International Journal of General Medicine

Dovepress
open access to scientific and medical research

Open Access Full Text Article

ORIGINAL RESEARCH

Prescribing Renally Inappropriate Medication to Hospitalized Geriatric Patients in Makkah, Saudi Arabia

Hamsah S Alqashqri[1], Ahmed Siddiqi[2], Halah T Albar[3], Enas H Alfalogy[1,4], Nahla H Hariri[1], Yosra Z Alhindi[5], Asim M Alshanberi[1], Safaa M Alsanosi[5], Alaa H Falemban[5]

[1]Department of Community Medicine and Pilgrims Health Care, Faculty of Medicine, Umm Al Qura University, Makkah, Saudi Arabia; [2]Department of Internal Medicine, National Guard Hospital, Jeddah, Saudi Arabia; [3]Department of Physiology, Faculty of Medicine, Umm Al-Qura University, Makkah, Saudi Arabia; [4]Family Medicine, Faculty of Medicine, Suez-Canal University, Ismailia, Egypt; [5]Department of Pharmacology and Toxicology, Faculty of Medicine, Umm Al Qura University, Makkah, Saudi Arabia

Correspondence: Alaa H Falemban, Email ahfalemban@uqu.edu.sa

Introduction: As a result of the physiological decline in renal function that comes with age and the common failure to recognise renal insufficiency, older adults aged 65 and above are at increased risk of receiving medications that are inappropriate for their level of renal function which in turn lead to increased risk of adverse effects. Little is known about how many older adults receive medications that are inappropriate for their level of renal function. This study aimed to determine the prevalence of renally inappropriate medications in elderly adults by reviewing patient files and evaluating the appropriateness of medication doses relative to renal function in patients aged ≥ 65 years at inpatient healthcare departments.

Methods: A retrospective cross-sectional study of patients aged ≥ 65 years was conducted, covering cases from 2015 to 2021. Patient's medical records were reviewed, their renal function and medications lists were evaluated, determined whether they had been prescribed at least one renally inappropriate medication based on drug-dosing recommendations for different degrees of renal function.

Results: A total of 317 elderly inpatients were included, 10% of whom had received inappropriate doses relative to their renal function. Glomerular filtration rate was associated with inappropriate dosing in this study. Of the patients CKD stage 5, 36.8% had at least one drug administered at an inappropriate dose, while this figure was 6.5% among the patients at CKD stage 1; this difference was statistically significant ($p = 0.001$).

Conclusion: A notable portion of older adults may be at risk of adverse effects due to inappropriate medication dosing related to their renal function. Further studies with large samples, drug use analyses based on comprehensive geriatric references and a prioritisation of actual outcomes over potential outcomes are needed to further determine elderly adults' exposure to inappropriate drugs.

Keywords: older adults, geriatric, inappropriate medication, healthcare outcomes, elderly inpatients, renally inappropriate medication, physiological decline, healthcare evaluation, insufficiency

Introduction

Saudi Arabia is working on improving its healthcare system as part of its Vision 2030 and National Transformation Program. The nation aims to provide a better quality of health services by cutting down on ineffective care, carefully reviewing treatments and focusing more on preventing health issues.[1] To make this happen, it is crucial to assess the current state of healthcare and tackle challenges. One effective approach to doing so involves identifying medication-related problems (MRPs) and accordingly implementing best practices and innovative strategies to enhance patient healthcare outcomes.[2]

Older adults, or those aged 65 and above, are an important group that needs special attention in healthcare. They comprise a growing patient population whose proportion is increasing at a pace more than three times that of the general population.[3] In addition to ailments such as frailty, functional limitations, depression, cognitive impairment and

Received: 30 January 2024
Accepted: 24 April 2024
Published: 1 May 2024

malnutrition, older adults face an elevated risk of MRPs, including polypharmacy, use of potentially inappropriate medication (PIM), adverse events, harmful drug interactions and non-adherence to prescribed treatments.[4]

PIM refers to a group of medications that are generally considered unadvisable for elderly patients due to their limited efficacy and high risk of causing adverse effects. Anticholinergic medications, tricyclic antidepressants and nonsteroidal anti-inflammatory drugs (NSAIDs) are example of medication classes classified as PIM. Another significant PIM category is renally inappropriate medications (RIMs). These are medications that may be difficult to safely pass through the body in individuals with compromised kidney function, leading to increased risk of adverse effects or toxicity.[5]

When a person grows elderly, most of their organs do as well. In addition to undergoing intrarenal vascular changes, the kidneys decrease in size and volume with age, producing a decrease in the filtration area of the glomerular basement membrane. Renal function, as evaluated by glomerular filtration rate (GFR), typically decreases by approximately 8 mL/min with each decade of life after 40. This decline accelerates notably after 65–70 years of age.[6] Consequently, elderly patients are particularly susceptible to drug toxicity due to diminishing GFR and resultant lower excretion rates of drugs and their metabolites from the kidneys. In cases with renal insufficiency, adjustment such as dose reduction of renally excreted drugs or elongation of time intervals between doses are recommended.[5] Renal insufficiency, however, is often missed in the elderly, especially since decreasing muscle mass may still yield an average serum creatinine concentration.[6]

A study conducted at family and community medicine clinics in King Saud Medical City in Riyadh showed that the prevalence of PIM was 60.7%.[7] At King Abdulaziz Medical City in Saudi Arabia, 80% of elderly patients were found to have used at least one listed PIM.[8] The same percentage was reported in a Swedish retrospective study conducted in a large tertiary hospital, 80.6% of geriatric patients had been prescribed at least one medication listed in PIM.[9] Meanwhile, studies from Europe and North America indicate that PIM and subsequent adverse drug reactions may cause 1.5–15% of emergency department visits and unplanned hospitalisations in older people.[10]

In studies that investigated Australian and American community-dwelling older persons and nursing home residents, 6–28% were prescribed contraindicated drugs or required dosage adjustments due to inhibited kidney function.[11] In several studies of drug administration to hospitalised adults, 15–67% of drugs that required renal adjustment were given at inappropriate doses or intervals.[12,13]

There is no doubt that RIM can have adverse effects. Approximately 14% of admissions to a university hospital in Stockholm, Sweden, were adverse drug reactions, while one-third were impairments of renal function.[14] According to studies of older patients with renal impairment, use of RIM was associated with an increase in mortality of 40% to 46%.[11,15] Moreover, exposure to nephrotoxic medications increased healthcare utilization, including prescription drug use, emergency department visits, and hospitalizations. A study has demonstrated that total health expenditures were nearly 30% higher in groups exposed to nephrotoxic medications than in those who were not exposed.[16]

Little is known about how many older adults receive medications that are inappropriate for their level of renal function. This study aimed to determine the prevalence of RIM in elderly adults by reviewing patient files and evaluating the appropriateness of medication doses relative to renal function in patients aged ≥ 65 years at inpatient healthcare departments in Makkah City, Saudi Arabia from 2015 to 2021.

Materials and Methods

Ethical Approval

This study was approved by The Ethics Committee of the Institutional Review Board, Ministry of Health, Saudi Arabia (H-02-K-076-1021-581) under the Declaration of Helsinki. Patient consent was waived by the Ethics Committee due to the study's minimal risk and the impracticability of obtaining individual consent for retrospective data analysis.

Study Design

We conducted a retrospective cross-sectional study of patients aged ≥ 65 years and treated at Al-Noor Specialist Hospital in Makkah City from 2015 to 2021 by assessing the patients' files, evaluating the patient's renal function and determining whether they had received at least one RIM. Al-Noor Hospital is a specialist, secondary-level hospital serving

a population of 364,255 inhabitants, with 565 beds and six different specialised medical centres. The sample size was calculated using a 95% confidence interval, a 5% margin of error, and an estimated sample of 218 patients.

Data Collection

In order to determine the prevalence of RIM in in patients aged ≥ 65 years at inpatient healthcare departments in Makkah City, Saudi Arabia, a team of two physicians trained in geriatric medicine and clinical pharmacology reviewed the medical records of the patients and evaluated the appropriateness of medication doses relative to renal function from 2015 to 2021. The inclusion criteria were for males or females aged ≥ 65 years, who contacted any medical unit at Al-Noor Hospital from 2015 to 2022. Patients for whom creatinine clearance could not be assessed due to an absence of recent weight records or serum creatinine measurements (calculated using the assessment procedures described below) and patients whose records had incomplete prescription data were excluded. Patients were excluded when they received any form of renal replacement therapy (eg dialysis). Data including age, gender, height, weight, BMI, race, and serum creatinine were collected from each patient's file. Creatinine clearance was calculated using the Cockcroft–Gault equation to estimate glomerular filtration rate (GFR), which was then used to classify patients into the five stages of Chronic Kidney Disease (CKD): Stage 1 (CrCl >90 mL/min), Stage 2 (CrCl 60–89 mL/min), Stage 3 (CrCl 30–59 mL/min), Stage 4 (CrCl 15–29 mL/min), and Stage 5 (CrCl <15 mL/min). Medication lists were reviewed, and specific recommendations regarding dose adjustment according to renal function were obtained from reference books. Each medication's recommended dose adjustment was compared to the actual patient dose, and its appropriateness was determined accordingly. All data were inputted, calculated, and securely stored in an Excel document for analysis. "The Renal Drug Handbook (5th edition)" was used to determine detailed drug-dosing recommendations for different degrees of renal failure.[17] This handbook is useful in understanding how renal impairment affects drug management and provides accessible, practical information on dosing in such conditions.

Data Analysis

After the data were extracted, they were revised, coded and entered into the statistical software programme SPSS version 22 (IBM, Chicago, IL). All statistical analysis was conducted using two-tailed tests. A p value less than 0.05 was considered statistically significant. Descriptive analysis based on frequency and percent distribution was performed for all categorical variables, while means with standard deviations and medians were used to display numerical variables. The prevalence of inappropriate doses among the patients was tabulated per group, and the total was graphed. All relationships between patient demographic data and number of drugs administered at inappropriate doses were tabulated using an exact probability test. The percentage distribution of inappropriate doses per patient by biodemographic category was assessed using Mann–Whitney and Kruskal–Wallis tests.

Results

A total of 317 elderly patients were included. The patients' ages ranged from 65 to 109 years, with a mean of 76.5 ± 7.5 years. Of the patients, 187 (59%) were male. As for CKD, stage 3 was observed among 125 (39.4%) patients, Stage 2 among 61 (19.2%), stage 1 among 58 (18.3%) and stage 4 among 51 (16.1%), while only 22 patients (6.9%) were at stage 5. Comorbidities of the study participants included hypertension in 170 (53.6%), cardiac disease in 165 (52.1%), diabetes in 139 (43.8%), COVID-19 in 39 (12.3%), and stroke in 25 (7.9%) (Table 1).

The drugs most commonly prescribed at inappropriate doses were meloxicam (analgesic; 75%), cefepime (antibiotic; 66.7%), edoxaban (anticoagulant and blood; 60%), rivaroxaban (anticoagulant; 50%) and ranitidine (gastrointestinal tract, GIT; 42.4%). The drugs most rarely prescribed at inappropriate doses were perindopril (renin–angiotensin–aldosterone system RAAS; 5.6%), hydralazine (cardiac; 3.4%) and paracetamol (analgesic; 2.4%) (Table 2). The the proportions of inappropriate prescriptions relative to the total inappropriate prescriptions is shown in Figure 1.

In total, only 10% of drugs were prescribed at inappropriate doses. The number of renal drugs prescribed ranged from 1 to 15, with a median of 4. Only 0–3 drugs per patient were inappropriate, and more than half of the patients did not receive any inappropriate doses. Only CKD stages was associated with number of drugs, number of inappropriate doses and percentage of inappropriate doses per patient (Table 3). Of the patients at CKD stage 5, 37% had at least one drug

Table 1 Bio-Demographic Data of Elderly Patients (N=317)

Bio-demographic Data	No	%
Age in years		
< 70	74	23.3%
70–80	147	46.4%
> 80	96	30.3%
Range	65–109	
Mean ± SD	76.5 ± 7.5	
Gender		
Male	187	59.0%
Female	130	41.0%
CKD stage		
1	58	18.3%
2	61	19.2%
3	125	39.4%
4	51	16.1%
5	22	6.9%
Co-morbidities		
HTN	170	53.6%
Cardiac disease	165	52.1%
DM	139	43.8%
Others	48	15.1%
Covid-19	39	12.3%
Stroke	25	7.9%

Abbreviations: HTN, Hypertension; DM, Diabetes Mellitus.

Table 2 Prevalence of Inappropriate Drug Dose by Their Group Among Study Elderly Patients (N=317)

Group	Drugs	Appropriate		Inappropriate	
		No	%	No	%
GIT	Ranitidine	19	57.6%	14	42.4%
	Metoclopramide	16	84.2%	3	15.8%
DM	Metformin	11	84.6%	2	15.4%
	Gliclazide	5	100.0%	0	0.0%
	Sitagliptin	8	66.7%	4	33.3%
	Glimepiride	2	100.0%	0	0.0%
Anticoagulants and blood	Apixaban	23	100.0%	0	0.0%
	Edoxaban	2	40.0%	3	60.0%
	Rivaroxaban	1	50.0%	1	50.0%
Cardiac	Digoxin	7	100.0%	0	0.0%
Diuretics	Spironolactone	59	100.0%	0	0.0%
	Thiazide	4	100.0%	0	0.0%

(*Continued*)

Table 2 (Continued).

Group	Drugs	Appropriate		Inappropriate	
		No	%	No	%
Antihypertensive	Atenolol	4	100.0%	0	0.0%
	Methyldopa	3	100.0%	0	0.0%
	Metoprolol	50	100.0%	0	0.0%
	Enalapril	3	100.0%	0	0.0%
	Perindopril	34	94.4%	2	5.6%
	Ramipril	19	100.0%	0	0.0%
Anti-lipid	Rosuvastatin	56	82.4%	12	17.6%
Antibiotics	Amoxicillin	19	100.0%	0	0.0%
	Tazocin	66	93.0%	5	7.0%
	Ciprofloxacin	25	100.0%	0	0.0%
	Levofloxacin	49	86.0%	8	14.0%
	Oseltamivir	8	100.0%	0	0.0%
	Cefepime	5	33.3%	10	66.7%
	Ceftazidime	8	100.0%	0	0.0%
	Metronidazole	22	100.0%	0	0.0%
	Cefuroxime	20	100.0%	0	0.0%
Psychotics	Tamsulosin	4	100.0%	0	0.0%
	Amitriptyline	5	100.0%	0	0.0%
	Clozapine	2	100.0%	0	0.0%
	Escitalopram	5	100.0%	0	0.0%
Antidepressants	Gabapentin	1	100.0%	0	0.0%
	Pregabalin	9	100.0%	0	0.0%
CNS and antiepileptics	Levetiracetam	12	92.3%	1	7.7%
	Memantine	4	66.7%	2	33.3%
	Risperidone	3	100.0%	0	0.0%
Gout	Allopurinol	6	100.0%	0	0.0%
Analgesic	Paracetamol	41	97.6%	1	2.4%
	Tramadol	18	100.0%	0	0.0%
	Meloxicam	1	25.0%	3	75.0%
	Mirtazapine	4	100.0%	0	0.0%
	Celecoxib	3	100.0%	0	0.0%
Antiviral	Ribavirin	1	50.0%	1	50.0%

Abbreviations: GIT, The gastrointestinal tract medication; DM, Diabetes Mellitus; RAAS, Renin-angiotensin-aldosterone system inhibitors.

administered at an inappropriate dose, while this figure was 7% among the patients at CKD stage 1; this difference was statistically significant (p = 0.001). The average percentage of inappropriate drug doses per patient was 15.8% for patients at CKD 5, compared to 5.8% at CKD 1 (p = 0.015).

Discussion

Most published studies exploring medication use in geriatric patients have focused on inappropriate medication uses, including those deemed inappropriate for renal conditions, albeit without specific details. However, studies that address RIM in geriatric populations are scarce. Among the studies that have explored RIM and investigated compliance with renal dosing guidelines, a wide range of values has been reported, spanning from 19% to 80%.[5,10,18] Our study involved

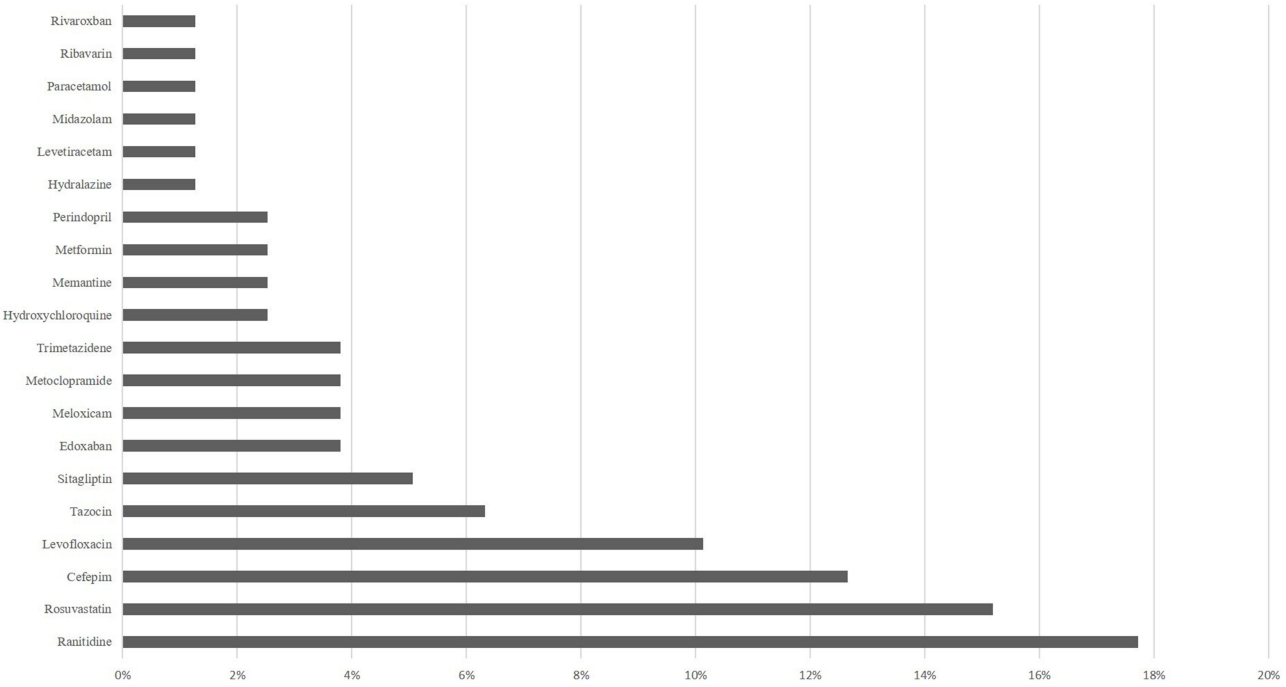

Figure 1 Prevalence of inappropriate prescriptions relative to the total inappropriate prescriptions.

inpatients admitted for medical treatment at Al-Noor Specialist Hospital during the study period. In our study, only 10% of the medications administered were found to be renally inappropriate.

Inappropriate prescription related to renal function is recognised to be common in specific healthcare settings, but the prevalence varies based on the type of service offered. RIM prescriptions have been reported at rates of 13%, 34%, and 68–80.5% in hospitals, long-term care facilities and ambulatory settings, respectively.[16] A systematic review found that rates of non-adherence to renal dosing guidelines range from 19% to 69% across all settings, with the highest rate occurring in ambulatory care.[19] Another systematic review found that renally inappropriate drug use is prevalent in outpatient settings (1–37%).[6]

Table 3 Relation Between Inappropriate Drug Doses Among Elderly Patients and Their Bio-Demographic Data

Biodemographic Data	Number of Inappropriate Drug Doses								p-value ^
	0		1		2		3		
	No	%	No	%	No	%	No	%	
Age in years									0.207
< 70	54	81.8%	9	13.6%	3	4.5%	0	0.0%	
70–80	112	83.0%	21	15.6%	1	0.7%	1	0.7%	
> 80	57	72.2%	20	25.3%	2	2.5%	0	0.0%	
Gender									0.743
Male	128	78.5%	31	19.0%	3	1.8%	1	0.6%	
Female	95	81.2%	19	16.2%	3	2.6%	0	0.0%	

(*Continued*)

Table 3 (Continued).

Biodemographic Data	Number of Inappropriate Drug Doses								p-value ^
	0		1		2		3		
	No	%	No	%	No	%	No	%	
Co-morbidities									0.123
DM	99	79.2%	21	16.8%	4	3.2%	1	0.8%	
HTN	120	78.4%	29	19.0%	3	2.0%	1	0.7%	
Covid-19	26	78.8%	4	12.1%	2	6.1%	1	3.0%	
Cardiac disease	114	79.2%	29	20.1%	1	0.7%	0	0.0%	
Stroke	15	65.2%	7	30.4%	1	4.3%	0	0.0%	
Others	35	81.4%	6	14.0%	2	4.7%	0	0.0%	
CKD stages									0.001*
1	43	93.5%	3	6.5%	0	0.0%	0	0.0%	
2	57	98.3%	1	1.7%	0	0.0%	0	0.0%	
3	83	71.6%	30	25.9%	3	2.6%	0	0.0%	
4	28	68.3%	10	24.4%	2	4.9%	1	2.4%	
5	12	63.2%	6	31.6%	1	5.3%	0	0.0%	

Notes: *P < 0.05 (significant).

In a study that evaluated the use of contraindicated medications or inappropriately high doses according to renal function in patients with renal impairment, 32.3% were given PIM at the time of admission, although this figure decreased by almost half at discharge.[20] The authors suggested that the high prevalence upon admission was a result of staff failing to recognise renal impairment and adjust medication dosages or of reference texts for dosage adjustments and laboratories not calculating creatinine clearance when creatinine tests are requested, requiring clinicians to perform the calculations themselves.[20] Conversely, most of these interventions were conducted in inpatient settings, where accessibility, availability and resource quality are often higher than in outpatient settings, which could explain the relatively low prevalence of RIM in our study.

The variation in prevalence is not solely attributable to clinical setting but has numerous contributing factors. Differences in inclusion/exclusion criteria, varied methods, inconsistent definitions, the use of different equations to estimate renal function and the application of variable references and guidelines in cases of renal impairment collectively contribute to the observed variance in prevalence.[13]

In our study, we used The Renal Drug Handbook as a key reference.[17] This handbook is useful in understanding how renal impairment affects drug management and provides accessible, practical information on dosing in such conditions. However, it primarily focuses on drug prescription without specifying age groups, potentially rendering it less comprehensive regarding dosing in geriatric populations with renal impairment. Other publications specialising in geriatric treatment often consider unique factors in drug prescription, such as multiple comorbidities and polypharmacy. In these texts, the number of drugs categorised as inappropriate is likely higher compared to general sources. Nevertheless, given our study's primary focus on determining appropriate dosages, we opted to use The Renal Drug Handbook because it provides dosing information for every stage, a feature not commonly found in many geriatric-centred guidelines.

In a recent study, 33% of elderly patients with different stages of CKD were prescribed at least one RIM; the medications were classified by Lexicomp category – "should be avoided", "use is contraindicated", "use is not

recommended" or "consider alternative" – or flagged when a dose was adjusted to the "max dose" based on the patient's GFR or creatinine clearance.[18,21] Similarly, in a large, population-based study that included 30,372 people aged ≥ 65 years who attended primary care in Stockholm, Sweden, the overall prevalence of excessive dosing in the total population of patients at CKD stages 3 and 4 was approximately 43.6%.[10] In the Swedish study, RIMs were defined with reference to Janusmed Drugs and Renal Function, a comprehensive knowledge base with recommendations on drug use in people with renal impairment. Janusmed is integrated into the electronic patient journal system in Stockholm County and refers to internationally accepted categories of CKD.

Since the information on dosage adjustments in renal impairment given in this Handbook is based on Cockcroft–Gault creatinine clearance, we opted to use the Cockcroft–Gault equation to determine renal function in our study population. Indeed, most published information is based on creatinine clearance, and the Cockcroft–Gault equation is the recommended reference for adjusting renal medication doses in elderly patients.[5,17]

There is a debate regarding the suitability of using Estimated Glomerular Filtration Rate (eGFR) to adjust medication doses. The concerns arise from the variable standardisation of serum creatinine measurements over the years. As a result of these methodological changes, creatinine clearance results may be different from those obtained when many medications were first tested and renal dosing parameters were developed. This discrepancy can create challenges in accurately assessing renal function to adjust medication doses appropriately. Meanwhile, the Modification of Diet in Renal Disease and Chronic Kidney Disease Epidemiology Collaboration equations were initially developed for epidemiological research and CKD staging, not for calculating dosages for patients with altered renal function. Both equations significantly overestimate creatinine clearance in elderly individuals, resulting in incorrect dose calculations.[5,22] Different RIMs have been investigated in different studies. NSAIDs are among the most frequently contraindicated drugs in elderly patients with renal insufficiency.[23] Aside from renal vasoconstriction and clinically significant reductions in GFR, NSAIDs can also have nephrotoxic effects. It has been shown that inhibiting renal prostaglandins can result in interstitial nephritis, membrane glomerulonephritis, renal tubular acidosis and papillary necrosis.[23] The NSAID meloxicam was the most frequently misprescribed RIM in our study. It is known that NSAIDs should not be used if the patient's eGFR is < 50 mL/min/1.73m2 since it can risk further deterioration in renal function.[24] The three patients in our study considered to have received inappropriate doses were administered more than the recommended daily dose.

It is common for excessive drug dosages to affect the renin-angiotensin-aldosterone system.[23] Angiotensin-converting enzyme inhibitors (ACEIs) and angiotensin receptor blockers (ARBs), by inducing efferent arteriolar vasodilation, significantly lower GFR.[23] However, ACE inhibitors pose risks of hyperkalaemia, metabolic acidosis and decreased GFR, complicating their use in advanced CKD. Despite these challenges, studies suggest that ACEI and ARB treatment can slow CKD progression.[5] Physicians must navigate the pros and cons of using ACE inhibitors in these patients and seek a balance between benefits and potential harm. In our study, 36 patients were on perindopril, 2 of whom had excessive doses relative to their renal function.

Inappropriate use of antidiabetic medications increases the risk of hypoglycaemia, cardiovascular disease and lactic acidosis in CKD patients. Metformin poses an increased risk of lactic acidosis in those with advanced CKD.[25] Out of 12 patients on metformin, only 2 had improper dosages in this study.

On the whole, rosuvastatin was observed to be one of the most common medications prescribed (at 68 patients, or 21%) and inadequately dosed (12 patients, or 17.60%). The cases identified as inappropriate were those involving a daily dosage of 40 mg, which is considered excessive for patients with renal impairment. It is recommended to limit the dose to 20 mg, as doses beyond this threshold can result in myopathy.[17] However, it remains unclear whether such high doses are clinically necessary for these patients, raising questions about whether they are appropriate based on their actual needs. In a study that evaluated the impact of different rosuvastatin doses on elderly patients with unstable angina pectoris, it was determined that a daily dosage of 10 mg yielded optimal efficacy.[26]

In this study, the only factor contributing to the prevalence of RIMs was the stage of chronic kidney disease. Notably, the percentage of patients with RIMs appeared highest among those in CKD stage 5, at 37%. This finding suggests that despite receiving intensive nephrology care and potentially stricter prescription restrictions, a significant proportion of patients at this advanced stage still experience challenges with medication appropriateness. Conversely, while patients with CKD stage 3 have a lower percentage of RIMs, it is noteworthy that renal impairment may still remain undiagnosed during this stage. Hence, this study highlights the complex interplay between CKD stage and medication appropriateness, emphasizing the need for tailored prescribing practices and vigilant monitoring at all stages of renal impairment.

While others studies have reported contributing factors other than renal function stage, such as numbers of medications and comorbidities,[13] such factors could not be identified in this study. This may be due to the sample size, which we believe to be one of this study's limitations.

Hence, in future research with older adults, large-scale population-based samples, drug use analysis using comprehensive geriatric reference materials and a prioritisation of actual outcomes over potential outcomes should be considered to determine exposure to inappropriate drugs.

Nevertheless, this study remains the first to investigate RIM in Saudi Arabia and, to the best of our knowledge, in the Middle East. The era of Saudi Vision 2030 calls for an integrated healthcare system, cross-referencing of laboratory data with medication prescriptions, automated creatine clearance reporting in e-prescribing systems and automated alerts when medications are prescribed at renally inappropriate doses. In addition, implementing systems and education programmes that enhance awareness of these tools in daily practice shows promise for addressing this issue and improving this population's healthcare outcomes.[2]

Conclusions

Ten percent of the elderly inpatients studied received inappropriate medication doses relative to their renal function with a significant correlation observed between CKD stages and the frequency of inappropriate doses administered. Further studies with large samples, drug use analyses based on comprehensive geriatric references and a prioritisation of actual outcomes over potential outcomes are needed to further determine elderly adults' exposure to inappropriate drugs. Enhancing integrated health systems and implementing tools and education programmes that enhance awareness of these tools in daily clinical practice offers promising potential for addressing this issue and improving this population's healthcare outcomes.

Data Sharing Statement

Data available upon request.

Institutional Review Board Statement

The Ethics Committee of the Institutional Review Board, Ministry of Health, Saudi Arabia. The approval number is (H-02-K-076-1021-581).

Acknowledgments

The authors would like to thank the deanship of Scientific Research at Umm Al-Qura University.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work. All authors have read and agreed to the published version of the manuscript.

Funding

"This research received no external funding".

Disclosure

The authors declare no conflicts of interest.

References

1. Transformation, H.S.. *Program Delivery Plan 2020-2021*. Health Sector Transformation: Saudi Arabia; 2021.
2. Falemban AH. Medication-related problems and their intervention in the geriatric population: a review of the literature. *Cureus*. 2023;15(9):e44594. doi:10.7759/cureus.44594

3. Molnar AO, Bota S, Jeyakumar N, et al. Potentially inappropriate prescribing in older adults with advanced chronic kidney disease. *PLoS One*. 2020;15(8):e0237868. doi:10.1371/journal.pone.0237868
4. Alhumaidi RM, Bamagous GA, Alsanosi SM, et al. Risk of polypharmacy and its outcome in terms of drug interaction in an elderly population: a retrospective cross-sectional study. *J Clin Med*. 2023;12(12):3960. doi:10.3390/jcm12123960
5. AlQashqri H. Renally Inappropriate Medications in the Old Population: Prevalence, Risk Factors, Adverse Outcomes, and Potential Interventions. *Cureus*. 2023;15(11).
6. Dörks M, Allers K, Schmiemann G, et al. Inappropriate medication in non-hospitalized patients with renal insufficiency: a systematic review. *J Am Geriatr Soc*. 2017;65(4):853–862. doi:10.1111/jgs.14809
7. Alturki A, Alaama T, Alomran Y, et al. Potentially inappropriate medications in older patients based on beers criteria: a cross-sectional study of a family medicine practice in Saudi Arabia. *BJGP Open*. 2020;4(1):bjgpopen20X101009. doi:10.3399/bjgpopen20X101009
8. Jastaniah NA, Almaqati AS, Alsuraihi AK, Abughanim SA, Aseeri M. Inappropriate prescribing in elderly inpatients at a university hospital in Saudi Arabia. *Drugs Real World Outcomes*. 2018;5(4):211–216. doi:10.1007/s40801-018-0142-0
9. Alshehri S, Alshibani M, Magboul G, et al. Adherence to beers criteria in geriatrics: a retrospective study in a Saudi teaching hospital. *Geriatrics*. 2020;5(4):97. doi:10.3390/geriatrics5040097
10. Schmidt-Mende K, Wettermark B, Andersen M, et al. Prevalence of renally inappropriate medicines in older people with renal impairment - A cross-sectional register-based study in a large primary care population. *Basic Clin Pharmacol Toxicol*. 2019;124(3):256–265. doi:10.1111/bcpt.13127
11. Heinjoki M, Karjalainen M, Saltevo J, et al. Kidney function and nephrotoxic drug use among older home-dwelling persons with or without diabetes in Finland. *BMC Nephrol*. 2020;21(1):11. doi:10.1186/s12882-020-1684-4
12. Helldén A, Bergman U, von Euler M, et al. Adverse drug reactions and impaired renal function in elderly patients admitted to the emergency department: a retrospective study. *Drugs Aging*. 2009;26(7):595–606. doi:10.2165/11315790-000000000-00000
13. Chang F, O'Hare AM, Miao Y, et al. Use of renally inappropriate medications in older veterans: a national study. *J Am Geriatr Soc*. 2015;63 (11):2290–2297. doi:10.1111/jgs.13790
14. Kondo N, Nakamura F, Yamazaki S, et al. Prescription of potentially inappropriate medications to elderly hemodialysis patients: prevalence and predictors. *Nephrol Dial Transplant*. 2015;30(3):498–505. doi:10.1093/ndt/gfu070
15. Gigante A, Proietti M, Petrillo E, et al. Renal function, cardiovascular diseases, appropriateness of drug prescription and outcomes in hospitalized older patients. *Drugs Aging*. 2021;38(12):1097–1105. doi:10.1007/s40266-021-00903-0
16. Tesfaye WH, Castelino RL, Wimmer BC, et al. Inappropriate prescribing in chronic kidney disease: a systematic review of prevalence, associated clinical outcomes and impact of interventions. *Int J Clin Pract*. 2017;71(7):e12960. doi:10.1111/ijcp.12960
17. Ashley C, Dunleavy A. *The Renal Drug Handbook: The Ultimate Prescribing Guide for Renal Practitioners*. 5th ed. CRC Press; 2018. doi:10.1201/9780429460418
18. Silva-Almodóvar A, Hackim E, Wolk H, et al. 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):2346–2352. doi:10.1007/s11606-020-06537-z
19. Long CL, Raebel MA, Price DW, et al. Compliance with dosing guidelines in patients with chronic kidney disease. *Ann Pharmacother*. 2004;38 (5):853–858. doi:10.1345/aph.1D399
20. Doody HK, Peterson GM, Watson D, et al. Retrospective evaluation of potentially inappropriate prescribing in hospitalized patients with renal impairment. *Curr Med Res Opin*. 2015;31(3):525–535. doi:10.1185/03007995.2015.1010036
21. L. Lexicomp Drug Interactions Analysis. Available from: https://www.wolterskluwer.com/en/solutions/uptodate/enterprise/lexidrug. Accessed 1 May 2023.
22. Hartmann B, Czock D, Keller F. Drug therapy in patients with chronic renal failure. *Dtsch Arztebl Int*. 2010;107(37):647–55; quiz 655–6. doi:10.3238/arztebl.2010.0647
23. Bosi A, Xu Y, Gasparini A, et al. Use of nephrotoxic medications in adults with chronic kidney disease in Swedish and US routine care. *Clin Kidney J*. 2021;15(3):442–451. doi:10.1093/ckj/sfab210
24. O'Mahony D, O'Sullivan D, Byrne S, et al. STOPP/START criteria for potentially inappropriate prescribing in older people: version 2. *Age Ageing*. 2015;44(2):213–218. doi:10.1093/ageing/afu145
25. Tanner C, Wang G, Liu N, et al. Metformin: time to review its role and safety in chronic kidney disease. *Med j Aust*. 2019;211(1):37–42. doi:10.5694/mja2.50239
26. Fang J, Zhang X. Effect of various doses of rosuvastatin in the treatment of elderly patients with unstable angina pectoris. *Am J Transl Res*. 2022;14 (1):594–602.