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Chronic kidney disease and adherence improvement program by clinical pharmacistprovided medication therapy management; a quasi-experimental assessment of patients' self-care perception and practice

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Abstract

Rationale One of the critical roles of pharmacists in the field of community and hospitals is to provide medication therapy management (MTM) services and reconciliation.

Objectives This study aimed to assess the perceptions, adherence, and performance of the patients with chronic kidney disease (CKD) to the clinical pharmacist-provided MTM before and after receiving this service.

Method A cross-sectional survey was conducted from June 2023 to January 2024. A validated questionnaire assessed patients' knowledge, attitude, and performance, and the Morisky medication adherence scale evaluated the medical adherence of the patients before and after the clinical pharmacist-provided MTM. Inclusion criteria were patients with CKD according to NKF KDOQI guidelines and GFR < 60 mL/min/1.73 m². Before and after the MTM service, CKD patients' knowledge, attitude, performance, and adherence to their pharmacotherapy were assessed.

Results A total of 100 patients enrolled in the study and completed the questionnaire. Before and after the MTM service, total knowledge was 3.38 ± 1.82 and 7.59 ± 1.11 , respectively. Before and after the MTM service, the attitude score was 54.53 ± 5.05 and 59.24 ± 4.68 , respectively. Before and after the MTM service, the mean performance score was 30.15 ± 4.27 and 34.54 ± 2.56 , respectively. Adherence score to medications before and after the MTM service was 4.86 ± 1.99 and 6.22 ± 1.39 , respectively. In all fields, outcomes significantly improved (P < 0.05).

Conclusion The current study showed the critical role of clinical pharmacists in training patients about medications and improving adherence to their pharmacotherapy.

Keywords Clinical pharmacy, Medication adherence, Medication Therapy Management, Chronic kidney disease, Selfcare, Nephrology, Practice, Pharmacotherapy, Pharmaceutical Care

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Introduction

Nowadays, the role of pharmacists in the health system has extended from mere medication counseling and medication application to the management of pharmacotherapy and efforts to enhance adherence of the patients [1-3]. The principles of good pharmacy practice seek to improve health-related quality of life (HRQoL) and drug safety in collaboration with other treatment team members [4-6].

One of the critical roles of pharmacists in the field of community pharmacies and hospitals is to provide medication therapy management (MTM) services. MTM means a thorough review of the patient's medication therapy, including a comprehensive review of medication history (including all over-the-counter, prescribing drugs, and supplements used or currently used by the patient), solving medication-related problems (MRPs), optimizing complex treatment strategies, management of polypharmacy, designing high-adherence medication regimes, and cost-effective treatment schedules [3, 7-11]. The ultimate goal of MTM is to optimize pharmacotherapy consequences, minimize medication errors, and improve the HRQoL and the patient's health status [12, 13]. According to the epidemiology of medication error in Iran, the nationwide incidence of medication error in hospitals was 0.35% in 2005-2019. Physicians and nurses committed 31% and 37% of them. Errors were distributed at different stages of medication processing. As a result, it is recommended to use clinical pharmacist-provided MTM services to prevent the incidence of current medication errors [14, 15].

One of the diseases in which MTM and pharmaceutical care are essential is chronic kidney disease (CKD) [16–18]. Due to the irreversible and complex etiology of CKD, the treatment approach is to manage and break the progression of the disease [19]. The role of clinical pharmacists in providing MTM for CKD patients is crucial because these patients face high rates of MRP and medication rejection, more vulnerability to drug poisoning, a high probability of drug-drug interactions (DDIs), comorbidities (such as diabetes, hypertension, osteopathy, anemia, and electrolyte instabilities) due to the possible progression of CKD, and the need to dose adjustment of medications with renal elimination [9, 20, 21].

This survey was aimed to assess the knowledge, attitude, performance, and adherence of CKD patients to the clinical pharmacist-provided MTM in Tehran, Iran, before and after receiving this service.

Method

Overview of the study

A single-center cross-sectional analytical survey was conducted from June 2023 to January 2024. This study was performed among outpatients attending the nephrology clinic at in Labbafinejad hospital, Tehran, Iran. A questionnaire assessed patients' knowledge, attitude, and performance toward CKD treatment. Finally, the medical adherence of the patients was evaluated by the Morisky medication adherence scale (MMAS) [22–25]. Medication adherence was assessed using the validated Persian version of the MMAS (α =0.83).

The MTM intervention consisted of structured clinical pharmacist services: [26]

- 1. Comprehensive medication review (CMR) to resolve medication-related problems.
- 2. Personalized care plan.
- 3. Patient education sessions.
- 4. Follow-up care.

Sample size

G-Power software was used to estimate the sample size. With an effect size of 0.25, 0.05 margin of error, and 80% power and a 10% non-response rate, the sample size calculated as 105 patients.

Study criteria

Inclusion criteria according to NKF KDOQI clinical practice guideline [27], the inclusion criteria were patients aged 18 years or older with CKD stage 3–5 (GFR < 60 mL/min/1.73 m²), on stable medication regimen for over 3 months and willing to participate in follow-up sessions. **Exclusion criteria**: participants were excluded from the study based on the following criteria: cognitive impairment affecting comprehension, acute kidney injury, hospitalization during the study period and end-stage illness.

Data collection and clinical consultation

We informed the patients about the study process and explained how to complete the questionnaire in the first step. In addition, to collect data through the questionnaire, we gathered the patients` medical history and previous medicine consumption. After data collection, medical consultation services were provided by a clinical pharmacist. A questionnaire was conducted to evaluate the CKD patients' knowledge, attitude, and performance. After extracting the main criteria of the subject by searching texts and interviewing experts, the questionnaire was structured. To confirm internal consistency, Cronbach's alpha was calculated. The questionnaire showed an acceptable internal consistency with the Cronbach's alpha of 0.706.

The questionnaire was divided into five parts. Patients' demographic information was asked, including age, height, weight, lean body weight (LBW), body mass index (BMI), gender, occupation, education, geographic area, marriage status, and the number of drugs consumed per

Table 1 Demographic information

	%	n
Gender	66% Male	66
	34% Female	34
Marriage	2% Single	2
	98% Married	98
Education	19% Illiterate	19
	36% Elementary	36
	38% High school	38
	7% Bachelor	7
Occupation Type	31% Housewife	31
	69% Employed	69
Geographic Area	74% Urban	74
	26% Rural	26
Medication History	11% Less than 5 Medications	11
	51% Between 5 and 10	51
	38% More than 10	38
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day in the first section. The second section assessed the patients' knowledge about CKD by nine (two options: correct, incorrect) items. In the third section, the attitude of the patients toward CKD was evaluated by 17 items. The attitude section was designed in a five-point response scale (strongly agree, agree, not sure, disagree, and strongly disagree).

To evaluate the performance, patients were scored in eight items. The score of responses was ranged from one to five. To determine patient adherence, MMAS was used. In the first seven questions, each negative response and each positive response is given one and zero point, respectively, except for the fifth question in which the scoring process is inverse. The last question has five scales (0, 0.25, 0.5, 0.75, and 1). The final scores are classified as poor (less than 6), average [6–8], and high (more than 8) adherence.

100

90

93

97

99

100

Statistical analysis

Finally, collected data were analyzed using SPSS v.25 software. Descriptive results were reported using frequency, mean±standard deviation (SD). To check the parametricity of the data, the Kolmogorov-Smirnov test was used. Paired T-test was used to compare the subgroup outcomes. Kruskal-Wallis and Mann-Whitney tests were used to compare non-parametric data. Pearson correlation coefficient was used to assess relationships between continuous variables including age and variations in attitude, performance, and adherence scores.

Results

Participant characteristics

A total of 105 patients enrolled in the study and 100 ones completed the questionnaire before and after the MTM service. The mean \pm SD for age, height, weight, LBW, and BMI were 64.26 \pm 13.29, 167.67 \pm 10.14, 79.07 \pm 14.65, 53.59 \pm 9.97, and 28.18 \pm 5.34, respectively. Table 1 shows the continuation of the demographic information.

Knowledge

Before and after the MTM service, total knowledge was 3.38 ± 1.82 and 7.59 ± 1.11 (out of 9), respectively (P < 0.001). Knowledge improved after the MTM service in both men and women (P < 0.001). Due to the uneven distribution between married (n=89) and single (n=11) participants, comparisons based on marital status were not performed. Patients with high-school education had the most change in knowledge (P < 0.001). In terms of medication history, patients who took less than five medications showed the most significant change in knowledge (P < 0.001). Figure 1 shows the questions in the knowledge section as well as the frequency of correct answers before and after the MTM service. In all questions, after providing the service, the number of people who chose the correct answer increased markedly (P < 0.001).



CKD Patients Answered the Knowledge Questions Correctly

■ Before (%) ■ After (%)

Attitude

Attitude score before and after the MTM service was 54.53 ± 5.05 and 59.24 ± 4.68 (*P*<0.001), respectively. Women showed more improvements in attitude scores (*P*<0.001). Illiterate patients had the highest change

in attitude (P<0.001). In terms of medication history, patients who took less than five medications changed their attitude more than others (P<0.001). Table 2 shows the questions in the attitude questionnaire and the



Fig. 2 Results of Performance of Participants in the Study before and after the MTM service

	Before (%)	After (%)	Result
Q1. The Attitude of Patients towards the Issue that If	drugs be More Effective, the Disease will b	e Better Controlled	
Strongly Agree	60	92	P<0.001
Agree	31	7	
Not sure	8	1	
Disagree	1	0	
Strongly Disagree	0	0	
Q2. The Attitude of Patients towards the Issue that Ta	king Medications Prescribed by Famous D	octors is Better	
Strongly Agree	47	59	P=0.71
Agree	41	26	
Not Sure	6	5	
Disagree	6	9	
Strongly Disagree	0	1	
O3. The Attitude of Patients towards the Issue that Ta	king More Medication Can Harm the Kidne	evs and Liver	
Stronaly Aaree	38	49	P<0.05
Agree	45	45	
Not Sure	15	4	
Disagree	2	1	
Strongly Disagree	0	1	
O4 The Attitude of Patients towards the Issue that In	iectable Drugs have Fewer Side effects tha	n Oral Drugs	
Strongly Agree	21	23	P < 0.05
Agree	33	50	1 (0.05
Not Sure	41	22	
Disagree	1	1	
Strongly Disagree	1	1	
O5 The Attitude of Patients towards the Issue that Sc	' me Symptoms Can be Believed without D)rug Treatment	
Strongly Agree	6	a	P-0.926
Agroo	37	41	1 = 0.920
Not Sura	30	17	
Disarea	21	22	
Strongly Disagree	21	22	
O6 The Attitude of Dation to towards the Issue that Ar	U Nadication may have Side Effects		
Strongly agree		70	R > 0.001
Agroo	20	72	1 > 0.001
Not Sura	11	27	
Disarra			
Change Disagree	0	0	
O7 The Attitude of national towards the Issue that the	U De Regular Lice of the Drug Can Bottor Cont	u Irral the Disease	
Q7. The Attitude of patients towards the issue that th	re Regular Use of the Drug Can Better Com	.roi the Disease	0.0001
Strongly Agree	51	92	P>0.001
Agree	42	8	
Not Sure	4	0	
Disagree	3	0	
Strongly Disagree	0	0	
Q8. The Attitude of Patients towards the Issue that De	ose Changing according to their Discretior	n will Help Cure the Disease	0 0 001
Strongly Agree	2	1	P>0.001
Agree	11	2	
Not sure	13	0	
Disagree	31	15	
Strongly Disagree	43	82	
Q9. The Attitude of Patients towards the Issue that th	e Doctor who Prescribes More Medication	s has more Authority	

Table 2 (continued)

	Before (%)	After (%)	Result
Strongly Agree	9	5	P>0.001
Agree	18	5	
Not Sure	18	5	
Disagree	27	16	
Strongly Disagree	28	69	
Q10. The Attitude of Patients towards the Issue that Pharmaci	sts Help them Solve Drug-Related	d Problems	
Strongly Agree	2	5	P>0.001
Agree	18	83	
Not Sure	44	7	
Disagree	28	3	
Strongly Disagree	8	2	
Q11. The Attitude of Patients towards the Issue that Your Heal	th is Now Dependent on your Me	edications	
Strongly Agree	23	45	P>0.001
Agree	66	50	
Not Sure	7	4	
Disagree	4	1	
Strongly Disagree	0	0	
Q12. The Attitude of Patients towards the Issue that The More	Medication you take, the more A	nxious you Become	
Strongly Agree	18	28	P=0.116
Agree	53	50	
Not Sure	15	5	
Disagree	10	14	
Strongly Disagree	4	3	
Q13. The Attitude of Patients towards the Issue that You are u	sually Worried about the Long-Te	rm Medication Effects	
Strongly agree	9	21	P=0.006
Agree	57	55	
Not Sure	16	10	
Disagree	17	13	
Strongly Disagree	1	1	
Q14. The Attitude of Patients towards the Issue that a Patient'	s Quality of Life Depends on the l	Jse of Medication	
Strongly Agree	32	59	P>0.001
Agree	46	32	
Not Sure	8	2	
Disagree	9	5	
Strongly Disagree	5	2	
Q15. The Attitude of Patients towards the Issue that You are S	ometimes Concerned with Drug	Addiction	
Strongly Agree	13	21	P=0.014
Agree	54	56	
Not sure	14	9	
Disagree	17	12	
Strongly Disagree	2	2	
Q16. The Attitude of Patients towards the Issue that Treatmen	t Should be Stopped Occasionall	y if the Drugs are Used for a Long T	īme
Strongly agree	3	4	P>0.001
Agree	18	7	
Not Sure	30	3	
Disagree	24	19	
Strongly Disagree	25	67	
Q17. The Attitude of Patients towards the Issue that You Expe	ct from the Doctor to Prescribe th	e Least amount of Medicine accor	ding to the Indi-
vidual's Condition			

Table 2 (continued)

	Before (%)	After (%)	Result
Strongly agree	21	21	P=0.052
Agree	25	30	
Not Sure	31	35	
Disagree	12	6	
Strongly Disagree	11	8	

frequency of participants' answers and statistical changes after clinical pharmacist-provided MTM service.

Performance

The mean performance score before and after the clinical pharmacist-provided MTM service was 30.15 ± 4.27 and 34.54 ± 2.56 (P < 0.001), respectively. Performance score increased in men and women (P < 0.001). Patients with elementary education enhanced their performance more than other subgroups (P < 0.001). In terms of medication history, patients who took less than five medications indicated the most improvement in performance score (P < 0.001). Figure 2 shows the section of performance in the questionnaire and the frequency of participants' answers and statistical changes after clinical pharmacist-provided MTM service.

Adherence

Table 3 shows the questions in the adherence section to a therapy regimen and the frequency of participants' answers and statistical changes after clinical pharmacistprovided MTM service. Adherence score to medications before and after the MTM service was 4.86 ± 1.99 and 6.22 ± 1.39 (P<0.001), respectively. While both genders were improved their drug adherence, the difference between genders was not statistically significant (P>0.05). Patients with elementary and high-school education scored better than illiterate patients and bachelors (P<0.001). Most progress in terms of medication history belong to patients who have taken more than ten medications (P<0.001).

Table 3 Morisky medication adherence scale (MMAS-8) results

Questions	Before (%)	After (%)	Р
1. Do you sometimes forget to take your medications?			
Yes	64	54	< 0.05
No	36	46	
2. People sometimes miss taking their medications for readays when you did not take your medicines?	asons other than forgetting. Thinking over the	past two weeks, were	there any
Yes	39	14	< 0.001
No	61	86	
3. Have you ever cut back or stopped taking your medicat	tion without telling your doctor, because you f	elt worse when you to	ok it?
Yes	35	14	< 0.001
No	65	86	
4. When you travel or leave home, do you sometimes forg	et to bring along your medications?		
Yes	50	24	< 0.001
No	50	76	
5. Did you take your medications yesterday?			
Yes	96	99	0.181
No	4	1	
6. When you feel like your condition is under control, do y	ou sometimes stop taking your medicines?		
Yes	28	4	< 0.001
No	72	96	
7. Taking medication every day is a real inconvenience for	some people. Do you ever feel hassled about	sticking to your treatn	nent plan?
Yes	59	40	< 0.001
No	41	60	
8. How often do you have difficulty remembering to take	all your medications?		
Never	21	19	< 0.001
Almost Never	23	58	
Sometimes	52	22	
Often	4	1	
Always	0	0	

Table 4 Descriptive results and relationship between patients' demographic variables and variations in scores of knowledge, attitude, performance, and adherence

		Knowledge		Attitude		Adherence		Performance	
		$Mean \pm SD$	P value	$Mean \pm SD$	P value	$Mean \pm SD$	P value	Mean ± SD	P value
Gender	Female	4.35 ± 1.76	0.351	5.65 ± 4.92	0.197	1.70 ± 1.50	0.109	4.50 ± 3.22	0.750 (Mann-
	male	4.14 ± 1.56	(Mann-Whitney)	4.23 ± 5.41	(Mann-Whitney)	1.19 ± 1.71	(Mann-Whitney)	4.33 ± 3.70	Whitney)
Marriage	Single	4.00 ± 1.41	0.836	2.50 ± 0.71	0.440	-1.25 ± 1.41	0.017	0.50 ± 2.12	0.085 (Mann-
	Married	4.21 ± 1.63	(Mann-Whitney)	4.76 ± 5.31	(Mann-Whitney)	1.42 ± 1.61	(Mann-Whitney)	4.47 ± 3.51	Whitney)
Education	Illiterate	3.79 ± 1.65	0.134	5.63 ± 6.78	0.246	1.05 ± 1.81	0.586	4.11 ± 4.37	0.181
	Elementary	4.33 ± 1.62	(Kruskal-Wallis)	5.61 ± 4.70	(Kruskal-Wallis)	1.50 ± 1.58	(Kruskal-Wallis)	5.14 ± 2.90	(Kruskal-
	High school	4.47±1.69		3.32±4.78		1.49±1.57		3.82±3.59	Wallis)
	Bachelor	3.29 ± 0.49		5.14 ± 5.52		0.82 ± 2.04		4.43 ± 3.69	
Medica-	< 5	4.45 ± 2.02	0.339	5.82 ± 6.49	0.337	0.25 ± 1.33	0.070	5.27 ± 4.20	0.660
tion history	5-10	4.41 ± 1.55	(Kruskal-Wallis)	3.96 ± 5.02	(Kruskal-Wallis)	1.40 ± 1.58	(Kruskal-Wallis)	4.37 ± 3.61	(Kruskal-
	>10	3.87±1.58		5.39 ± 5.22		1.64±1.72		4.16±3.26	Wallis)

Descriptive results

Pearson correlation analysis reported significant relationships between patients' age and variations in attitude (r=0.28, P=0.009), performance (r=0.31, P=0.003) and adherence scores (r=0.25, P=0.019). No significant relationship was found between age and variation in patients' knowledge scores (r=0.15, P=0.174). Table 4 shows the descriptive results as well as the relationship between the demographic variables and the variation in knowledge, attitude, practice and adherence scores.

Discussion

Clinical pharmacists are well placed with their clinical and practical proficiency to offer pharmacologic as well as nonpharmacological recommendations and interventions in CKD. In a prospective controlled study published by Schütze et al. in 2021 in Germany, CKD medicines optimization by clinical pharmacists was done. In six months of intervention, among 256 patients (intervention: 96, control: 160), MRPs were significantly reduced (P < 0.001) and concluded that adding clinical pharmacists to the treatment team promoted the implementation of nephrologists' pharmacotherapy and reduced MRPs [28]. Another prospective observational study was performed in 2018-2019 in India, which aimed to detect DDIs in critically ill CKD patients and evaluate clinical pharmacist's interventions in DDI management. Clinical pharmacists delivered diverse forms of modifications to manage and minimize DDIs. 92% of pharmacists' interventions were accepted by prescribers [29]. The findings of all the studies showed the critical role of clinical pharmacists in training patients about medications and making patients loyal to their pharmacotherapy.

The deterioration in attitude scores for specific items (Q-3, 4, 9, 12, 13, 15) after MTM services suggests the need for revision of the MTM educational content for these specific aspects, additional follow-up sessions

focusing on these particular areas and implementation of a patient feedback system to better understand these changes.

Our study had some limitations. First, being a monocentric survey affected the generalizability of our results. Second, the cross-sectional nature of our study design limits our ability to establish causal relationships between the MTM service and observed changes. Third, the uneven distribution of participants across marital status groups limited our ability to make meaningful comparisons based on this demographic factor.

Conclusion

This study demonstrates the critical role of clinical pharmacist-provided MTM on CKD patients' knowledge, attitude, performance, and medication adherence. The findings suggest that integrating clinical pharmacists into the nephrology care team could enhance patient outcomes through improved medication management and patient education. Future multi-center studies with longer follow-up periods are needed to establish the long-term impact of MTM services on patient outcomes. Additionally, addressing the identified areas of attitude deterioration through targeted interventions could further optimize the effectiveness of MTM services in CKD patient care.

Supplementary Information

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Supplementary Material 1

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Research group for giving us the license to use the MMAS scale (Certificate Number: 7799-8371-5354-4091-1040).

Author contributions

G.M. conducted the sampling and survey design, S.E. and S.Z. drafted the manuscript, G.M., M.S., and B.A. interpreted the statistical analyses, M.S., H.E., S.A., and G.M. collaborated in idea generation, conceptualizing the survey, and editing the manuscript. All authors reviewed the manuscript.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

The Ethics Committee of the Faculty of Pharmacy of Shahid Beheshti University of Medical Sciences approved this study with the ethics code IR.SBMU.PHARMACY.REC.1398.045. Informed consent to participate was obtained from all of the eligible patients.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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References

- Mossialos E, Courtin E, Naci H, Benrimoj S, Bouvy M, Farris K, et al. From retailers to health care providers: transforming the role of community pharmacists in chronic disease management. Heal Policy (New York). 2015;119(5):628–39.
- Thomas JA, Snigdha KS, Karanath PM, Swaroop AM, IMPACT OF PATIENT COUNSELLING ON KNOWLEDGE, ATTITUDE, AND PRACTICE OF HYPER-TENSIVE PATIENTS IN A TERTIARY CARE HOSPITAL. Int J Pharm Pharm Sci. 2017;9(9):122.
- Paneerselvam GS, Aftab RA, Sirisinghe RG, Mei Lai PS, Lim SK. Study protocol: effectiveness of patient centered pharmacist care in improving medication adherence, clinical parameters and quality of life among hemodialysis patients. PLoS ONE. 2022;17(2):e0263412.
- Vande Griend JP, Rodgers M, Nuffer W. Effect of an advanced pharmacy practice experience on medication therapy management services in a centralized retail pharmacy program. J Manag Care Spec Pharm. 2017;23(5):561–5.
- Tan R, Cvetkovski B, Kritikos V, Yan K, Price D, Smith P et al. Management of allergic rhinitis in the community pharmacy: identifying the reasons behind medication self-selection. Pharm Pract. 2018;16(3).
- Kim AJ, Lee H, Shin EJ, Cho EJ, Cho YS, Lee H et al. Pharmacist-led collaborative Medication Management for the Elderly with chronic kidney Disease and Polypharmacy. Int J Environ Res Public Health. 2021;18(8).
- Barnett MJ, Frank J, Wehring H, Newland B, VonMuenster S, Kumbera P, et al. Analysis of pharmacist-provided medication Therapy Management (MTM)

services in community pharmacies over 7 years. J Manag Care Pharm. 2009;15(1):18–31.

- De Oliveira DR, Brummel AR, Miller DB. Medication therapy management: 10 years of experience in a large integrated health care system. J Manag Care Pharm. 2010;16(3):185–95.
- 9. Shivaprasad S, Mateti UV, Shenoy P, Shastry CS, Dharmagadda S. REVIEW: clinical pharmacists' scope of knowledge for medication therapy management in chronic kidney disease patients. Pharm Educ. 2021;21(1):781–8.
- Rettig SM, Wood Y, Hirsch JD. Medication regimen complexity in patients with uncontrolled hypertension and/or diabetes. J Am Pharm Assoc (2003). 2013;53(4):427–31.
- 11. Dalton K, Byrne S. Role of the pharmacist in reducing healthcare costs: current insights. Integr Pharm Res Pract. 2017;6:37.
- Sloeserwij VM, Hazen ACM, Zwart DLM, Leendertse AJ, Poldervaart JM, de Bont AA, et al. Effects of non-dispensing pharmacists integrated in general practice on medication-related hospitalisations. Br J Clin Pharmacol. 2019;85(10):2321–31.
- Rodriguez de Bittner M, Chirikov VV, Breunig IM, Zaghab RW, Shaya FT. Clinical effectiveness and cost savings in diabetes care, supported by pharmacist counselling. J Am Pharm Assoc (2003). 2017;57(1):102–108.e4.
- Khammarnia M, Ansari-Moghaddam AR, Setoodehzadeh F, Rezaei K, Clark CCT, Peyvand M. A systematic review and Meta-analysis of the Medical Error Rate in Iran: 2005–2019. Qual Manag Health Care. 2021;30(3):166–75.
- Shahrami B, Forough AS, Najmeddin F, Hadidi E, Toomaj S, Javadi MR et al. Identification of drug-related problems followed by clinical pharmacist interventions in an outpatient pharmacotherapy clinic. J Clin Pharm Ther. 2022.
- Stemer G, Lemmens-Gruber R. Clinical pharmacy activities in chronic kidney disease and end-stage renal disease patients: a systematic literature review. BMC Nephrol. 2011;12(1):35.
- Al Raiisi F, Stewart D, Fernandez-Llimos F, Salgado TM, Mohamed MF, Cunningham S. Clinical pharmacy practice in the care of chronic kidney Disease patients: a systematic review. Int J Clin Pharm. 2019;41(3):630–66.
- 18. Managing C. Kidney Disease With MTM.
- Vaidya SR, Aeddula NR. Chronic renal failure. Sci Basis Urol Second Ed. 2021;257–64.
- Silva-Almodóvar A, Hackim E, Wolk H, Nahata MC. Potentially inappropriately prescribed medications among Medicare Medication Therapy Management Eligible Patients with chronic kidney disease: an observational analysis. J Gen Intern Med. 2021;36(8):2346–52.
- Khan YH, Sarriff A, Adnan AS, Khan AH, Mallhi TH. Progression and outcomes of Non-dialysis Dependent chronic kidney Disease patients. Value Heal. 2016;19(7):A847–8.
- Moon SJ, Lee WY, Hwang JS, Hong YP, Morisky DE. Accuracy of a screening tool for medication adherence: a systematic review and meta-analysis of the Morisky Medication Adherence Scale-8. PLoS ONE. 2017;12(11):1–18.
- Morisky DE, Ang A, Krousel-Wood M, Ward H. Predictive validity of Medication Adherence measure in an outpatient setting. J Clin Hypertens. 2008;10(5):348–54.
- Berlowitz DR, Foy CG, Kazis LE, Bolin L, Lonroy LB, Fitzpatrick P, for the SPRINT Study Research Group, et al. Ipact of intensive blood pressure therapy on patient-reported outcomes:outcomes results from the SPRINT Study. N Engl J Med. 2017;377:733–44.
- Bress AP, Bellows BK, King J, Hess R, Beddhu S, Zhang Z, for the SPRINT Research Group and the SPRINT Economics and Health Related Quality of Life Subcommittee, et al. Cost-effectiveness of intensive versus standard blood pressure control. N Engl J Med. 2017;377:745–55.
- 26. Johnson E, Bartman B, Briesacher B. Medication Therapy Management Interventions in Outpatient Settings Executive Summary. Agency Healthc Res Qual [Internet]. 2012;(90):1–24. Available from: www.effectivehealthcare.
- 27. NKF KDOQI clinical. practice guidelines | National Kidney Foundation.
- Schütze A, Hohmann C, Haubitz M, Radziwill R, Benöhr P. Medicines optimization for patients with chronic kidney disease in the outpatient setting: the role of the clinical pharmacist. Int J Pharm Pract. 2021;29(6):587–97.
- 29. Aghili M, Kasturirangan MN. Management of drug-drug interactions among critically ill patients with chronic kidney disease: impact of clinical pharmacist's interventions. Indian J Crit Care Med. 2021;25(11):1226–31.

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