

Original Research Article

Integrated clinical pharmacy and clinical biochemistry in optimizing drug therapy and biomarkers in patients with chronic kidney disease

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Abstract

Purpose: To investigate the role of an integrated clinical pharmacy and clinical biochemistry model in improving medication safety and biomarker profiles in adults with chronic kidney disease (CKD) compared with usual nephrology care in Iraq.

Methods: This study was a controlled trial in which 80 adults with CKD (stages 3-5) were randomized into an integrated intervention (study group) or conventional care program (control group). The follow-up period lasted for 6 months. This intervention involved pharmacist-led medication review, renal dose optimization, drug-related problems (DRPs) resolution, adherence support, protocol-based monitoring, and interdisciplinary interpretation of renal and biochemical markers. Primary (mean DRPs per patient, rates of renally cleared medicines) and secondary outcomes (estimated glomerular filtration rate (eGFR), key biochemical parameters, adherence, and drug-related hospitalisations) were compared.

Results: A total of 80 patients were randomized into study and control groups ($n = 40$). Study group showed no significantly lower mean DRPs per patient compared to control group ($p > 0.05$). Furthermore, appropriate renal dosing significantly increased in study group compared to control group ($p < 0.001$). Mean change in eGFR was significantly lower in study group ($p < 0.05$), with more stable potassium and phosphate levels, fewer serious DRPs and drug-related hospitalisations and better adherence scores.

Conclusion: Integrating clinical pharmacy and clinical biochemistry into CKD outpatient management improves medication safety and stabilizes renal and biochemical parameters.

Keywords: Biomarkers, Chronic kidney disease, Clinical biochemistry, Clinical pharmacy, Drug-related problems

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INTRODUCTION

Chronic kidney disease (CKD) is a primary global concern worldwide, associated with persistent decrease in glomerular filtration rate (GFR), kidney structural abnormalities, or both, lasting at

least three months [1]. According to recent Global Burden of Disease studies, CKD affects about 14 % of adults worldwide, equivalent to approximately 800–850 million people, and prevalence continues to rise globally [2]. The disease is largely caused by diabetes and

hypertension, accounting for gross disability and high economic costs to patients, families, and health systems [3].

According to the Kidney Disease Improving Global Outcomes (KDIGO) 2024 guideline, CKD is associated with gradual progression of renal failure starting with early (G1-G2) and then progressively reducing to moderate and severely impaired GFR (G3-G4) and eventually renal failure (G5) [4]. Alongside this, patients develop metabolic complications, such as anaemia, mineral and bone diseases, volume overload, electrolyte imbalance, and cardiovascular damage. Vitamin D deficiency is highly prevalent among patients with chronic kidney disease due to impaired renal conversion of 25-hydroxyvitamin D to its active form, 1, 25-dihydroxyvitamin D, as kidney function declines [5]. Although both clinical pharmacy and clinical biochemistry play important roles in the management of CKD, a combined and coordinated care model is still lacking in most healthcare organizations [6]. An integrated model combining clinical pharmacist-led drug therapy optimization with comprehensive clinical biochemistry monitoring will result in fewer drug-related problems, improved biochemical control, and better renal and clinical outcomes in patients with CKD, compared to standard care. This study evaluated the impact of integrated clinical pharmacy and clinical biochemistry intervention on medication safety and renal outcomes in patients with CKD.

METHODS

Study design and setting

This study was a prospective, parallel-group, randomized controlled trial comparing integrated clinical pharmacy and clinical biochemistry services with usual care in patients with CKD. Participants were randomized (1:1) into study and control groups using permuted block randomization with concealed allocation. Outcomes were assessed over a 6-month follow-up period. Although participants and physicians were unblinded, outcome assessors and data analysts remained blinded. The study was conducted in the nephrology outpatient clinic of a teaching hospital in Baghdad, Iraq, managing approximately 1,500–1,700 patients monthly and supported by trained clinical pharmacists, a well-equipped clinical biochemistry laboratory, and electronic medical records to facilitate integrated patient care [7].

Ethical approval was obtained from the Iraqi Medical Research Center and the Ministry of

Health (approval no. 2925/2024), and the study was conducted in compliance with the Declaration of Helsinki [8].

Selection criteria

Inclusion criteria

Patients ≥ 18 years, CKD stages 3–5, patients receiving ≥ 3 medications for at least 3 months prior to enrolment, ability to attend follow-up, and provided informed consent.

Exclusion criteria

Presence of acute kidney injury, dialysis or history of kidney transplant, active malignancy, advanced liver disease, or heart failure, severe cognitive/psychiatric impairment, pregnancy or breastfeeding, concurrent participation in another interventional trial [7].

Sample size

The sample size was calculated based on the primary outcome of the mean number of drug-related problems (DRPs) per patient at 6 months. Assuming a baseline mean of 3.0 ± 1.5 DRPs and a 30 % reduction with the intervention, a minimum of 64 participants (32 per group) was required ($\alpha = 0.05$, power = 80 %, Cohen's $d = 0.6$). To account for an anticipated 20 % attrition rate, the sample size was increased to 80 participants (40 per group).

Study groups

Eligible patients were randomized to study and control groups. Study groups received integrated clinical pharmacist care (protocol-driven clinical biochemistry monitoring), and control group received usual nephrology care. Participants were assessed at baseline and 6 months, with clinical, biochemical, and medication-related data collected at every visit. Efforts were made to obtain primary outcome data for all participants, including those who discontinued follow-up [7].

Data collection and study procedures

At enrolment, baseline data, which include socio-demographic (age, sex, marital status, education, employment, income, smoking), clinical (BMI, blood pressure, CKD stage, primary renal diagnosis, CKD duration, comorbidities), medication (Number of drugs, therapeutic classes, nephrotoxic drugs, high-risk drugs), and biochemical (Creatinine, eGFR, urea, Na^+ , K^+ , Ca^{2+} , PO_4^{3-} , HCO_3^- , albumin, CRP, $\pm$ cystatin C, NGAL).

Evaluation of parameters/indices

Clinical biochemistry monitoring

Both groups underwent routine laboratory testing. However, in study group, biochemical monitoring was standardized and protocol-driven. Results were explicitly linked to pharmacotherapy decisions. Laboratory assessments were scheduled and measured at baseline (visit 1) and 6 months (visit 2; Table 1). Abnormal results prompted urgent communication from the clinical biochemist to the clinical pharmacist and nephrologist.

Outcome measures

Primary outcomes

Primary outcomes were defined at 6 months, and mean number of DRPs per patient, and proportion of medications with dosing appropriate to renal function were compared.

Secondary outcomes

Changes in renal function (difference in eGFR and serum creatinine) from baseline to 6 months, and biochemical parameters such as changes in serum urea, electrolytes (Na^+ , K^+ , Ca^{2+} , PO_4^{3-}), bicarbonate, albumin, and CRP over time were compared. Medication adherence was assessed using the 8-item Morisky Medication Adherence Scale (MMAS-8) scores at baseline and 6 months (categorized as low, medium, or high adherence according to standard cut-off). Progression of CKD, such as proportion of patients experiencing decline in eGFR of ≥ 5 mL/min/1.73 m² over 6 months or higher CKD stage and Healthcare utilization, including the number of CKD- or drug-related hospitalizations or emergency department visits during follow-up, were also compared.

RESULTS

Participant flow and recruitment

Between March and December 2025, 120 patients with CKD were screened for eligibility,

and 40 were excluded. However, 25 did not meet the inclusion criteria, 10 declined to participate, and 5 were excluded for other reasons. A total of 80 patients were then randomized into the study group ($n = 40$) and control group ($n = 40$). During the 6-month follow-up, 2 patients were lost to follow-up in the study group (1 withdrew consent, 1 missed all follow-up visits), and 3 patients in the control group discontinued (2 moved to another city, 1 died from a non-CKD-related cause). Thus, 75 patients (38 in the intervention group, 37 in the control group) completed the study.

Baseline characteristics

There was no significant difference in baseline characteristics between the study and control groups ($p > 0.05$; Table 2).

Description of the intervention

In the study group, the clinical pharmacist performed 113 structured medication reviews over 6 months, with a total of 186 interventions documented. The most frequent type of pharmacist interventions were dose adjustments. The Nephrologists accepted 83.3 % of pharmacist recommendations, partially accepted 9.7 %, and rejected 7.0 %. In addition, adherence counselling was provided to all patients in the study group, with specific adherence-enhancing strategies implemented in 63.2 % of participants with low or medium adherence at baseline.

Drug-related problems and medication safety

There was no significant difference in mean DRP counts per participant between study and control groups ($p > 0.05$). After 6 months, both groups exhibited a significant reduction in DRPs ($p < 0.001$; Figure 1).

Changes in renal and biochemical biomarkers

Average eGFR decreased moderately in both groups over time. However, the reduction was significantly smaller in study group compared to control group ($p < 0.05$; Table 3).

Table 1: Schedule of visits and key assessments

Time point	Clinical assessment	Medication review (intervention)	Biochemical tests	Adherence (MMAS-8)
Baseline	Demographics, comorbidities, vitals	Yes	Creatinine, eGFR, urea, electrolytes, albumin, CRP, $\pm$ cystatin C, NGAL	Yes
6 months	Final clinical evaluation	Yes	Creatinine, eGFR, urea, electrolytes, albumin, CRP, $\pm$ cystatin C, NGAL	Yes

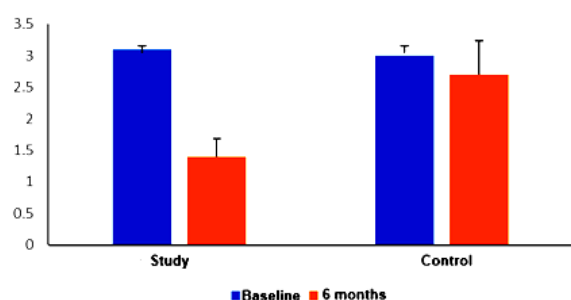
Electrolytes (Na^+ , K^+ , Ca^{2+} , PO_4^{3-}), MMAS-8 (Morisky Medication Adherence Scale)

Table 2: Baseline characteristics of study population (mean $\pm$ SD)

Characteristic	Study (n = 38)	Control (n = 37)	P-value
Age, years, mean $\pm$ SD	58.2 $\pm$ 10.7	57.5 $\pm$ 11.3	0.78
Male sex, n (%)	20(52.6)	20(54.1)	0.90
BMI, kg/m ² , mean $\pm$ SD	28.4 $\pm$ 4.6	27.9 $\pm$ 4.9	0.64
CKD stage, n (%)			
Stage 3	17(44.7)	16(43.2)	
Stage 4	13(34.2)	13(35.1)	0.99 ²
Stage 5	8(21.1)	8(21.6)	
Hypertension, n (%)	33(86.8)	32(86.5)	0.97
Diabetes mellitus, n (%)	25(65.8)	24(64.9)	0.93
Ischemic heart disease, n (%)	11(28.9)	10(27.0)	0.85
Number of chronic medications, mean $\pm$ SD	9.1 $\pm$ 2.8	8.9 $\pm$ 3.0	0.77
Potentially nephrotoxic drug use, n (%)	15(39.5)	14(37.8)	0.87
eGFR, mL/min/1.73 m ² , mean $\pm$ SD	32.4 $\pm$ 7.6	31.9 $\pm$ 7.9	0.75
Serum creatinine, mg/dL, mean $\pm$ SD	2.30 $\pm$ 0.52	2.34 $\pm$ 0.55	0.69
Serum potassium, mmol/L, mean $\pm$ SD	4.7 $\pm$ 0.5	4.6 $\pm$ 0.5	0.41
Serum albumin, g/dL, mean $\pm$ SD	3.6 $\pm$ 0.4	3.5 $\pm$ 0.4	0.32
CRP (mg/L, median (IQR))	7.8(4.1–13.2)	8.1(4.3–14.0)	0.84 ⁴

Table 3: Changes in renal function parameters at baseline and 6 months (mean $\pm$ SD)

Parameter	Time point	Study (n = 38)	Control (n = 37)	P-value
eGFR (mL/min/1.73 m ² , mean $\pm$ SD)	Baseline	32.4 $\pm$ 7.6	31.9 $\pm$ 7.9	–
	6 months	31.9 $\pm$ 7.9	28.7 $\pm$ 8.4	–
	Change	–0.5 $\pm$ 3.2	–3.2 $\pm$ 4.1	0.01
Serum creatinine (mg/dL)	Baseline	2.30 $\pm$ 0.52	2.34 $\pm$ 0.55	–
	6 months	2.35 $\pm$ 0.56	2.55 $\pm$ 0.60	–
	Change	+0.05 $\pm$ 0.18	+0.21 $\pm$ 0.24	0.004

**Figure 1:** Bar graph comparing mean number of drug-related problems (DRPs) per patient at baseline and 6 months in study and control groups

Changes in biochemical parameters

Study group showed significantly lower serum potassium, phosphate, albumin, and CRP compared to control group at baseline and 6 months ($p < 0.05$; Table 4).

Estimated glomerular filtration rate (eGFR)

Estimated glomerular filtration rate (eGFR) was significantly reduced in control group compared to study group at the end of 6 months ($p < 0.05$; Figure 2).

Table 4: Changes in biochemical parameters from baseline to 6 months

Parameter	Time	Study (n = 38)	Control (n = 37)	P-value
Serum potassium (mmol/L)	Baseline	4.7 $\pm$ 0.5	4.6 $\pm$ 0.5	
	6 months	4.6 $\pm$ 0.4	4.9 $\pm$ 0.6	
	Change	–0.1 $\pm$ 0.4	+0.3 $\pm$ 0.5	0.003
Serum phosphate (mg/dL)	Baseline	4.7 $\pm$ 0.7	4.8 $\pm$ 0.8	
	6 months	4.5 $\pm$ 0.6	5.0 $\pm$ 0.9	
	Change	–0.2 $\pm$ 0.5	+0.2 $\pm$ 0.6	0.01
Serum albumin (g/dL)	Baseline	3.6 $\pm$ 0.4	3.5 $\pm$ 0.4	
	6 months	3.7 $\pm$ 0.4	3.5 $\pm$ 0.5	
	Change	+0.1 $\pm$ 0.3	0.0 $\pm$ 0.3	0.08
CRP (mg/L, median, IQR)	Baseline	7.8(4.1–13.2)	8.1(4.3–14.0)	
	6 months	6.1(3.5–11.0)	8.3(4.5–14.5)	
	Change	–1.7(–4.0–0.5)	0.0(–1.0–1.2)	0.04

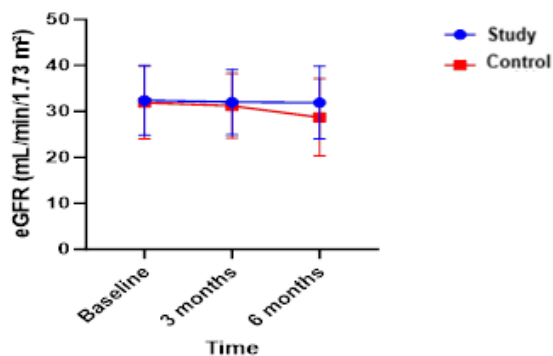


Figure 2: Mean eGFR values at baseline, 3 months, and 6 months in study and control groups

Levels of C-reactive protein (CRP)

Levels of CRP were significantly lower in study group compared to control group at 6 months ($p < 0.05$; Figure 3).

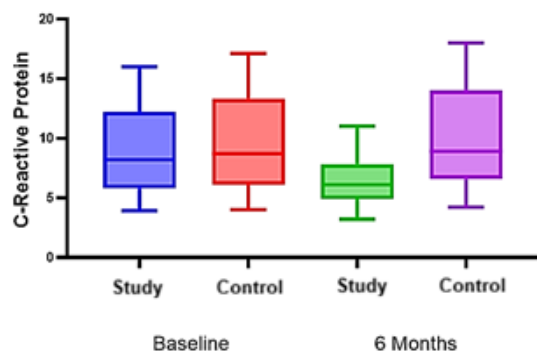


Figure 3: Box-and-whisker plot showing median CRP levels at baseline and 6 months

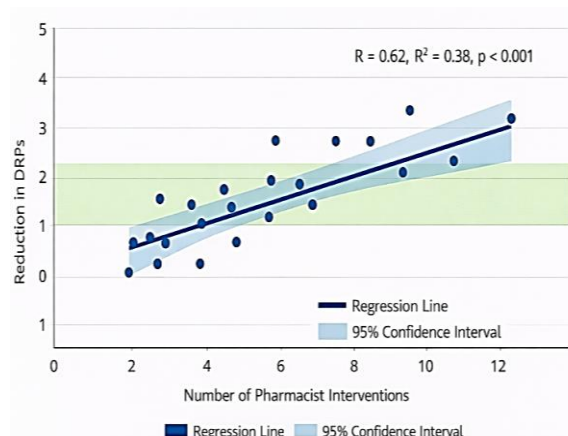


Figure 4: Scatter plot illustrating relationship between number of pharmacist-led medication adjustments and change in DRPs per patient. Greater reduction in DRPs ($\beta = -0.98$, 95 % CI -1.41 to -0.55 ; $p < 0.001$), and smaller decline in eGFR over 6 months ($\beta = +2.1$ mL/min/1.73 m², 95 % CI 0.6 to 3.6 ; $p < 0.05$)

Relationship between biomarkers and therapy adjustments

Correlation analyses in the study group revealed a moderate inverse correlation between the number of pharmacist-led dose adjustments and change in DRPs per patient (Pearson $r = -0.52$, $p < 0.001$), indicating that patients with more active medication optimization experienced greater reductions in DRPs (Figure 4).

Medication adherence

Medication adherence improved significantly in study group compared to control group ($p < 0.001$). Also, the difference in changes in medication adherence was significant between control and study groups ($p < 0.002$).

DISCUSSION

Integrated intervention combining pharmacist-led medication review with biochemical monitoring significantly reduced DRP and improved appropriateness of renal dose adjustments among patients with CKD. These findings support the importance of incorporating kidney function biomarkers into medication management to identify and resolve clinically significant medication-related problems, consistent with current CKD management recommendations. The observed reduction in DRPs of approximately 55 % also aligned with previous studies demonstrating that pharmacist-led interventions effectively minimize inappropriate drug selection, dosing errors, and clinically important drug interactions while improving medication-related outcomes and quality of life in CKD patients [9].

The novelty of the present study lies in integrating pharmacist interventions into a biomarker-guided workflow, enabling both optimization of pharmacotherapy and longitudinal monitoring of clinical outcomes. The study group demonstrated more favorable biochemical outcomes over the 6-month follow-up, including slower decline in eGFR, smaller increase in C-reactive protein (CRP), and better maintenance of serum potassium and phosphate concentrations, resulting in fewer cases of clinically significant hyperkalemia and hyperphosphatemia. These findings are consistent with previous reports that effective medication management improves biochemical control and slows CKD progression while reducing cardiovascular risk [10]. Also, integrating pharmacist-led medication review with routine biomarker monitoring may provide clinical benefits in CKD management [10].

Previous studies have shown that pharmacist-led education and follow-up improve medication adherence in patients with CKD and those on dialysis, depending on intensity and duration of the intervention [11]. The study group showed significant improvement in medication adherence compared to control, supporting evidence that individualized counselling and regimen simplification increased adherence in patients with complex medication regimens [12]. Although decrease in drug-related hospitalizations was not significant, the lower incidence of serious DRPs suggested that integrated pharmacy–biochemistry services may also be cost-effective, in agreement with recent economic evaluations of pharmacist-led medication management in CKD [9].

Limitations of this study

This study has some limitations. The follow-up time was short and the sample size was small, which may affect the generalizability of the research findings.

CONCLUSION

This randomized controlled trial shows that a unified model integrating clinical pharmacy and clinical biochemistry significantly improves the quality of care for patients with chronic kidney disease in an Iraqi tertiary care environment.

DECLARATIONS

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Ethical approval

Ethical approval was obtained from the Iraqi Medical Research Center and the Ministry of Health (approval no. 2925/2024).

Use of Artificial intelligence/Large language models

The authors confirm that AI-based tools were used solely for language editing and manuscript polishing purposes (e.g., grammar, phrasing, and clarity). No AI tools were used to generate content, interpret data, or influence study design,

results, or conclusions. All intellectual contributions, study analyses, and interpretations reported in the manuscript are the original work of the authors.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflict of interest

No conflict of interest is associated with this work.

Contribution of authors

We declare that this work was done by the author(s) named in this article, and all liabilities pertaining to claims relating to the content of this article will be borne by the authors.

REFERENCES

1. Zylberberg AK, Cottle DL, Runtig J, Rodrigues G, Tham MS, Jones LK, et al. Modulating inflammation with interleukin 37 treatment ameliorates murine autosomal dominant polycystic kidney disease. *Kidney Int* 2024; 105(4): 731-743. doi: 10.1016/j.kint.2023.12.006.
2. Kovesdy CP. Epidemiology of chronic kidney disease: an update 2022. *Kidney Int Suppl* (2011) 2022; 12(1): 7-11. doi: 10.1016/j.kisu.2021.11.003.
3. Laliberté F, Bookhart BK, Vekeman F, Corral M, Duh MS, Bailey RA, et al. Direct all-cause health care costs associated with chronic kidney disease in patients with diabetes and hypertension: a managed care perspective. *J Manag Care Pharm* 2009; 15(4): 312-322. doi: 10.18553/jmcp.2009.15.4.312.
4. Stevens PE, Ahmed SB, Carrero JJ, Foster BJ, Francis A, Hall RK, et al. KDIGO 2024 clinical practice guideline for the evaluation and management of chronic kidney disease. *Kidney Int* 2024; 105(4): S117-S314. doi:10.1016/j.kint.2023.10.018.
5. Hashim RZ, Qasim AQ, ALabbod HM. The association of serum calcium and vitamin D with insulin resistance and beta-cell dysfunction among people with type 2 diabetes. *Arch Razi Inst* 2022; (Online First). doi:10.22092/ari.2022.357641.2081
6. 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): 630-666. doi: 10.1007/s11096-019-00816-4.
7. Alam K, Hayat AH, Ullah A, Syed Sulaiman SA, Ahmad W, Ooi GS. The prevalence and impact of clinical pharmacists' intervention on drug-related problems in

- patients with chronic kidney disease. *Cureus* 2024; 16(4): e59402. doi: 10.7759/cureus.59402.
8. World Medical Association. World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. *JAMA* 2013; 310(20): 2191-2194.
9. Zafar R, Rehman IU, Shah Y, Ming LC, Goh KW, Suleiman AK, et al. Impact of pharmacist-led intervention for reducing drug-related problems and improving quality of life among chronic kidney disease patients: a randomized controlled trial. *PLoS One* 2025; 20(2): e0317734. doi: 10.1371/journal.pone.0317734.
10. O'Callaghan CA, Camidge C, Thomas R, Reschen ME, Maycock AJ, Lasserson DS, et al. Evaluation of a simple low-cost intervention to empower people with CKD to reduce their dietary salt intake: oxckd1, a multicenter randomized controlled trial. *Kidney360* 2023; 4(7): 890-898. doi: 10.34067/KID.000000000000160.
11. Calleja L, Glass BD, Cairns A, Taylor S. Pharmacist-led interventions for medication adherence in patients with chronic kidney disease: a scoping review. *Pharmacy (Basel)* 2023; 11(6): 185. doi: 10.3390/pharmacy11060185.
12. Elnaem MH, Irwan NA, Abubakar U, Syed Sulaiman SA, Elrggal ME, Cheema E. Impact of medication regimen simplification on medication adherence and clinical outcomes in patients with long-term medical conditions. *Patient Prefer Adherence* 2020; 14: 2135-2145. doi: 10.2147/PPA.S268499.