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Potentially inappropriate medication prescribing based on 2019 Beers criteria and the impact of pharmacist intervention in elderly patients with kidney diseases: A report from Iran

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Abstract

Background and Aims: A potentially inappropriate medication (PIM) is a pharmaceutical agent that poses a greater risk of harm than potential benefit to elderly patients. This study aimed to detect PIMs and their risk factors in hospitalized elderly patients with kidney disease.

Methods: This cross-sectional study assessed medication orders of elderly patients (≥65 years old) with kidney diseases admitted to the hospital. In the first 6 months, we retrospectively evaluated all medications to identify PIMs according to the 2019 Beers criteria. In the second phase, a clinical pharmacist prospectively evaluated all medications and suggested modifications as needed. Data were analyzed to determine risk factors for prescribing PIMs.

Results: Based on our evaluation of 258 patients, we observed that the utilization of PIMs was prevalent among the study population. Of the total patients evaluated, 273 instances of PIM use were identified, with only 23.3% of patients not having any PIMs. Notably, proton pump inhibitors and benzodiazepines were the most frequently prescribed PIMs. The risk of experiencing a PIM was significantly amplified by a higher degree of polypharmacy, with odds approximately 2.68 times higher ($p < 0.01$). Several factors were found to be associated with an increased likelihood of having a PIM, including being male, undergoing hemodialysis, having chronic kidney disease or other comorbidities, and having an extended hospital stay. The second phase of study, in terms of addressing these issues, physicians adhered to 67.5% of the 120 recommendations made by pharmacists regarding the discontinuation of PIM usage.

Conclusion: High prevalence of PIMs was detected in our study population. Preventing medication-associated harms in the elderly can reduce the financial burden imposed on healthcare systems. Therefore, routine evaluation of medications

with clinical pharmacists and/or implementation of computerized medication decision support systems is recommended to prevent PIMs use.

KEYWORDS
Beers criteria, elderly, kidney disease, patient safety, PIM, potentially inappropriate medication

1 | INTRODUCTION

In 2019, there were 703 million people aged 65 and over in the world, which is expected to double by 2050 to about 1.5 billion (16% of the world's population).[1] This continued growth of the elderly population will inevitably lead to increased financial expenditure on geriatric healthcare systems. Elderly patients experience multiple comorbidities, which require them to use various medications. The pharmacokinetics (PK) (i.e., absorption, bioavailability, half-life, metabolism, and elimination) and pharmacodynamics (PD) properties (i.e., biochemical and physiological effects) of medicines change with aging, mainly due to changes in anthropometric parameters, a reduction in first-pass metabolism, and declining renal function.[2] As a result of the interplay of changes in PK and PD properties in elderly patients, some drugs may show possible harm and toxic side effects that outweigh their expected therapeutic benefits in this population.[3] Hence, such drugs are considered potentially inappropriate medications (PIMs) for the elderly. These PIMs can lead to undesirable outcomes such as increased mortality and morbidity rates, hospital admissions or readmissions, and growth in elderly care expenditure.[4]

To reduce the potential harms of pharmacotherapy in the elderly and improve their care by physicians and pharmacists, the American Geriatrics Society (AGS) published the Beers criteria for PIMs in this population in 1991.[5] The Beers criteria have been updated every 3 years since then, with the most recent version released in 2019.[6] The Beers criteria are an explicit list of PIMs that is available for use by healthcare staff worldwide. The goals of the Beers criteria are to prevent PIMs, choose the safest medications, prevent harmful unintended side effects, improve quality of life, and alleviate the financial burden on the healthcare system. The AGS classifies PIMs into five types: (1) should be avoided in almost all older adults, (2) should be avoided in specific health conditions, (3) should be used with caution, (4) should be avoided due to drug–drug interactions, and (5) should be avoided or dose-reduced based on creatinine clearance.

According to the United States Renal Data System, renal impairment is the most common complication in the elderly, deteriorating with age. Two out of three elderly people have chronic kidney complications.[7] Geriatric people with impaired renal function are more prone to drug-induced toxicity, adverse drug events (ADEs), and side effects.[8] Considering comorbidities and different health complications, elderly patients are on polypharmacy (5–9 medications per day) or high-level polypharmacy (≥10 medications per day).[9] Therefore, they are at high risk of experiencing unintended ADEs. Pharmacotherapy in the geriatric population, especially those with kidney disease, is fraught with many problems and demands interventions from geriatric specialists (physicians and pharmacists) to change medications, adjust doses, prescribe new drugs with clear indications, omit inappropriate agents (e.g., due to therapy duplication, drug–drug or drug–disease interactions, no indication, and dose adjustment based on kidney function), and promote therapeutic success.[10-12]

Keypoints

- The prevalence of potentially inappropriate medication in the elderly with kidney diseases according to the Beers 2019 criteria, is still high.
- Considering the persistent evaluation of medication therapy in elderly patients by consultation with clinical pharmacists would facilitate decreasing medication errors.
- Preventing medication errors would potentially lead to decreased risk of adverse drug reaction.

A recent meta-analysis of prescribing PIMs in the geriatric population in developing countries showed a high prevalence of PIM use in older adults.[13] This study highlighted that polypharmacy, comorbidities, concomitant diseases, and aging increase the risk of PIM use. Another systematic review evaluated the prevalence and impact of PIMs on medical costs in the elderly population in developing countries and found that PIM prevalence ranges from 8.7% in Germany to 81% in Australia.[14] In this study, most of the included studies reported a prevalence of over 30%. This study also mentioned that using inappropriate medications causes an excess cost burden on geriatric society (an extra $2000 is spent on older patients with a PIM over their lifetime). Although some studies have been conducted to evaluate the prevalence of PIMs in outpatients/hospitalized geriatric patients and have emphasized the high rate of PIM use,[15-18] few studies have assessed different interventions, including the effects of a clinical pharmacist or clinical decision support systems (CDSS), on reducing the PIM use rate and their economic implications on geriatric care.[19-22]

Despite the fact that the current literature strongly suggests identifying and preventing PIM use, especially in elderly inpatients, to reduce the economic burden of medical care for the elderly and prevent adverse drug reactions that may lead to life-threatening conditions, the prevalence of PIMs in elderly patients diagnosed with kidney diseases and hospitalized in the internal wards of a major hospital according to the 2019 Beers criteria remains high. This study

aimed to assess the prevalence of PIMs in this population, determine the risk factors for PIMs, evaluate the impact of clinical pharmacists' interventions on optimizing PIM use, and measure the acceptance rate of these interventions.

2 | MATERIALS AND METHODS

2.1 | Study setting

The present cross-sectional study was performed at inpatient setting of an internal medical department in a major academic hospital, affiliated to Urmia University of Medical Sciences (UUMS) (Urmia, Iran) between July 2020 and 2021. The study protocol was reviewed and approved by the ethics committee of UUMS.

The study was conducted in two 6-month phases to cover all seasons of the year and avoid missing any seasonal effects on patient admissions. Data collection for the first phase was conducted retrospectively from patients' medical records by a well-trained pharmacy student and double-checked by a clinical pharmacist. Because the first phase was retrospective, all data were gathered from medical records. Therefore, medications such as proton pump inhibitors (PPIs) were considered PIMs if they did not have any indication, regardless of their duration of administration.

The second phase was conducted prospectively with the goal of optimizing medication use. During this phase, patients were visited by a clinical pharmacy attending, who prepared their drug history and checked medication orders and physicians' notes to provide recommendations when necessary. All indications of medication administration were evaluated and checked against the Beers criteria. Recommendations were also prepared according to the 2019 Beers criteria during the hospital stay. Finally, the acceptance rate of these recommendations by prescribing physicians was recorded.

2.2 | Study population

The inclusion criteria for the study population were as follows:

- All patients aged 65 years and older.
- Hospitalized in internal wards for more than 1 day.
- Received at least one medication.
- Admitted due to kidney disease or other health problems with concurrent decreased kidney function.

Patients with incomplete medical records were excluded from the study.

2.3 | Data collection

Patient demographics, drug history, final diagnosis, physical examinations, coexisting diseases, duration of hospitalization, and laboratory data were gathered at the beginning and end of hospitalization. A pharmacist checked all medications, including dosing, dosage form, duration of administration, and polypharmacy status. All medications in the records were reviewed, and every PIM was identified according to the 2019 Beers criteria,[12] with a focus on patients diagnosed with renal disease. PIMs are defined as medications that are:

- Generally considered potentially inappropriate in older adults or the elderly with a certain medical condition.
- Should be used with caution due to drug-related problems such as adverse effects, drug–drug interactions, and drug–disease interactions.
- Should be avoided or have their dose adjusted based on the stage of kidney disease.

Obtaining medication history is necessary for identifying PIMs due to long duration of administration, such as PPIs. Therefore, in the second phase of our study, the pharmacist obtained patients' medical history directly from patients or their companions, while in the first phase, medication history was retrospectively collected through medical records. The indication of medication administration and the necessity of choice were defined by consensus among physicians and clinical pharmacists to determine PIMs, such as digoxin, which is considered a PIM if used as a first-line treatment for rate control of atrial fibrillation and heart failure, especially in patients with stage 4 or 5 chronic kidney disease (CKD).

To decrease PIMs or optimize medication therapy, a clinical pharmacist scientifically evaluated all medications and proposed recommendations to the prescribing physicians related to pharmacotherapy interventions, including dose adjustment, therapeutic substitution, and others. The Modification of Diet in Renal Disease and Cockcroft-Gault formulas were used to determine the stage of CKD and adjust medication doses in renal impairment, respectively.[23,24] For patients with acute kidney disease (AKI), we used the Jelliffe formula.[25]

2.4 | Statistical analysis

The continuous variables were reported as mean ± standard deviation (SD) and median and quartile (minimum and maximum). Frequency (percentage) was used to report the categorized variables. The Kolmogorov–Smirnov test was performed to evaluate the normality distribution. An independent *t*-test and Mann–Whitney *U* test were used to compare parametric and nonparametric variables, respectively. χ^2 test was used to investigate the difference of categorical-dependent variables. The correlation of variables was evaluated using the Pearson's correlation test. A logistic regression and a linear regression model were used to evaluate the correlation between the variables and to determine the factors that can potentiate prescribing the PIMs with 95% confidence intervals (CI). A *p*-value of <0.05 was considered as significant. The statistical analysis was done

using the Statistical Package for the Social Sciences (SPSS) software (version 19).

3 | RESULTS

From 282 patients admitted in the study period, 258 elderly patients with kidney diseases met the inclusion criteria, from whom 141 patients (54.7%) were male. In 36.82% of cases, the admission was for non-renal complications. The mean (±SD) of patient age and hospital length of stay (LOS) were 74.40 ± 7.59 years (range 65–99) and 8.48 ± 5.69 days (range 2–11), respectively. The basic characteristics of the study participants and their laboratory findings are shown in Table 1.

Totally, 3257 medications were administered over the study period (median number of medications of 13/patient), from which the oral (2017 [61.92%]) and injectable dosage forms (1026 [31.50%]) had the highest frequency.

Polypharmacy was detected in 251 patients (97.3%) of all patients, from which a majority (177 out of 251 [70.51%]) was categorized in the high-level polypharmacy group. Totally, 273 medications were found as PIMs according to the 2019 Beers and 76.7% of patients (N = 193) had at least one PIM. In 19.8% of patients (51 out of 258), more than one case of PIMs was detected. The number and dosage form of patients' medications and the overall prevalence and types of PIMs were summarized in Table 2. PPIs, alpha-blockers, and benzodiazepines were the most frequent classes involved in a PIM with the prevalence of 48.83%, 10.46%, and 9.30%, respectively. Generally, 154, 102, and 17 PIMs were detected in the end-stage renal disease under hemodialysis, CKD, and AKI groups in the current study, respectively (Table 2).

According to the logistic regression outcomes, female gender, high-level polypharmacy, a longer hospital LOS (>7 days), and being CKD (GFR < 60 mL/min) were the predictors of PIMs in prescriptions, placing the patients at the risk of ADEs. Table 3 displays the odds ratio (OR) and CI of all risk factors for PIMs. The number of medication items (polypharmacy) correlated with PIM prescribing ($p < 0.01$); however, no significant correlation was detected between the number of comorbidities and hospital LOS with the PIMs ($p > 0.05$).

In the second phase of our study, 159 patients were closely evaluated by a clinical pharmacist in which the 175 PIMs were identified in total of 159 patients' medication forms. The 187 recommendations (120 comment about guiding medication selection to prevent PIMs use and 67 comment not related to PIM) were provided to physicians with 62.03% acceptance rate. From 120 comments related to preventing PIM use, 81 (46.25% out of 175 PIM) were implemented and the number of PIMs decreased to 94; therefor, PIMs were eliminated from 73 patients' medication forms. The most frequent approved comments related to preventing PIM, were associated with the dose adjustment based on patient's renal function (in 31 cases [38.27%]) and discontinuation of inappropriate medications (in 24 cases [29.63%]). In 6.6% of cases, replacing the detected PIMs with another safer medication was necessary. Frequency and types of clinical pharmacist interventions to deal with a prescription associated with PIMs were elucidated in Table 4.

TABLE 1 Descriptive information on study population.

Demographics (n = 258)		Number of patients (%)
Gender	Male	141 (54.7)
	Female	117 (45.3)
Age	65–74 years	149 (57.75)
	≥75 years	109 (42.25)
Hospital length of stay (LOS)	Equal or less than 7 days	143 (55.43)
	More than 7 days	115 (44.57)
Body mass index (BMI)	Less than 26	141 (54.6)
	Equal or more than 26	117 (45.4)
Clinical findings		
Types of kidney disease	AKI (AKI or AKI on CKD)	24 (9.30)
	CKD	139 (53.88)
	ESRD (under hemodialysis)	95 (36.82)
Codiseases with kidney disease	HTN	165 (63.95)
	Diabetes mellitus	122 (47.27)
	Heart disease (e.g., heart failure, AF)	61 (23.64)
	others (e.g., asthma, COPD)	59 (22.86)
Estimated glomerular filtration rate (eGFR) (mL/min/1.73m^2)	Equal or more than 60	14 (5.43)
	45 to less than 60	14 (5.43)
	30 to less than 45	22(8.53)
	15 to less than 30	52 (20.15)
	Less than 15 (non-dialysis)	61 (23.64)
	On dialysis	95 (36.82)
Laboratory findings admission time (number of patients)		(Mean ± SD)
Urea (153) mg/dL		124.35 ± 70.72
Creatinine (non-dialysis patients) (153) mg/dL		4.65 ± 3.05
Sodium (258) meq/dL		134.1 ± 12.51
Potassium (258) meq/dL		4.73 ± 1.00
Calcium (169) mg/dL		8.86 ± 6.92
White blood cells (258) ×10^9/L		11.17 ± 6.35
Hemoglobin (258) g/dL		11.11 ± 2.23

Abbreviations: AKI, acute kidney disease; CKD, chronic kidney disease; ESRD, end-stage renal disease.

TABLE 2 Information on the prescribed drugs and potentially inappropriate medications (PIMs).

Pharmaceutical findings (258 patients)		Number (%)
Number of pharmaceutical items	0–4 (no polypharmacy)	7 (2.7)
	5–9	74 (28.7)
	10–14	121 (46.9)
	≥15	56 (21.7)
Forms of pharmaceutical items	Oral agents (tablet, capsule, and syrup)	2017 (61.92) (1917 [58.9], 36 [1.1], 64 [1.9])
	Injectable agents	1026 (31.50)
	Others (spray, drop, etc.)	214 (6.57)
Drugs associated with PIMs (which are recommended to use with caution (with dose adjustment, check laboratory marker, etc.) or avoided)	Proton pump inhibitors (e.g., pantoprazole)	126 (48.83)
	Benzodiazepines	53 (19.41)
	Alpha blockers	27 (10.46)
	Antipsychotic and depressant agents	24 (9.3)
	Anti-arrhythmia (e.g., digoxin and amiodarone)	18 (6.97)
PIMs per patient	0	60 (23.3)
	1	147 (57)
	2	36 (14)
	3	8 (3.1)
	4	6 (2.3)
	5	0
	6	1 (0.4)
PIMs use frequency according to the type of renal diseases		
AKI	17	
CKD	102	
ESRD (under dialysis)	154	

Abbreviations: AKI, acute kidney disease; CKD, chronic kidney disease; ESRD, end-stage renal disease.

TABLE 3 Results of logistic regression analysis for potentially inappropriate medications use.

Factors		OR	95% CI	*p* Value
Gender	Female	1	0.85–2.91	0.11
	Male	1.58		
Age	Less than 75	1	0.71–2.26	0.42
	Equal or more than 75	1.26		
Length of stay (LOS) (day)	Equal or Less than 7	1	0.75–1.22	0.33
	More than 7	1.32		
Number of medicines	Less than 10	1	1.42–5.07	0.003
	Equal or more than 10	2.68		
eGFR (mL/min/1.73 m^2)	Less than 30 (no dialysis)	1	0.47–4.64	0.51
	Equal or more than 30	1.47		
Received hemodialysis (AKI or ESRD)		1.37	0.54–1.57	0.61
CKD (GFR < 60 mL/min)		2.12	0.83–5.46	0.13
ERSD (hemodialysis)		2.42	(0.91–6.47)	0.07
HTN		1.75	0.92–3.32	0.08
Diabetes		1.50	0.84–2.70	0.17
Heart diseases		1.42	0.75–2.74	0.30
Codiseases (more than one disease except kidney diseases)		2.20	0.82–5.91	0.11

Abbreviations: AKI, acute kidney disease; CI, confidence interval; CKD, chronic kidney disease; ESRD, end-stage renal disease; OR, odds ratio.

4 | DISCUSSION

In the current study, we evaluated the prevalence of PIMs in older adults with kidney diseases according to the latest updated version of the 2019 Beers criteria and found high prevalence of PIMs and their associated risk factors that place this group of already high-risk patients at a greater risk. Our findings also highlighted the crucial role that clinical and hospital pharmacists can play in detecting PIMs and optimizing prescriptions to prevent PIM use and its following ADE.

Various studies have been conducted to evaluate the patterns of medication prescribing and the prevalence of PIMs. These studies have shown a wide range of PIM prevalence ranging from 8.7% to 81%, while different explicit criteria were used in different studies to identify inappropriate medication and prevent PIM use.[15-18]

Currently, it is widely accepted that generally in different wards, pharmacist collaboration in patients' medication management has been associated with a reduction in adverse medication outcomes compared to sole physician management.[26] Although various interventions to optimize treatment plans have been employed to reduce PIMs including medication review by pharmacists and computerized systems, the rate of prescribing inappropriate medications is still high in some healthcare centers all over the world. Hence, it's necessary to evaluate the prescribing rate of PIMs and evaluate the impact of receiving a pharmacist's medication consultation on reducing PIM use.

In our study, more than half of participants with kidney disease (57%) had at least one case of PIM (273 reports for 198 patients, in total).

TABLE 4 Frequency and types of recommended pharmacotherapy interventions to deal with a prescription associated with potentially inappropriate medications.

Total number of clinical pharmacist recommendation (acceptance rate) (for 159 patient) 187 (62.03%) Provided recommendations to deal with the detected PIMs For 123 out of 159 patients	PIM related (acceptance rate) 120 (67.5%)	Non-PIMs related (acceptance rate) 67 (52.23%) Number of patients (%)
Frequency of "need to adjust medication dosing" based on renal function per patient (37 patients)	1 medication 2 medications 3 medications	25 (9.7) 11 (4.3) 1 (0.4)
Medication discontinued due to the lack of indication per patients (28 patients)	1 medication 2 medications 3 medications 4 medications	17 (6/6) 6 (2.3) 2 (0.8) 1 (0.4)
Medication added due to indication (38 patients)	1 medication 2 medications 3 medications 4 medications 5 medications	17 (6/6) 12 (4.3) 6 (2.3) 2 (0.8) 1 (0.4)
Changing the time of medication administration (12 patients)	1 medication 2 medications 3 medications	9 (5/3) 2 (8/0) 1 (4/0)
Changing the rout of medication administration (7 patients)	1 medication 2 medications	6 (3/2) 1 (0.4)
Replacing with a safer medicine (one patient)	1 medication	7 (2.7)

Abbreviation: PIM, potentially inappropriate medication.

Aucella et al. in multicenter retrospective cross-sectional study on 2058 older hospitalized patients, showed that 1401 subjects (68.1%) had polypharmacy. the PIM prevalence based on beers criteria at nephrology ward and the others were 37% (206 out of 560) and 11.4% (174 out of 1497), respectively[27]; that indicated necessity of evaluating prescribed medications in geriatric patients with CKD.

According to two other studies on a similar population in Cyprus and Lebanon, high rates of PIM use were reported (48.8% and 34.3%, respectively).[28,29] As stated in a meta-analysis by Leiw et al. in developed countries, the prevalence of PIMs was about 33.3% in primary care centers for adults.[30] This study reported that decreasing PIM use by half resulted in a 3.7%−7.9% reduction in ADEs. Tegegn et al.'s study in Ethiopia revealed that polypharmacy was associated with poorer medication-related quality of life in three-quarters of older adults. They also mentioned that an increase in medication number and duration of hospital stay resulted in a 1.45- and 1.9-fold increase in worsened quality of life in the elderly.[31] It is worth noting that the higher prevalence of PIM uses in our study underlines the need for a holistic view in the field of pharmaco-economic policy through different methods to prevent PIM prescribing, reduce geriatric patient healthcare costs, and improve medication-related quality of life.

Malakouti et al. also reviewed similar studies conducted in developed countries until 2020[14]; their results were consistent with the studies mentioned above, reporting that the prevalence of PIM use was almost the same as in developing countries, with more than 30% of the elderly population receiving PIMs.[14] This study also found that benzodiazepines and nonsteroidal anti-inflammatory agents were the most commonly prescribed PIMs globally. Our results aligned with this systematic review, and benzodiazepines were one of the most prescribed PIMs in our study.

In our study, 126 and 53 out of 273 PIMs were pharmacologically categorized in gastrointestinal and central nervous system groups. Pantoprazole and alprazolam were touched the highest proportion of prescribed PIMs. Our results are consistent with some studies that reported PPIs and benzodiazepines as the most prevalent PIM classes.[14,27,32] Additionally, our results are consistent with the results of a previously published study by Díez et al., which reported that PPIs and benzodiazepines were the most prescribed PIMs in elderly residents in a nursing home.[33]

According to the literature, long-term PPI administration (for more than 8 weeks) can result in some adverse effects, including an increased risk of gastrointestinal infection, such as Clostridium difficile infection.[34] Long-term PPI use can also restrict calcium intestinal absorption, leading to the risk of osteoporosis.[35] In addition to PPIs, benzodiazepines are the most commonly prescribed medication for insomnia in older adults, which poses a risk of harm, such as falling.[36] Considering this wealth of evidence, it is imperative to avoid overtreating the elderly with unnecessary medications, which can pose patients with ADEs and contribute to morbidity.

Polypharmacy, especially high-level polypharmacy, significantly potentiates the risk of prescribing PIMs, as previously reported in studies of the elderly population.[28,37,38] Our findings confirmed this, showing that high-level polypharmacy increases the PIM prevalence by about three times. Our findings were also in line with Chahine's and Aucella's studies, which had a similar design to ours and found that comorbidities such as hypertension and cardiovascular disease were risk factors for prescribing PIMs.[29] However, in our subgroup analysis, in addition to these two comorbidities, we also identified diabetes as a potentiating factor for PIMs. Additionally, contrary to Chahine's study, we found that LOS and male gender increased the likelihood of PIM use in the elderly with kidney disease. The risk of PIM use in our study population with CKD stages 3 and 4a was higher than in those with CKD stages 4b and 5 (non-dialysis). This finding was in agreement with Chahine's finding. This outcome highlights that physicians commonly pay more attention to correctly dosing medication with increasing severity of CKD, while in the earlier stages, this is not the case. In other words, patients in earlier stages of CKD are more predisposed to be treated with incorrect dosages.

However, conversely, as is presented in Aucella et al. study, the distribution of PIM uses was increased by deteriorating CKD stage and reducing in GFR.[27]

Pharmacists, especially clinical pharmacists, play a crucial role in identifying patients at risk of drug harms.[39-41] In the second phase of the current study, a clinical pharmacist actively checked the medical records, identified PIMs, and gave recommendations to the prescribing physicians to achieve optimal prescribing practice in the elderly. Of the recommendations, 67.5% were relevant to reducing PIM prevalence or medication side effects and were accepted by physicians. These recommendations were mostly related to drug dose adjustments according to kidney function. As a result of pharmacist intervention, the prevalence of PIMs decreased from 175 (1.1 PIM/patient) before the intervention to 94 (0.59 PIM/patient) thereafter (a decrease of 46.28%). Our findings indicate that pharmacist intervention can play a pivotal role in decreasing total health expenditures following PIMs. However, further pharmacoeconomic studies should be conducted in this regard. Due to the high prevalence of PIMs in both developing and developed countries, intervening to stop/reduce PIMs should become a priority to prevent the financial burden on healthcare systems and address the life-threatening medication-induced harms, especially in elderly patients.

Computerized medication order entry and CDSSs are known to improve the management of appropriate drug selection in treatment by notifying prescribing clinicians when an inappropriate medication is prescribed.[19] The recommendations provided by these systems can help both physicians and clinical pharmacists to manage the medication therapies of high-risk patient populations, such as the elderly and chronic patients.[20,21] A study in Thailand found that a specific CDSS for PIMs in a community hospital setting could significantly reduce PIM prescription in elderly patients from 87.7% to 74.4%.[42] Another study in the Netherlands showed similar positive results with a CDSS in community pharmacies, in which its underlying clinical rules could help detect inappropriate drug use in older patients, resulting in changes to drug therapy based on the alerts.[43]

Our detected high prevalence of PIM points to the need for such systems in the complex medication therapy of elderly people with comorbidities, such as kidney disease, in both inpatient and outpatient settings. It is recommended to conduct further studies in association to assess different methods, including pharmacist intervention and CDSSs, for reducing PIM use. It is also better to follow-up with patients to evaluate the long-term outcomes of preventing PIM prescribing and economic efficiency in healthcare system spending budgets on the elderly. Additionally, it is recommended to compare the quality of life and prevalence of morbidity among elderly patients whose medication management was evaluated by geriatric specialists with those of other elderly patients to clarify the long-term impact.

4.1 | Limitations

Prescribing habits between physicians vary widely. Additionally, we only evaluated elderly patients with an already diagnosed kidney disease. Therefore, our results cannot be generalized to the general elderly population or to pharmacotherapy patterns in different settings. Another limitation of our study is that we did not conduct an economic evaluation of our pharmacist intervention. It is recommended to evaluate the economic impact of clinical pharmacist interventions on reducing PIM use and healthcare costs in the elderly. It is also recommended to conduct studies that demonstrate the benefit of decreasing the use of medications considered PIMs in comparison to the risk of administration. Finally, we conducted this study in the inpatient setting. It would be better to follow patients in the outpatient setting to evaluate the impact of optimizing treatment on patient safety and quality of life. It is worth noting that, due to the large population of outpatients, preparing a list of PIMs would have a significant impact on improving the quality of life of geriatric patients and preventing excessive financial waste.

5 | CONCLUSION

Considering the current pattern of drug administration in elderly patients with kidney disease, as defined by the Beers 2019 criteria, the prevalence of PIMs in our study population was high. However, our study highlighted the critical role of clinical pharmacists in managing PIMs and preventing ADEs. Due to the high prevalence of PIMs in this high-risk population, it is recommended to consider ongoing evaluation of medication therapy in elderly patients by clinical pharmacists. This would facilitate reducing medication errors and the financial burden of geriatric care, especially in healthcare systems of developing countries.

AUTHOR CONTRIBUTIONS

Yasaman Nader Babaie: Investigation; software; writing—original draft. **Zahra Niazkhani**: Conceptualization; methodology; validation; writing—review and editing. **Khadijeh Makhdoomi**: Conceptualization; data curation; methodology; supervision; writing—review and editing. **Ayda Esmaeili**: Conceptualization; data curation; investigation; methodology; project administration; supervision; validation; writing—review and editing. We all authors had read and approved the final version of the manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

we had full access to all of the data in this study and takes complete responsibility for the integrity of the data and the accuracy of the data analysis.

ETHICS STATEMENT

This study was approved by Urmia university of Medical sciences (No. IR.UMSU.REC.1400.301).

TRANSPARENCY STATEMENT

The lead author Ayda Esmaeili affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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