pre-test measures of kidney disease knowledge ($p = 0.043$), fluid control knowledge ($p = 0.012$), and dietary knowledge ($p = 0.001$). The study group also had lower perceived

benefits of exercise ($p = 0.005$). After such baseline disadvantages, it was somewhat dramatic that the study group achieved such large and very highly significant gains on all five knowledge scales at post-test 1 (all $p < 0.001$), especially in perceived barriers

to exercise (mean difference = -20.041 points) and dietary knowledge (mean difference = 9.605 points). All improvements were fully sustained at post-test 2 with no significant decline, confirming the strong effectiveness of the educational program.

Table 3: Independent Samples T-Test – Comparison of All Knowledge Scale Scores

Scale	Time Point	Group	Independent Samples t-test Statistics				
			Mean	SD	Mean Diff.	t-Value	P-Value
Kidney Disease Knowledge	Pre-Test	Study	7.04	2.40	-1.164	-2.046	0.043* S
		Control	8.20	3.47			
	Post-Test 1	Study	17.22	2.78	9.022	14.473	<0.001*** VHS
		Control	8.20	3.61			
	Post-Test 2	Study	17.16	2.68	9.850	14.926	<0.001*** VHS
		Control	7.31	4.03			
FCHPS – Fluid Control Knowledge	Pre-Test	Study	11.64	3.41	-1.600	-2.564	0.012* S
		Control	13.24	3.13			
	Post-Test 1	Study	16.80	1.84	4.408	9.314	<0.001*** VHS
		Control	12.39	2.88			
	Post-Test 2	Study	16.87	1.83	4.834	9.144	<0.001*** VHS
		Control	12.04	3.34			
Dietary Knowledge (SDKHP)	Pre-Test	Study	0.75	1.14	-1.691	-3.458	0.001** HS
		Control	2.44	3.44			
	Post-Test 1	Study	12.29	2.63	9.605	17.259	<0.001*** VHS
		Control	2.69	3.10			
	Post-Test 2	Study	12.40	2.66	9.125	11.586	<0.001*** VHS
		Control	3.27	5.15			
Exercise Benefits (DPEBBS)	Pre-Test	Study	23.25	5.91	-3.582	-2.891	0.005** HS
		Control	26.84	7.03			
	Post-Test 1	Study	40.42	3.78	15.732	14.765	<0.001*** VHS
		Control	24.69	6.68			
	Post-Test 2	Study	40.62	3.67	16.246	15.068	<0.001*** VHS
		Control	24.37	6.84			
Exercise Barriers (DPEBS)	Pre-Test	Study	37.95	5.75		-0.404	0.687

		Control	38.33	4.01	-0.382		S
	Post-Test 1	Study	19.27	3.49	-20.041	-27.423	<0.001*** VHS
		Control	39.31	4.03			
	Post-Test 2	Study	19.13	3.38	-19.951	-23.073	<0.001*** VHS
		Control	39.08	5.37			

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

4.4. Comparison of All Adherence Scale Scores Between Study and Control Groups (Pre-Test, Post-Test 1, and Post-Test 2)

Table 4 presents the between-group comparison of all adherence scales. At pre-test, the control group had significantly better hemodialysis adherence ($p = 0.018$) and medication adherence ($p = 0.039$), while fluid control behavior, attitude, and dietary behavior were comparable. Despite these baseline

disadvantages, the study group demonstrated dramatic and highly significant improvements on all five adherence scales at post-test 1 (all $p < 0.001$), with the largest improvements in dietary behavior (mean difference = +14.912 points) and fluid control behavior (mean difference = +8.744 points). All improvements were fully sustained and marginally strengthened at post-test 2, confirming the strong and durable effectiveness of the educational program on treatment adherence.

Table 4: Independent Samples T-Test – Comparison of All Adherence Scale Scores

Scale & Time Point	Group	Mean	SD	t	df	p-value	Mean Diff.
Hemodialysis Adherence (HAS)							
Pre-Test	Study	15.96	3.66	-2.404	99.3	0.018*	-2.000
	Control	17.96	4.97				
Post-Test 1	Study	22.84	2.39	6.568	72.2	<0.001***	4.895
	Control	17.94	4.80				
Post-Test 2	Study	22.98	2.40	6.588	73.0	<0.001***	4.845
	Control	18.14	4.72				
Medication Adherence (MMAS)							
Pre-Test	Study	3.42	1.78	2.085	108	0.039*	0.745
	Control	2.67	1.96				
Post-Test 1	Study	2.07	0.94	-4.019	75.6	<0.001***	-1.104
	Control	3.18	1.74				
Post-Test 2	Study	2.05	0.93	-4.227	77.1	<0.001***	-1.122
	Control	3.17	1.66				
Fluid Control Behavior – FCHPS							
Pre-Test	Study	17.93	5.17	-0.869	108	0.387	-0.873
	Control	18.80	5.37				
Post-Test 1	Study	27.02	2.14	11.610	66.8	<0.001***	8.744

	Control	18.27	4.97				
Post-Test 2	Study	27.09	2.15	11.606	66.5	<0.001***	8.856
	Control	18.24	5.04				
Fluid Control Attitude – FCHPS							
Pre-Test	Study	13.27	4.44	0.074	98.1	0.941	0.055
	Control	13.22	3.20				
Post-Test 1	Study	7.89	2.56	-9.219	104	<0.001***	-5.227
	Control	13.12	3.26				
Post-Test 2	Study	7.85	2.57	-9.307	104	<0.001***	-5.263
	Control	13.12	3.24				
Dietary Behavior (SDBHP)							
Pre-Test	Study	36.00	6.21	-0.476	108	0.635	-0.545
	Control	36.55	5.79				
Post-Test 1	Study	50.62	4.44	15.379	104	<0.001***	14.912
	Control	35.71	5.52				
Post-Test 2	Study	50.65	4.46	15.732	104	<0.001***	15.419
	Control	35.24	5.61				

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

5. Discussion

Chronic renal failure (CRF) significantly impacts patients' lives, necessitating adherence to complex treatment regimens such as hemodialysis. Hemodialysis treatment is the most common type of renal replacement and a lifesaving procedure for patients with end-stage kidney disease. Although three times a week for four hours of dialysis equates to less than 10% of normal renal clearance, patients are exposed to various problems and adverse effects (Quion & Gaspar, 2025).

Non-adherence to the prescribed regimen is a common problem in hemodialysis and is associated with increased morbidity and mortality. Adherence to treatment and management recommendations is essential for the optimal health and survival of persons with end-stage renal disease (ESRD). Research indicates that educational interventions and continuous support can lead to better treatment outcomes for CRF patients (Irajpour et al., 2024). Enhancing patients' knowledge about hemodialysis

can improve adherence and quality of life. Patients with critical needs must adhere to these complex treatment regimens, and enhancing their knowledge helps them fully understand the dimensions and restrictions of hemodialysis, ultimately leading to improved adherence (Alikari et al., 2019).

5.1. Sociodemographic characteristics

According to the current study's findings, nearly half of patients in both the study and control groups were aged 50–64 years, followed by those aged 65–79 years (study group: 32.7%; control group: 30.9%), while younger adults (20–34 years) were slightly more common in the control group (18.2%) than in the study group (7.3%). This age pattern aligns closely with a previous quasi-experimental study at Kirkuk General Hospital by Mohammed (2023), which reported that most hemodialysis patients (66.7%) fell within the 50–59-year age group, with a mean age of 56.27 years, suggesting that hemodialysis populations in this setting are predominantly middle-aged and older adults.

Similar findings emerge from other regional and international studies; for instance, Goma et al. (2021) conducted a cross-sectional study at the Educational Hospital of Tanta University in Egypt's Menoufia Governorate and found a mean age of 52 years, with most patients in the 50–60-year range, while Sharif et al. (2017) noted that over half of end-stage renal disease (ESRD) patients in Sulaimani governorate were older than 50 years. In Iran, Nooriani et al. (2019) reported mean ages of 56.64 ± 9.85 years in the intervention group and 52.95 ± 11.32 years in the control group a randomized clinical trial among 86 chronic hemodialysis patients, and in Turkey, Aktepe Coşar & Demirağ. (2024) observed mean ages of 64.00 ± 12.08 years (experimental group) and 58.77 ± 13.81 years (control group) at Gümüşhane Province Kelkit State Hospital all reinforcing a dominance of middle-aged and older adults. This distribution is consistent with global epidemiological trends, as chronic kidney disease predominantly affects middle-aged and elderly populations (Kovesdy, 2022), with the higher proportion of older adults in the present study likely attributable to age-related increases in ESRD risk after 50 years, driven by comorbidities such as hypertension, diabetes mellitus, and prostatic enlargement (Goma et al., 2021; Wilson et al., 2021).

Gender Distribution

The gender distribution in this study was fairly balanced, showing a slight female predominance (52.7% in the study group; 50.9% in the control group) with males comprising 47.3% and 49.1%, respectively. This more equitable pattern contrasts with many global trends that report a significant male preponderance in hemodialysis populations—for instance, a nationwide study in India found 70.01% males versus 29.99% females (Shankar et al., 2024) and Goma et al. (2021) similarly observed 84.0% males and 16.0% females. However, it aligns with certain regional findings, such as a Turkish randomized controlled study at Gümüşhane Province Kelkit State Hospital where 56.7% of the experimental group participants were female (Aktepe Coşar & Demirağ., 2024) and with evolving demographic patterns where the gender gap is less pronounced in incident (new) cases

compared to prevalent ones (Bamikefa et al., 2023). Women now comprise an increasing proportion of the hemodialysis population worldwide, often starting dialysis at lower estimated renal function and slightly older ages than men, while their general longevity advantage may contribute to a more even survival-based distribution in established dialysis units. The absence of a strong male majority here may reflect a healthcare environment where sociocultural barriers to women's treatment have been minimized, enabling equitable enrollment across study groups (Shankar et al., 2024).

Marital Status

In the present study, the majority of hemodialysis patients were married (83.6% in the study group; 85.5% in the control group), with never-married individuals slightly more prevalent in the study group (16.4% vs. 12.7%) and only one separated participant in the control group. These findings align with studies in Saudi Arabia's Al-Ahsa Region (Alhamad et al., 2023) and in Pakistan (Islam et al., 2025) both reporting married status as predominant among patients, while contrasting with a Turkish study showing higher proportions of single and widowed individuals (Ozen et al., 2019b). The low rate of never-married participants is consistent with the middle-aged and elderly profile of hemodialysis populations (Sharif et al., 2017).

Educational Level

Educational levels were low, with illiteracy prevalent (69.1% in the study group; 67.3% in the control group) and higher education (institute or college) rare at just 7.3% across groups. This pattern matches reports from developing regions, including Akre in Iraqi Kurdistan (Mirza, 2025), Jordan (Alshraifeen et al., 2020) and Pakistan (Islam et al., 2025), where most maintenance hemodialysis patients had limited or no formal education. This high rate of illiteracy is often attributed to the older age of the hemodialysis population, as older generations in these regions may have had less access to formal schooling. Lower educational levels are frequently associated with poorer "health literacy," which can lead to difficulties in understanding complex dietary restrictions and medication schedules essential for hemodialysis patients. In contrast, Western or urbanized settings

like Turkey report higher secondary and vocational education rates (Ozen et al., 2019b; Johansen et al., 2024). These results underscore that most patients in Duhok have low education levels, potentially hindering baseline knowledge of hemodialysis, dietary habits, and treatment adherence, thus emphasizing the need for tailored, low-literacy interventions.

Occupational Status

In this study, homemakers represented the largest occupational group among hemodialysis patients (45.5% in the study group; 40% in the control group), followed by self-employment or paid work, which was slightly more common in the control group (20%) than the study group (16.4%). Retirement rates were higher among control participants (20% vs. 9.1%), while unemployment due to health reasons (study group: 5.5%; control group: 3.6%) or unemployment due to other reasons (study group: 5.5%; control group: 1.8%) remained low overall.

This pattern closely aligns with regional studies in the Kurdistan Region of Iraq, where Faraj and Sharif (2025) found most Sulaymaniyah-based hemodialysis patients were housewives, and (Sharif et al., 2017) reported similar occupational trends among end-stage renal disease patients in Sulaimani Governorate. It also matches findings from Jordan, with (Alshraifeen et al., 2020) noting that female dialysis patients in Middle Eastern cultures predominantly identify as homemakers a reflection of sociocultural norms. The lower paid employment in the study group aligns with (Impis et al., 2025), who argued that the exhausting nature of hemodialysis and the rigid treatment schedule often prevent patients from maintaining full-time jobs. Furthermore, the higher retirement rate in the Control group (20%) suggests that healthy individuals are more likely to reach the official age of retirement, whereas those in the Study group may be forced into non-active occupational categories (like "homemaker" or "unemployed") prematurely due to their clinical condition. In Saudi Arabia, Alhamad et al. (2023) similarly observed high rates of unemployment or homemaking due to dialysis demands. By contrast, Western and industrialized settings like Turkey show greater occupational

diversity, with Ozen et al. (2019) emphasizing formal disability pensions and higher registered unemployment—far exceeding the low health-related joblessness (5.5%) here. This regional difference likely arises from robust family support systems in Duhok and the Kurdistan Region, favoring domestic roles over formal social security.

Smoking Status

Regarding smoking status, the present study showed that most participants were non-smokers in both groups, accounting for 69.1% in both the Study and Control groups, with ex-smokers higher in the study group (23.6% vs. 16.4%) and current smokers more frequent in controls (14.5% vs. 7.3%). This distribution aligns with (Provenzano et al.(2021), who reported 61.1% never-smokers, 10.8% current, and 28.1% former smokers among 1,306 CKD patients, reinforcing that ESRD progression is driven more by comorbidities like diabetes and hypertension than smoking alone. Similarly, Korean cohort study patients with Chronic Kidney Disease (KNOW-CKD) . Analyzed data for 1,951 patients showed there were 967 never-smokers, 276 current, and 339 smokers who smoked 30 pack-years (Lee et al., 2021). Data from National Health and Nutrition Program Testing Survey, confirmed increased smoking quantity leads to decreased renal function, supporting our controls' higher active smokers as a future renal decline risk (Fu et al., 2022). A multicenter study; n=134 hemodialysis patients found 6.7% current and 39.6% former smokers (53.7% never-smokers), mirroring our low active smoking and elevated ex-smokers on hemodialysis, emphasizing tobacco's renal harm and need for cessation in CKD (Martinez, 2019). Our low hemodialysis current smoking (7.3%) contrasts with the ANZDATA Registry multicenter cohort (n=57,838 dialysis starters 1990-2016), reporting 13.6% current, 40.7% former, and 45.6% never smokers (Bek et al., 2023), and Tapolyai et al. (2020) retrospective Hungarian cohort (n=63 prevalent hemodiafiltration patients), linking smoking to higher blood pressure (105.9 vs. 94.3 mmHg). These suggest persistent smoking in some ESRD populations despite risks. Zhang et al. (2024) used data for half million participants aged 40 to 69 years found no causal smoking-CKD link after

confounding adjustment, contrasting observational associations like ours .

Nearly all participants reported smoking zero cigarettes per day (study group: 92.7%; control group: 85.5%), with a small percentage smoking up to 20 cigarettes daily (study group: 7.3%; control group: 14.5%). These findings align with Abdel Hakeim et al. (2024), who studied 160 adult maintenance hemodialysis patients at the Kasr Al-Ainy Center for Nephrology, Dialysis, and Transplantation (KAC-NDT) using a quasi-experimental design and reported 75% nonsmokers (yes: 25%; no: 75%), and, among smokers daily cigarette consumption as more than five (1.67%), more than ten (8.33%), and more than twenty (15%) (Abdel Hakeim et al., 2024).

5.2. Clinical Characteristics and Comorbidities

Duration of Renal Disease Diagnosis

According to the clinical data presented in Table 2, most participants were diagnosed with renal disease 1–5 years ago (Study: 43.6%, Control: 52.7%). The second largest group consisted of patients diagnosed 6–10 years ago, representing 27.3% of the Study group and 20% of the Control group. Fewer were diagnosed for more than 10 years (Study: 14.5%, Control: 18.2%), with a smaller portion diagnosed under 1 years (Study: 14.5%, Control: 9.1%) prior to the study.

These results align with a quasi-experimental study at Kirkuk General Hospital hemodialysis unit, which reported hemodialysis therapy durations with the majority (46.7%) in the 3–5 year range followed by 1–2 years (26.7%), and >6 years (26.7%). This consistency reflects similar mid-term disease chronicity (peaking at 1–5 years diagnosis vs. 3–5 years therapy) in regional hemodialysis populations (Mohammed & Hassan., 2023). Also align with a descriptive cross-sectional study at Al-Sadder Medical Hospital in Al-Najaf City (20 December 2020–28 February 2021), which reported renal failure durations of <1 year (9.4%), 2–3 years (40.6%), 4–5 years (31.3%), and ≥6 years (18.8%). This consistency reflects similar mid-term disease chronicity (peaking at 1–5 years diagnosis vs. 2–5 years renal failure) in regional CKD populations

(Alkhaqani, 2023). Another hospital-based quasi-experimental study with a pre- and posttest design; conducted among patients in hemodialysis units in Khartoum state in Sudan are consistent with the this study , which revealed that 40% of the patient's received hemodialysis for three years and more (Fadlalmola & Elkareem , 2020). Both studies show limited long-term (≥6–10 years) representation, likely due to early-stage patient selection.

Family History of Renal Failure

This study revealed notable differences in family history of renal failure between the study and control groups. A higher proportion of participants in the study group reported a family history of renal failure (34.5%) compared to the control group (21.8%). Among those with positive family history, most cases involved first-degree relatives (study: 30.9%; control: 20%), while the majority had no family history (study: 65.5%; control: 78.2%). Result is consistent, a quasi-experimental study of 60 hemodialysis patients at Al-Hussein Teaching Hospital in Thi-Qar Governorate, Iraq (December 2022–May 2023), which reported no family history in the vast majority (study group: 76.7%; control group: 90%) (Alkhafaji & Al-Mayahi, 2023). Similarly,(Nabaa et al., 2023) found family history of renal disease in 29% of cases versus 21% of controls among 300 participants in a Baghdad case-control study across multiple hospitals.

In contrast, (Alkhaqani, 2023) in a descriptive cross-sectional study at Al-Sadder Medical Hospital in Al-Najaf City (December 2020–February 2021) reported that 62.5% of patients had a family history of renal disease , potentially due to differences in patient selection, regional genetics, or broader inclusion criteria beyond hemodialysis cohorts. This pattern of elevated risk among first-degree relatives is consistent with (J. Y. Kim et al., 2023), who demonstrated that familial aggregation—particularly with close relatives—substantially increases chronic kidney disease incidence and progression. Regional variations are further evident in (Khaleel et al., 2019) from Mosul City, where family history conferred 7.1 times higher risk, though often driven by environmental and social factors rather than genetics alone, and in study from sub-Saharan Africa (Cameroon), where 15.8% of 82

first-degree relatives of hemodialysis patients had chronic kidney disease—above the global average (11–13%) and comparable to Asian rates (14.6–15.8%)—underscoring the need for targeted screening (Mazou N, 2020).

Comorbidities

The present study demonstrated that virtually all hemodialysis patients in both groups carried at least one comorbid condition, with 100% of the Study group and 98.2% of the Control group affected, with only a single participant in the Control group reporting no comorbidities. Nephritis affected about half (Study: 54.5%, Control: 50.9%), diabetes was common (Study: 49.1%, Control: 41.8%), and hypertension was highly prevalent (Study: 85.5%, Control: 81.8%). Heart disease was more common in Controls (54.5% vs. 29.1%), while hyperthyroidism and other comorbidities were rare underpinned by well-documented mechanisms of glomerular hyperfiltration, progressive nephron loss, and impaired renal autoregulation further sustains and worsens elevated blood pressure, creating a self-reinforcing cycle of organ damage (Golafshan & Shafieyoon, 2024).

These results align precisely with Iraqi studies, including (Kamil et al., 2021b), who in their investigation of CKD and hypertension prevalence in Basrah province, Iraq, identified hypertension as one of the most common comorbidities among CKD patients, with prevalence rates exceeding 80%, mirroring our results with remarkable precision. (Khaleel and Hmood., 2019), conducted in Mosul City, Iraq, demonstrated that hypertension carried a 3.5-fold increased risk for CKD development, with the risk escalating to 12.9 times among patients with a hypertension duration exceeding 15 years. Additionally, case-control study, conducted across Baghdad's Medical City complex hospitals (Baghdad Teaching Hospital, Nursing Home Private Hospital, Ghazy Al-Hariri Hospital for Surgical Specialties, and Kidney Diseases and Transplant Center) with 300 participants (150 CKD cases and 150 controls) over five months and showed hypertension had a highly significant difference ($P=0.000$) and the high percentage of the case group that had hypertension was 121 (81%)

while the control group had 56 (37%) and the risk of having CKD was 7 times ($OR = 7.004$) if patient had hypertension (Nabaa et al., 2023), mirroring Saudi findings where 87% of cases had hypertension and it is very highly significant ($P < 0.00001$), with a 9-fold risk for hypertension patients to have CKD (SHAHEEN et al., 2020) and (Alkhaqani, 2023) shows that most patients with hypertension (62.5%) has a risk for developing CKD.

Hypertension was also the primary cause of kidney failure as shown in quasi experimental study conducted in hemodialysis center at Al-Hussein Teaching Hospital/ Thi-Qar governorate in Iraq republic from 29th of December, 2022 to 29th of May among 60 hemodialysis patients that ,hypertension was the primary factor in both the study group ($n=15$; 50.0%) and the control group ($n=14$; 46.7%) of hemodialysis patients (Alkhafaji & Al-Mayahi, 2023). Consistent with a Zagazig University Hospitals, Egypt, displays that hypertension was the most comorbidity of studied patients with 86.7% (Kameel Zatton et al., 2023). In contrast, an Egyptian quasi-experimental study at Qena General Hospital (100 adult patients) found over half (53.0%) free of associated diseases and only one third 35.0% hypertensive (Ahmed et al., 2021), likely reflecting design differences (case-control vs. quasi-experimental) and varying ESRD etiologies.

Regarding to diabetes mellitus was present in 49.1% of the study group and 41.8% of the control group, representing another major comorbidity in our hemodialysis population and underscoring its role as a key driver of chronic kidney disease progression, as emphasized in the KDIGO Diabetes Management in CKD Guideline executive summary (De Boer et al., 2020), supporting the substantial prevalence observed in our study. These prevalence rates align with regional studies, such as the quasi-experimental design at Al-Diwaniya Teaching Hospital (60 hemodialysis patients, October 2018–May 2019), where $n=19$; 63.3 %, and $n=18$; 60%) of study and control groups have diabetes respectively (Hermis & Abed, 2021), Similarly, Alkhaqani, (2023a) shows that most patients with diabetes mellitus (71.9%) has a risk for developing CKD, mirroring Saudi findings

among 328 patients with 71.93% type 2 diabetes prevalence and it is very highly significant ($P < 0.00001$), with a 5-fold risk for diabetes patients to have CKD (SHAHEEN et al., 2020).

In contrast, case-control study, conducted across Baghdad's Medical City complex hospitals (Baghdad Teaching Hospital, Nursing Home Private Hospital, Ghazy Al-Hariri Hospital for Surgical Specialties, and Kidney Diseases and Transplant Center) with 300 participants (150 CKD cases and 150 controls) over five months and showed patients with a history of diabetes had no significant difference with CKD ($P = 0.105$), were 53 (35%) of the cases and 40 (27%) of the controls with diabetes ($OR = 1.503$) (Nabaa et al., 2023). While an Egyptian quasi-experimental study at Qena General Hospital (100 adult patients) showed lower rates, with over half (53.0%) free of associated diseases and only 4.0% diabetic (Ahmed et al., 2021), likely due to variations in study design, population characteristics, and regional epidemiology.

Regarding to heart disease a notable disparity was observed in heart disease prevalence, with rates markedly higher in the control group (54.5%) than in the study group (29.1%). The high prevalence of cardiovascular disease in hemodialysis patients has been extensively documented. These findings are aligned with regional research, including a quasi-experimental study at Al-Diwaniya Teaching Hospital (60 hemodialysis patients, October 2018–May 2019) where ($n=14$; 46.7%, and $n=15$; 50%) of study and control group affected by heart disease respectively heart disease (Hermis & Abed, 2021). A case-control study, conducted across Baghdad's Medical City complex hospitals (Baghdad Teaching Hospital, Nursing Home Private Hospital, Ghazy Al-Hariri Hospital for Surgical Specialties, and Kidney Diseases and Transplant Center) with 300 participants (150 CKD cases and 150 controls) over five months and showed myocardial infarction, congestive heart failure, and atherosclerosis are considered heart diseases that had significant differences ($P = 0.04, 0.000, 0.015$) and ($OR = 1.833, 4.8, 2.149$) respectively (Nabaa et al., 2023) similar to Saudi findings 57.89% had a history of heart diseases prevalence and it is very highly significant ($P < 0.00001$), with a 7-fold risk for

heart diseases patients to have CKD (SHAHEEN et al., 2020). Meanwhile, an Egyptian quasi-experimental study at Qena General Hospital (100 adult patients) indicated lower cardiovascular rates, with over half (53.0%) free of associated diseases and only 8.0% having cardiac conditions (Ahmed et al., 2021), possibly due to differences in study populations and designs.

The prevalence of nephritis was similar between groups, affecting 54.5% of the study group and 50.9% of the control group underscoring glomerular diseases as a major driver of progression to end-stage renal disease among hemodialysis patients. This substantial burden aligns closely with an Iraqi multicenter study across three hemodialysis centers (400 subjects over one year), where glomerulonephritis emerged as the leading ESRD etiology at 50.4% (Dhaidan, 2018), and a Brazilian analysis reporting primary glomerular diseases in 51.1% of cases, predominantly membranous nephropathy, alongside lupus nephritis (51.9%) as the top secondary form (Sales et al., 2025). In contrast, Egyptian hemodialysis study showed lower prevalence of nephritis 11.7% at Zagazig University Hospitals (Kameel Zaton et al., 2023) and 21.0% recurrent nephritis among 100 Qena General Hospital patients (Ahmed et al., 2021), possibly reflecting diagnostic criteria.

While a Jordanian CKD awareness survey (2,181 participants) highlighted high nephritis recognition (88.9%) (Al-Momany et al., 2024b) and a Brazilian retrospective study on nephritic syndrome noted elevated regional more frequent in the North and Northeast regions. This suggests a significant presence of nephritis-related conditions in the population that could lead to hemodialysis (L. Z. Nunes et al., 2024).

Hyperthyroidism was relatively uncommon in both groups, affecting 16.4% of the study group and 12.7% of the control group, though notably higher than rates reported in most dialysis cohorts where overt and subclinical hyperthyroidism typically range from 1-3.3%. For instance, a single-center cross-sectional study of One hundred twenty-three chronic hemodialysis patients found subclinical hyperthyroidism in only 3.3% (Cotoi et al., 2020), while a Palestinian dialysis unit study of 209 patients

reported a 1% subclinical hyperthyroidism prevalence (Nazzal et al., 2020). Similarly, a prospective Pakistani study of 131 maintenance hemodialysis patients identified hyperthyroidism in just 3.1% (German et al., 2025). These consistently low international figures contrasting our elevated rates align with broader literature emphasizing hyperthyroidism's rarity relative to hypothyroidism in dialysis populations, potentially reflecting regional diagnostic practices, iodine exposure differences, or study population variations in our Iraqi context.

Other comorbidities were rare in both groups, affecting only 1.8% of the study group and 3.6% of the control group, suggesting that the major conditions captured (hypertension, diabetes, nephritis, heart disease) represent the primary disease burden in this hemodialysis population.

This low prevalence contrasts with regional studies showing higher "other" comorbidity rates. An Egyptian hemodialysis study at Zagazig University Hospitals reported other comorbidities in 12.5% of patients (Kameel Zetton et al., 2023), while an Iranian randomized clinical trial of 100 chronic hemodialysis patients found substantially higher rates 26.7% in the intervention group (12/45) and 36.6% in the control group (15/41) (Nooriani et al., 2019b).

5.3. Comparison of All Knowledge Scale Scores Between Study and Control

Table 3 presents the between-group comparison of all knowledge scales across the three time points. The control group scored significantly better than the study group on pre-test measures of kidney disease knowledge ($p = 0.043$), fluid control knowledge ($p = 0.012$), and dietary knowledge ($p = 0.001$). The study group also had lower perceived benefits of exercise ($p = 0.005$). After such baseline disadvantages, it was somewhat dramatic that the study group achieved such large and very highly significant gains on all five knowledge scales at post-test 1 (all $p < 0.001$), especially in perceived barriers to exercise (mean difference = -20.041 points) and dietary knowledge (mean difference = 9.605 points). All improvements were fully sustained at post-test 2 with no significant decline, confirming the strong effectiveness of the educational program.

The findings related to kidney disease knowledge in the present study reveal a striking and statistically meaningful pattern. At baseline, the study group scored marginally lower than the control group (7.04 ± 2.40 vs. 8.20 ± 3.47 ; $p = 0.043$), a disparity that makes the post-intervention gains even more clinically noteworthy. By Post-Test 1, the study group's mean score more than doubled (17.22 ± 2.78), and this was sustained at Post-Test 2 (17.16 ± 2.68), suggesting lasting cognitive acquisition.

These findings align closely with study among 100 patients with chronic renal failure undergoing regular hemodialysis in Khartoum state, Sudan, which revealed significant improvements in all knowledge components from pre-test to post-test following a structured intervention ($p < 0.05$). (Fadlalmola & Elkareem, 2020b). Consistency is also found in a randomized controlled trial (RCT) in Southern India involving 160 patients, demonstrated that structured educational programs produce measurable knowledge gains essential for self-management (Dsouza et al., 2023). However, your results contrast with a pilot study involving 74 patients in a primary care nephrology setting, which found no statistically significant differences in objective kidney knowledge between groups despite improved patient satisfaction. This suggests that the specific educational delivery method used in your study was uniquely effective at converting information into measurable knowledge (Nunes et al., 2023). Furthermore, while Kocyigit et al. (2023) noted a significant decrease in knowledge within two months in their Turkish cohort (80 patients), study group in this study maintained their gains, highlighting the durability of program.

The findings concerning Fluid Control Knowledge (FCHPS) in the present study reveal a pattern that is both clinically significant and analytically instructive, as the study group successfully reversed a baseline deficit (11.64 ± 3.41 vs. 13.24 ± 3.13 ; $p = 0.012$) to achieve a sustained improvement of 16.87 ± 1.83 by the final follow-up. This initial low knowledge base aligns with research by (Özkan et al., 2019), and (Karabulutlu & Yilmaz, 2019), both of whom identified low knowledge of fluid restriction and noted that while theoretical knowledge may be present, it often conflicts with

low attitudinal compliance and moderate behavioral performance.

These results are further supported by Fadlalmola et al. (2020) and Fauzi et al. (2022), both of whom found higher fluid self-care performance following education.

The dramatic reversal of the study group's scores mirrors the findings of Dsouza et al. (2023), whose randomized controlled trial of 160 patients in India showed that educational interventions significantly improved adherence to fluid and dietary restrictions compared to a control group that showed declining adherence. Furthermore, the most direct parallel to this study is found in the Turkish RCT by Şahin and Pakyüz (2019), involving 78 patients, which utilized the FCHPS and reported statistically significant increases in mean scores for the intervention group ($p < 0.05$). Ultimately, as supported by the baseline profiles in a two-center cross-sectional study of 148 patients whose baseline FCHPS knowledge subscale scores (12.54 ± 2.79) (Cin et al., 2024)

The findings concerning Dietary Knowledge (SDKHP) in the present study represent the most dramatic pattern of intervention-driven change across all outcome measures. At baseline, the study group entered the intervention with a strikingly low mean score (0.75 ± 1.14) compared to the control group (2.44 ± 3.44 ; $p = 0.001$), reflecting the well-documented reality that hemodialysis patients often possess substantial dietary knowledge deficits. Following the educational program, the study group's mean score rose dramatically to 12.29 ± 2.63 at Post-Test 1 and was sustained at 12.40 ± 2.66 by the final follow-up, while the control group remained stagnant (3.27 ± 5.15), confirming that the structured intervention was the primary driver of knowledge acquisition.

These results align closely with the quasi-experimental study by Kaur et al. (2023) in India, where a structured program led to a significant increase in nutritional knowledge among 160 patients. Similarly, Fadlalmola and Elkareem (2020) reported from Sudan that patient knowledge regarding fluid restrictions and phosphorus management increased significantly from pre-test to post-test, effectively closing the dietary knowledge

gap. The findings are further corroborated by study utilized a self-efficacy theory-based program in South Korea to demonstrate that tailored education significantly improves dietary habits, knowledge, and biochemical markers such as sodium and phosphorus levels (Kim et al., 2024). Direct support for the use of the SDKHP scale is found in the work of (Duzalan & Pakyuz, 2018) in Turkey, where an intervention group of 40 patients showed a statistically significant increase in dietary knowledge and behaviors, while the control group's scores actually decreased over time—a trend reflected in your own control group's relative stasis. Conversely, some recent research indicates that knowledge gains are not always so uniform. Al-Arabi et al. (2021) conducted a quasi-experimental study with 85 patients in Saudi Arabia and found that while dietary knowledge increased immediately post-intervention, the scores declined significantly at the three-month follow-up.

The findings of the present study demonstrate a profound shift in exercise perceptions, with Exercise Benefits (DPEBBS) increasing from 23.25 ± 5.91 to 40.62 ± 3.67 and Exercise Barriers (DPEBS) decreasing significantly from 37.95 ± 5.75 to 19.13 ± 3.38 by the second post-test. This transformation is consistent with the results of a quasi-experimental study by Kaur et al. (2023) in India, which utilized a pre-test/post-test design with 60 hemodialysis patients to show that structured education effectively heightens perceived exercise benefits while simultaneously lowering perceived barriers. Similarly, Ammouti et al. (2022) implemented a targeted educational program for 84 patients in Jordan, demonstrating that targeted education significantly improved patients' self-efficacy and reduced the perception of physical fatigue as a barrier. The baseline context for these perceptions is further supported by the cross-sectional study of 227 patients by (Ghafourifard et al., 2021), which found that while patients generally possess a positive perception of exercise benefits ($M = 68.2 \pm 7.4$), they often require structured support to overcome ingrained barriers. Furthermore, a study by (Wang et al., 2020) in China involving 120 patients used a longitudinal follow-up and found that consistent educational reinforcement sustained the reduction in "fear of injury". Hemodialysis

patients often recognize the benefits of exercise, such as improved mood, prevention of muscle wasting, and enhanced quality of life. Despite these, barriers can deter patients from participating in exercise programs (Lightfoot et al., 2021b). Structured education can help mitigate these barriers by providing patients with the knowledge and confidence needed to engage in physical activity (Herawati et al., 2025).

In contrast, (Nunes et al., 2024) examined 90 patients in Brazil using a pre-test/post-test design and reported that while benefits were recognized, the barrier of "post-dialysis recovery time" remained unchanged despite the intervention.

1. Hemodialysis Adherence Scale (HAS)

The present study demonstrated a significant improvement in overall hemodialysis adherence, with HAS scores increasing from 15.96 at baseline to 22.98 post-intervention. This substantial improvement reflects enhanced patient engagement across multiple dimensions of treatment adherence, including attendance at dialysis sessions, medication compliance, and adherence to dietary and fluid restrictions.

These findings align with several intervention studies that have documented similar improvements in hemodialysis adherence. Valsaraj et al. conducted a randomized controlled trial (N=67) at a tertiary multispecialty hospital in India, demonstrating that cognitive behavior therapy significantly increased dialysis adherence scores at six months (+0.94; effect size: 0.51; $p=0.001$) compared to the control group (-0.06). Similarly, (Sabouri et al., 2023) implemented positive thinking training in a randomized controlled trial (N=80) across two hemodialysis centers in Shiraz, Iran, finding that the intervention group achieved significantly higher mean adherence scores (1070.2 ± 80.1) compared to controls (1018.4 ± 105.3 ; $p=0.019$). (Abdel Monem et al., 2022) reported highly significant improvements in total compliance scores in their quasi-experimental study (N=100) conducted at hemodialysis units in Menoufia University and Shebin El-Kom Teaching Hospitals, Egypt, with compliance increasing from 14% pre-intervention to 86% post-intervention ($p=0.000$). However, not all interventions have demonstrated

such robust effects on adherence. These contrasting findings are echoed in more recent literature. In a systematic review conducted in the United States synthesizing evidence from three intervention studies with an aggregated sample of 130 Black patients with ESKD, found no robust data confirming that existing adherence interventions produced significant improvements in this population, noting the absence of culturally tailored, theoretically grounded designs as a critical limiting factor (Umeukeje et al., 2022).

Similarly, a randomized controlled pilot trial conducted at Columbia University Medical Center, New York (USA), found that an 8-session cognitive behavioral education intervention delivered over 12 weeks to hemodialysis patients did not produce consistently significant between-group improvements in self-care behaviors across all measurement time points, with the authors attributing this to the individualized delivery format and insufficient sample size, and recommending design adaptations for future trials (Shirazian et al., 2023). Collectively, these contrasting findings suggest that the effectiveness of adherence interventions may be substantially influenced by cultural context, the depth of theoretical grounding, intervention delivery format, follow-up duration, and the degree to which interventions are tailored to the specific social and behavioral needs of target populations.

2. Morisky Medication Adherence Scale (MMAS)

The study group demonstrated significant improvement in medication adherence, with MMAS scores decreasing from 3.42 to 2.05. In the MMAS scoring system, lower scores indicate better adherence, thus this reduction represents a clinically meaningful improvement in medication-taking behavior.

This improvement is consistent with pharmacist-led and educational interventions reported in the literature. (Falah & Jasim, 2023) conducted a prospective interventional study (N=118) at a hemodialysis center in Wasit Governorate, Iraq, showing that a pharmacist-led deprescribing program significantly reduced MMAS scores from 2.0 to 1.0, indicating improved adherence.

(Rodrigues et al., 2019) demonstrated in randomized observational study (N=100) at Coimbatore, Tamil Nadu, India, that pharmacist intervention significantly improved medication adherence scores from 5.62 pre-intervention to 7.04 post-intervention ($p<0.05$). (Schoenthaler et al., 2020) reported in randomized control trial (N=119) conducted in a community-based practice in New York that a systems-level intervention resulted in greater improvement in intervention group in MMAS scores (mean change 1.98 vs. 1.26, $p=0.03$), with scores increasing from baseline 4.32 (SD 1.41) to 6.46 (SD 1.65) at 6 months in the intervention group.

Despite these positive findings, some studies have reported less favorable outcomes. In contrast, (Kirman et al., 2020), in a cross-sectional study conducted at two hemodialysis centers in Turkey (N = 134 HD patients; mean age 64.1 ± 13.0 years), employed the Modified Morisky Scale to assess medication motivation and knowledge and found that only 17.2% and 11.9% of patients demonstrated low motivation and low knowledge, respectively. (Kaul et al., 2023) reported in cross-sectional study (N=120) that over 90% of respondents in both dialysis and non-dialysis groups demonstrated low-to-moderate adherence using MMAS, with 61.7% of dialysis patients showing low adherence. These findings suggest that while targeted interventions can improve medication adherence, baseline adherence levels, intervention design, and healthcare system factors may significantly influence outcomes.

3. Fluid Control in Hemodialysis Patients Scale (FCHPS) - Behavior Subscale

The behavior subscale of the FCHPS showed marked improvement, with scores increasing from 17.93 to 27.09. This substantial increase indicates that patients developed more effective behavioral strategies for managing fluid intake, translating knowledge and attitudes into concrete actions.

These behavioral improvements are well-supported by intervention studies targeting fluid management. (Başer & Mollaoğlu, 2019) conducted a study with 78 people assigned to the intervention (N = 38) and control groups (N = 40) demonstrating statistically significant increases in mean FCHPS scores and

subscales for the intervention group ($p<0.05$) compared to the participants in the control group. accompanied by decreases in pre- and post-dialysis interdialytic weight gain (IDWG). (Karabey & Karagözoğlu, 2019) reported in their experimental and cross-sectional study (N=80) at a hemodialysis unit that fluid management training led to statistically significant decreases in fluid intakes in the intervention group during the last two consecutive follow-ups compared to pre-observation, with corresponding decreases in pre- and post-dialysis dry weights.

However, the relationship between behavioral interventions and fluid control is complex.

(Kustimah, 2020) conducted a pre-post design study (N=14) showing that while cognitive behavior therapy significantly decreased IDWG scores after 6 weeks ($p=0.000$), the small sample size limits generalizability. (Rocco et al., 2023) reported in a single-group pilot study with a pre-post design (N=25) at a maintenance haemodialysis center in the United States that a four-week smartphone-based fluid monitoring application produced mean IDWG values during app use that were similar to baseline mean IDWG values before app use, indicating that self-monitoring technology alone was insufficient to produce significant aggregate reductions in fluid intake, despite 61% of completers individually demonstrating a decrease in IDWG.

4. Fluid Control in Hemodialysis Patients Scale (FCHPS) - Attitude Subscale

The attitude subscale of the FCHPS demonstrated significant improvement, with scores decreasing from 13.27 to 7.85. In the FCHPS attitude subscale, lower scores indicate more positive attitudes toward fluid restriction, thus this reduction represents a favorable shift in patients' cognitive and emotional orientation toward fluid management.

This attitudinal shift is consistent with educational and psychosocial interventions documented in the literature. (X. Zhang et al., 2023) conducted a cross-sectional study (N=253) among Chinese hemodialysis patients, finding that the attitude dimension of FCHPS mediated the effects of illness perceptions on IDWG, with sex, academic level,

marital status, treatment control, and causal factors explaining 12.7% variance in total FCHPS scores. The study by (Cin et al., 2024) examining the relationship between thirst distress and fluid control compliance (N=119) at three state hemodialysis centers in Turkey found mean FCHPS behavior subscale scores of 22.14 ± 5.74 and knowledge subscale scores of 12.54 ± 2.79 , suggesting that attitudes play a crucial role in mediating the relationship between knowledge and behavior. Despite interventional successes in improving attitudes some studies contrasts as (Demiralp & Taşkın Yılmaz, 2024) conducted a descriptive and correlational study (N=150) at a private hemodialysis center in Istanbul and reported that the mean Fluid Control Scale in Hemodialysis Patients score was 50.75 ± 8.13 , suggesting moderate attitude and behavior levels with considerable variability across the patient population.

5. Scale of Dietary Behavior in Hemodialysis Patients (SDBHP)

The SDBHP scores improved significantly from 36.00 to 50.65, indicating substantial enhancement in dietary adherence behaviors. This improvement reflects better compliance with dietary restrictions related to protein, phosphorus, potassium, and sodium intake.

These dietary improvements are supported by multiple intervention studies. (Arsan et al., 2024) implemented an information-motivation-behavioral skills model in a quasi-experimental study (N=80) at hemodialysis departments, finding significant changes in diet therapy adherence in the intervention group ($p=0.001$) compared to the control group ($p=0.005$), with significant between-group differences emerging in the post-test ($p=0.001$). (Waluyo et al., 2023) conducted a quasi-experimental study with case-control pre-test and post-test design (N=44, with 22 per group) at Ciamis District Hospital, demonstrating that combination of short message service reminder and diary significantly improved diet compliance, with the intervention group showing mean increase from 59.45 ± 5.829 pre-intervention to 70.09 ± 4.576 post-intervention (paired t-test $p=0.001$) compared to control group increase from 58.68 ± 4.379 to 61.23 ± 3.891 (paired t-test $p=0.002$), with

independent t-test showing significant between-group difference after intervention ($p=0.000$). Additionally, (Dsouza et al., 2023) reported in their randomized controlled trial (N=160, with 80 per group) at an HD center of a 2030-bed tertiary teaching hospital in Southern India that educational intervention resulted in statistically significant increases in adherence to dietary restriction, with the intervention group showing mean increase from baseline 164.37 ± 48.5 to follow-up 185.62 ± 31.0 (within-group comparison $p<0.001$, between-group comparison $p<0.001$). (Vr & Kang, 2023) reported in their randomised controlled trial that nurse-led interventions significantly decreased the number of non-adherence days to diet in the intervention group ($p=0.001$), with between-group analysis showing statistically significant reduction of non-adherence days at week 10 for diet ($p=0.018$); however, objective adherence to diet restrictions based on the composite scale showed no statistically significant improvement in the proportion of adherence in the intervention group after the interventions, indicating a discrepancy between self-reported non-adherence days and objective adherence measures.

(Prastya et al., 2024) conducted a quasi-experimental study with two group pre-post-test design (N=54, with 27 per group) at the Hemodialysis Room of Sidoarjo Hospital, showing that while the experimental group improved from moderate compliance (mean 83.85) to high compliance (mean 102.6) and the control group maintained high compliance (pre-test mean 87.93, post-test mean 98), the independent T-test revealed no significant difference between groups ($p=0.176$), suggesting that peer group support interventions may not consistently outperform standard care in all settings.

5. Conclusion

1. The structured educational program demonstrated highly significant effectiveness in improving kidney disease knowledge among hemodialysis patients, with the study group has increase in knowledge scores (from 7.04 ± 2.40 to 17.22 ± 2.78 , $p<0.001$), confirming that targeted

educational interventions can successfully bridge critical knowledge gaps.

2. The educational intervention produced substantial improvements in fluid control knowledge (from 11.64 ± 3.41 to 16.80 ± 1.84 , $p < 0.001$) which directly translated into enhanced fluid management behaviors (FCHPS behavior scores improving from 17.93 ± 5.17 to 27.09 ± 2.15 , $p < 0.001$) and more positive attitudes toward fluid restriction (FCHPS attitude scores improving from 13.27 ± 4.44 to 7.85 ± 2.57 , $p < 0.001$), demonstrating a clear knowledge-to-behavior pathway in fluid management adherence.

3. Dietary knowledge showed the most dramatic improvement among all knowledge domains, increasing from critically low baseline levels (0.75 ± 1.14) to adequate knowledge levels (12.29 ± 2.63 , $p < 0.001$), which corresponded with significant enhancement in dietary adherence behaviors (SDBHP scores improving from 36.00 ± 6.21 to 50.65 ± 4.46 , $p < 0.001$), indicating that addressing severe dietary knowledge deficits is essential for achieving meaningful dietary compliance in hemodialysis patients.

4. The educational program successfully improved medication adherence, as evidenced by significant improvement in MMAS scores (from 3.42 ± 1.78 to 2.05 ± 0.93 , $p < 0.001$), alongside enhanced overall treatment adherence measured by HAS (from 15.96 ± 3.66 to 22.98 ± 2.40 , $p < 0.001$), confirming that comprehensive patient education addressing medication knowledge and treatment protocols leads to better adherence to prescribed therapeutic regimens.

5. Exercise-related perceptions were significantly transformed by the educational intervention, with

perceived benefits of exercise increasing substantially (from 23.25 ± 5.91 to 40.62 ± 3.67 , $p < 0.001$) while perceived barriers to exercise decreased markedly (from 37.95 ± 5.75 to 19.13 ± 3.38 , $p < 0.001$), suggesting that education can effectively modify patients' cognitive appraisals and reduce psychological obstacles to physical activity engagement.

6. All knowledge and adherence improvements achieved in the study group were fully sustained at the second post-test follow-up assessment with no significant decline, while the control group showed no meaningful changes across any measures, providing strong evidence that the observed improvements were directly attributable to the educational intervention

7. The strong statistical significance ($p < 0.001$) and large effect sizes observed across all outcome measures, combined with sustained improvements at follow-up, provide robust evidence for the clinical significance and practical importance of implementing structured educational programs as a standard component of hemodialysis care.

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Conflict of Interest

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