






Potentially Inappropriate Medications in Hospitalized Older Patients in Tabuk, Saudi Arabia Using 2023 Beers Criteria: A Retrospective Multi-Centric Study

Kousalya Prabahar ¹, Manar Saleem Alhawiti², Asmaa Mokhtar Yosef², Raghad Saleh Alqarni², Fai Yahya Sayd², Mohammed Omar Alsharif³, Vikashini Subramani ⁴, Hanan Alshareef ¹, Ahmed ME Hamdan ¹, Saleh Alqifari ¹, Ghadi Saleh Alqarni⁵, Sumayah Mokhtar Yousuf⁶

¹Department of Pharmacy Practice, Faculty of Pharmacy, University of Tabuk, Tabuk, Saudi Arabia; ²Faculty of Pharmacy, University of Tabuk, Tabuk, Saudi Arabia; ³Director of Pharmaceutical Care Administration, Ministry of Health, Tabuk, Saudi Arabia; ⁴Department of Pharmacy Practice, JSS College of Pharmacy, JSS Academy of Higher Education & Research, Nilgiris, TN, India; ⁵Pharmacist and Store Manager, Alnahdi Company, Tabuk, Saudi Arabia; ⁶Pharmacist, Prince Sultan Military Medical City, Riyadh, Saudi Arabia

Correspondence: Kousalya Prabahar, Department of Pharmacy Practice, Faculty of Pharmacy, University of Tabuk, Tabuk, 71491, Saudi Arabia, Email kgopal@ut.edu.sa

Purpose: Older persons are frequently prescribed several medications; therefore, inappropriate medication prescriptions are common. Prescribing potentially inappropriate medications (PIMs) poses a serious risk and hence, we aimed to assess the PIMs in older patients in Tabuk, using the 2023 Beers criteria.

Patients and Methods: A retrospective cross-sectional study was carried out, including older persons ≥ 65 years of age admitted in two government hospitals from June 2022 to May 2023, and prescribed with five or more medications. PIMs were assessed using the 2023 Beers criteria. Descriptive analysis was performed for the categorical and continuous variables. Logistic regression was used to assess the influence of age, gender, number of medications and comorbidities on PIMs using SPSS version 27.

Results: The study included 420 patients. The mean age of the participants was 75.52 ± 8.70 years (range, 65–105 years). There was a slightly higher proportion of females (52%). The prevalence of PIMs was 81.43%, where 35.41% were prescribed one PIM, 26.48% were prescribed two PIMs, and 17.32% were prescribed three PIMs. The proportion of medications considered potentially inappropriate among older patients was 70.11%, and proton pump inhibitors were the most commonly prescribed medication (52.99%). The proportion of medications to be used with caution was 19.55%, with diuretics being the most frequently administered medication (91.43%). Gender and comorbidity did not influence PIMs, but age and number of medications significantly influenced the likelihood of PIMs.

Conclusion: PIMs are prevalent among older people and are significantly associated with age and multiple medications. Caution should be exercised while prescribing medications to older persons. Frequent audits should be performed to assess PIMs, and clinicians should be informed of the same to avoid serious outcomes associated with PIMs. Interventions designed to reduce PIM need to be initiated.

Keywords: older persons, inappropriate medication, American Geriatrics Society, prescription

Introduction

During the past century, people's life expectancy has dramatically increased. Older populations of 65 to 69 years are prescribed an average of 14 medications, and 80 to 84 years of age receive 18 medications.¹ The number of older people in Saudi Arabia is on the rise and is expected to reach 10 million by 2050, as reported by the United Nations.² With regard to the healthcare system, the older population has an increased morbidity burden.³ They are prone to multiple disease conditions and are therefore prescribed multiple medications.⁴

Prescribing multiple medications is termed polypharmacy and is commonly prescribed to older adults. Although there is no specific definition of polypharmacy, prescribing five or more medications concurrently is termed polypharmacy,⁵ and polypharmacy has been proven to be associated with declining physical and mental wellness in the older population.⁶ Despite this, older persons are prescribed ten or more medications, which can be life-threatening.⁷ The use of medications that carry more risks than benefits is known as inappropriate medication, especially when safer medications may be used in their place.⁸ Polypharmacy in older people elevates the risk of inappropriate medication use, which might increase the risk of medication interactions, morbidity, mortality, and healthcare issues.⁹ Pharmacokinetic and pharmacodynamic properties change with ageing, and this also influences the effect of medications.¹⁰

Studies on the prevalence of possibly inappropriate medications among older patients in many nations have been conducted, but the results have not consistently demonstrated the incidence of inappropriate prescriptions because each nation has a unique clinical practice environment.^{11,12} In China, the prevalence of PIMs was 73.4% in 2018¹¹ and in the United States it was 30%.¹² Therefore, effective optimization techniques are required to enhance the prescribing of medications for older patients.¹³ There is a requirement for an easy, affordable, and quick tool for screening to be used frequently to direct the practice of prescribers and lower inappropriate prescribing rates in older people. The tool used should be specific and sensitive, and the screening tool must provide positive clinical outcomes.¹⁴

Several tools have been developed to identify potentially inappropriate medications for older adults. The Beers Criteria are used to identify potentially inappropriate medications (PIMs) in older population. The American Geriatrics Society (AGS) is updated every three years and provides a medication list that is harmful or inappropriate for older people.¹⁵ The 2023 Beers Criteria provide five categories: medications considered potentially inappropriate, medications that are potentially inappropriate in patients with certain diseases or syndromes, medications to be used with caution, potentially inappropriate drug–drug interactions, and medications that require dose adjustment based on kidney function.

PIMs lead to a high risk of falls in older patients, decreased cognitive function, increased hospitalizations and mortality and increased healthcare costs.^{16,17} Antipsychotics, benzodiazepines, opioids and anticholinergics are common PIMs used in the older population.¹⁸ These medications should be used cautiously in older patients who really need them, keeping in mind that the benefits should outweigh the harm. Despite the familiarity of the Beers Criteria among clinicians, the proportion of PIMs in older adults is still on the rise.¹⁹

Although several studies have been published on PIMs in the older population using the Beers Criteria, no study has been conducted using the 2023 Beers Criteria. Hence, this study aimed to evaluate PIMs in older patients according to the Beers Criteria 2023 guidelines. To the best of our knowledge, this is the first multicenter study to assess PIMs in Tabuk using the 2023 Beers Criteria in older patients.

Materials and Methods

Study Design, Setting and Participants

This was a retrospective cross-sectional study in an inpatient setting. Electronic medical records were used to extract the data. Subjects aged ≥ 65 years, admitted to two government hospitals from June 2022 to May 2023, and prescribed five or more medications were included. Medical records with incomplete data, liver cirrhotic patients, chronic kidney disease stage 4 or 5 patients, dialysis patients and patients admitted to the intensive care unit or oncology department were excluded from this study. The sample size was calculated with a 99% confidence interval, 50% response distribution, and $\pm 5\%$ margin of error. The desired sample size was calculated using the Raosoft sample size calculator software to be 419 participants.²⁰ This study was conducted in accordance with the Declaration of Helsinki and approved by the Tabuk Institutional Review Board (TU-077/022/131).

Data Collection

Demographic details such as age, gender, height, weight, diagnosis, comorbid conditions, drug allergy or intolerance history, and prescription medications (generic name of the medication, dose, dosage, frequency, route of administration, duration of use) were extracted from the data records. Medications of older patients were assessed for PIMs using the 2023 Beers criteria.¹⁵ Creatinine clearance was calculated using the Cockcroft-Gault Equation.²¹

PIMs were categorized into medications considered potentially inappropriate, medications that are potentially inappropriate in patients with certain diseases or syndromes, medications to be used with caution, potentially inappropriate drug–drug interactions, and medications need dose adjustment based on kidney function.

Statistical Analysis

The data were analyzed using SPSS version 27. Descriptive analysis was performed for categorical and continuous variables and the results were expressed as means and standard deviations, numbers, percentages and p-values when necessary. Logistic regression was used to assess the influence of age, gender, number of medications and comorbidities on PIMs. A regression coefficient (Exp B) with a 95% confidence interval (CI) was reported, and the level of significance was set at $p < 0.05$.

Results

Based on the inclusion criteria, 420 patients' records were reviewed during the study period. Among them, 48% of the study population was male and 52% was female. The majority of the study population was in the age group 65–74 years (50.95%). The mean age of participants was 75.52 ± 8.70 years. Among the 420 study participants, the majority suffered from hypertension (72.38%) followed by diabetes mellitus (49.52%) (Table 1).

Based on the patient characteristics, Table 2 shows the frequency of PIMs among the participants. The frequency of PIMs increased as the number of diseases increased, and a similar pattern was observed for the number of medications. The prevalence of PIMs was similar between men and women.

The categorization of the PIMs is presented in Table 3. A total of 716 PIMs were identified. The proportion of medications considered as potentially inappropriate among older adults was 70.11% and the most commonly prescribed PIM were proton pump inhibitors (PPIs) (52.99%). The proportion of medications to be used with caution was 19.55%, and the most frequently prescribed medication to be used with caution was diuretics (91.43%).

Table 1 Characteristics of the Study Population

Variables	Male n (%)	Female n (%)	Total n (%)
	202 (48.1)	218 (51.9)	420 (100)
Age distribution (years)			
Mean age \pm SD	75.52 \pm 8.70		
65–74	102 (50.5)	112 (51.38)	214 (50.95)
75–84	64 (31.68)	68 (31.19)	132 (31.43)
\geq 85	36 (17.82)	38 (17.43)	74 (17.62)
Comorbidities			
Hypertension	136 (67.33)	168 (77.06)	304 (72.38)
Diabetes mellitus	104 (51.49)	104 (47.71)	208 (49.52)
Ischemic Heart Disease	58 (28.71)	58 (26.61)	116 (27.62)
Atrial fibrillation	8 (3.96)	24 (11.01)	32 (7.62)
Chronic Obstructive Pulmonary Disease	12 (5.94)	16 (7.34)	28 (6.67)
Congestive Cardiac Failure	6 (2.97)	14 (6.42)	20 (4.76)
Stroke / Transient Ischemic Attack	8 (3.96)	10 (4.59)	18 (4.29)
Osteoporosis	2 (0.99)	4 (1.83)	6 (1.43)
Peptic Ulcer Disease	0 (0%)	4 (1.83)	4 (0.95)

Table 2 Distribution of PIMs as per Patient Characteristics

Variables	Total no. of Participants n = 420	Participants with PIMs n = 342
Age distribution (years)	n (%)	n (%)
65–74	214 (50.95)	166 (77.57)
75–84	132 (31.43)	114 (86.36)
≥ 85	74 (17.62)	62 (83.78)
Gender		
Male	202 (48.1)	164 (81.19)
Female	218 (51.9)	178 (81.65)
Number of diseases		
1–2	252 (60)	194 (76.98)
3–4	140 (33.33)	122 (87.14)
≥ 5	28 (6.67)	26 (92.86)
Number of medications		
5–9	326 (77.62)	248 (76.07)
≥ 10	94 (22.38)	94 (100)

Table 3 Categorization of PIMS

Category of PIMS	Medications	n = 716 Number (%)
Medications considered as potentially inappropriate	Antihistamines	20 (3.98)
	Aspirin	138 (27.49)
	Amiodarone	6 (1.2)
	Digoxin	8 (1.59)
	Barbiturates	4 (0.8)
	Insulin	6 (1.2)
	Sulfonylureas	18 (3.59)
	Proton Pump Inhibitors	266 (52.99)
	Metoclopramide	6 (1.2)
	Nonsteroidal anti-inflammatory drugs (NSAIDs)	30 (5.98)
		Total: 502 (70.11)
	Medications to be used with caution	Diuretics
Tramadol		6 (4.29)
Carbamazepine		6 (4.29)
	Total: 140 (19.55)	
Potentially inappropriate drug–drug interactions	Alpha-1 blockers + Loop diuretics	8 (80)
	Corticosteroids + NSAIDs	2 (20)
	Total: 10 (1.4)	
Medications whose dosages should be adjusted based on renal function	Ciprofloxacin	22 (34.38)
	Enoxaparin	18 (28.13)
	Spironolactone	12 (18.75)
	Baclofen	2 (3.13)
	Levetiracetam	2 (3.13)
	NSAIDs	8 (12.5)
	Total: 64 (8.94)	

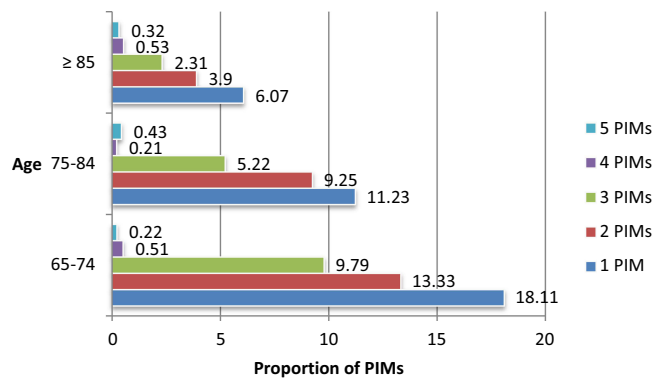


Figure 1 Proportion of older patients receiving PIMs.

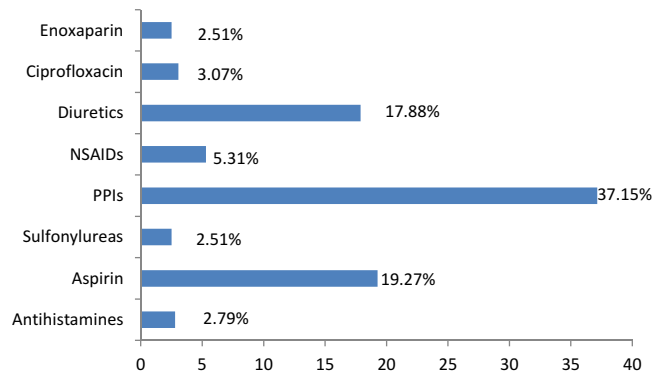


Figure 2 Commonly prescribed PIMs.

According to the AGS Beers Criteria 2023, 342 of 420 participants had PIMs (81.43%).

Of these, 35.41% were administered one PIM, 26.48% were administered two PIMs, and 17.32% were administered three PIMs. However, four (1.25%) and five (0.97%) PIMs were uncommon. The proportion of people who were prescribed PIMs according to age group is shown in Figure 1.

Among the 716 PIMs, the most commonly prescribed medications were PPIs (37.15%), followed by aspirin (19.27%) and diuretics (17.88%) (Figure 2).

Multivariate logistic regression was used to assess the influence of age, gender, number of medications and comorbidities on PIMs (Table 4). Gender and comorbidity did not influence PIMs, but age and number of medications significantly influenced the likelihood of PIMs.

Table 4 Logistic Regression Analysis Among Explanatory Variables and PIMs

Variables	B	S.E.	Sig.	Exp(B)	95% CI for Exp(B)	
					Lower	Upper
Age	0.045	0.017	0.008*	1.046	1.012	1.082
Gender	0.070	0.283	0.804	1.073	0.616	1.869
Comorbidities	0.044	0.133	0.743	1.045	0.805	1.356
Medications	0.991	0.180	<0.001*	2.693	1.891	3.835

Note: *p<0.05, statistically significant.
Abbreviation: CI, Confidence interval.

Discussion

This study assessed the prevalence of PIMs in the Tabuk population aged ≥ 65 years. Our study findings showed that most participants were in the age group of 65–69 years (32.38%), had one or two disease conditions (60%), hypertension (72.38%) and diabetes (49.52%) as common comorbidities, and were prescribed five to nine medications (77.62%) and 81.43% of the older patients were prescribed a PIM. The medications prescribed depend on the number of diseases; hence, multiple comorbidities compel the physicians to prescribe multiple medications.²² Our study found that one-third of the older persons had three to four comorbidities, which explains the prescription of more medications. In our study, nearly three-quarters of the study population had hypertension, and almost half of the study population had diabetes mellitus. Several studies have reported a positive association between PIMs and cardiovascular diseases and diabetes.^{23,24}

PIMs were commonly found among older persons in our study, which showed that 35.41% were prescribed one PIM and the prevalence of PIM was found to be 81.43%. A higher prevalence rate has also been observed in other studies. A study conducted in China reported 93.8% of PIM prevalence²⁵ and a Portuguese study reported the prevalence of PIMs to be 92%.²⁶ However, a study conducted in Riyadh, Saudi Arabia, reported that the prevalence of PIM in older adults was 57.2%, 63.6% and 60.4% in 2017, 2018 and 2019, respectively. They also reported an increase in the prevalence of PIMs from 2017 to 2019.²⁷ Different studies conducted in different settings reported the existence of PIMs – 53.1% in Kuwait,²⁸ 76% in Qatar²⁹ and 62.5% in Jordan.³⁰ The increased prevalence of PIMs in our older population could be related to the prescribing patterns of prescribers and difference in study setting and population. There may be limited awareness about PIMs and the tools used to assess PIMs, and the physicians' attitude of not making changes in the prescription prescribed by other physicians.³¹ Moreover, we used 2023 Beers criteria, which was a modified version of Beers criteria 2019. The modifications made in 2023 Beers criteria would also be a reason for this increasing prevalence of PIMs. For instance, aspirin was moved from “Medications to be used with caution” to “Medications considered as potentially inappropriate” on the basis of new evidence. In Saudi Arabia, most interns do not receive training in geriatric medicine.³² Moreover, 87% of residents reported that they did not wish to take geriatric medicine as their career in their future.³² These factors warrant further research to assess the local guidelines regarding medication prescribing in older persons. Studies have demonstrated that medication reviews resulted in a decrease in the prevalence of PIMs in older adults.^{33,34} The outcomes of pharmacist interventions have not yet been studied in Saudi Arabia. In addition, we included an older population prescribed at least 5 medications, which could be one of the reasons for the increased prevalence of PIMs.

According to our study, the proportion of medications considered as potentially inappropriate among older adults was 70.11% and the most commonly prescribed PIM were PPIs. Older adults generally expect the prescribers to prescribe them with PPIs and PPIs dramatically improve their quality of life.³⁵ The proportion of medications to be used with caution was 19.55%, and diuretics were the most frequently prescribed medications. Similar to our study results, another study reported that the prevalence of PIMs that should be avoided was 60.7%, with gastrointestinal drugs commonly prescribed, and the prevalence of PIMs that should be used with caution was 40.6%, with diuretics, antidepressants and antiplatelet drugs commonly prescribed.²⁹ Other studies also demonstrated that PPIs were the most common³⁶ and second most commonly prescribed PIM.³⁷ PPIs are most commonly used to treat ulcers and gastritis and are more frequently used in hospitalized patients to prevent stress ulcers.³⁸ Long-term use of PPIs results in renal toxicity or *Clostridium difficile* infection.³⁹ Pharmacists should intervene to improve the medication prescribing by reviewing the medication chart, assessing the appropriateness using different tools and discontinuing inappropriate medications.⁴⁰ The most common drug–drug interaction found in our study was alpha-1 blockers and loop diuretics, which was in accordance with another study that reported that loop diuretics-peripheral alpha-1 blockers were potentially inappropriate medication combinations.⁴¹ With regard to diuretics, PPIs and alpha-1 blockers, there were no differences between older Beers criteria and 2023 Beers criteria.

The current study found that gender and comorbidity did not influence PIMs, but age and number of medications significantly influenced the likelihood of PIMs. Similar results were obtained in another study, which reported that older populations with an increased number of diseases are more likely to be prescribed PIMs.²⁷ The number of medications dispensed is linked to the PIMs.⁴² An increased number of medications was found to be correlated with increased PIMs in older persons.^{23,43,44} The older population visits multiple physicians for their multiple health disorders, which further increases the risk of PIMs.³¹ Similar to our study, other studies have reported that age influences PIMs.^{45,46} A retrospective cohort study

conducted in the United States reported mixed results regarding age and PIMs.⁴⁷ In contrast, another study reported that age does not influence PIMs.⁴⁸ This difference in results might be due to the different PIMs criteria used, study populations, and study settings. Moreover, depending on the clinical setting, such as ambulatory care, home care, hospitalization, non-critically ill brain injury patients, and critically ill brain injury patients, the prevalence of PIMs among older patients varies.⁴⁹

To improve patient outcomes and care delivery, an increasing number of healthcare systems, healthcare providers, and primary care teams are seeking the expertise of pharmacists. A critical aspect of ensuring sound pharmaceutical practice is the deliberate and informed use of the most up-to-date evidence when making decisions regarding patient care. To promote rational drug use in these contexts, pharmacists should regularly evaluate medication usage patterns and guideline adherence in hospitals by relying on the best available data.⁵⁰

PIMs in older adults lead to high treatment costs and reduced quality of life; hence, prescribers should prescribe them appropriately.⁵¹ Physicians should consider all the factors associated with PIMs. The duration of medication and dose adjustment based on liver or kidney function should be strictly monitored in older individuals.

The main strength of our study is that this is the first multicenter study conducted in Tabuk using the 2023 Beers Criteria guidelines. This study calls for action by authoritative bodies to reduce the high prevalence of PIMs among older adults and advocates for a nationwide examination of this issue. Notably, no published studies have assessed the prevalence of PIMs in Saudi Arabia using the revised Beers Criteria 2023. Our study is not without limitations. We could not generalize the results because of the small sample size and limited number of study centers. The retrospective, cross-sectional nature of the study does not provide evidence of an association between the dependent and independent variables. However, this study provides additional knowledge about PIMs in older persons in Tabuk based on the recent Beers Criteria.

Conclusion

Our results showed that PIMs are prevalent among older adults and are significantly associated with multiple medications. Age-related changes in older persons may increase the risk of PIM prescription. Frequent audits should be performed to assess PIMs, and clinicians should be informed of the same to avoid serious outcomes associated with PIMs. Intervention designed to reduce PIM need to be initiated.

Abbreviations

PIMs, Potentially inappropriate medications; PPIs, Proton pump inhibitors; AGS, American Geriatrics Society; CI, Confidence interval.

Data Protection and Privacy

The data referenced in this study complied with relevant data protection and privacy regulations.

Ethics Approval and Consent to Participate

The study was approved by the Tabuk Institutional Review Board (TU-077/022/131). The data was collected from the medical records and hence waived from informed consent.

Acknowledgments

This research study has not received any funding.

Disclosure

The author(s) report no conflicts of interest in this work.

References

1. Khamis S, Abdi AM, Uzan A, Basgut B. applying beers criteria for elderly patients to assess rational drug use at a university hospital in Northern Cyprus. *J Pharm Bioallied Sci.* 2019;11(2):133–141. doi:10.4103/jpbs.JPBS_208_18
2. United Nations, Department of Economic and Social Affairs, Population Division (2017). World Population Ageing 2017 - Highlights (ST/ESA/SER.A/397). Available from: https://www.un.org/en/development/desa/population/publications/pdf/ageing/WPA2017_Highlights.pdf. Accessed October 10, 2023.

3. Aina FO, Fadare JO, Deji-Dada OO, Agbesanwa TA. increasing burden of aging population on health services utilization: a myth or reality in a country with predominantly young population. *Aging Med Healthc.* 2021;12(2):41–45. doi:10.33879/AMH.122.2020.07023
4. Alsuwaidan A, Almedlej N, Alsabti S, et al. A comprehensive overview of polypharmacy in elderly Patients in Saudi Arabia. *Geriatrics.* 2019;4(2):36. doi:10.3390/geriatrics4020036
5. Varghese D, Ishida C, Haseer Koya H. Polypharmacy. *StatPearls.* StatPearls Publishing; 2023. Available from: <http://www.ncbi.nlm.nih.gov/books/NBK532953/>. Accessed January 12, 2024.
6. Masnoon N, Shakib S, Kalisch-Ellett L, Caughey GE. What is polypharmacy? A systematic review of definitions. *BMC Geriatr.* 2017;17:230. doi:10.1186/s12877-017-0621-2
7. Walckiers D, Van der Heyden J, Tafforeau J. Factors associated with excessive polypharmacy in older people. *Arch Public Health.* 2015;73:50. doi:10.1186/s13690-015-0095-7
8. Lavan AH, Gallagher P. Predicting risk of adverse drug reactions in older adults. *Ther Adv Drug Saf.* 2016;7(1):11–22. doi:10.1177/2042098615615472
9. Rambhade S, Chakarborty A, Shrivastava A, Patil UK, Rambhade A. A survey on polypharmacy and use of inappropriate medications. *Toxicol Int.* 2012;19(1):68–73. doi:10.4103/0971-6580.94506
10. Chen Y, Zhu LL, Zhou Q. Effects of drug pharmacokinetic/pharmacodynamic properties, characteristics of medication use, and relevant pharmacological interventions on fall risk in elderly patients. *Ther Clin Risk Manag.* 2014;10:437–448. doi:10.2147/TCRM.S63756
11. Tian F, Liao S, Chen Z, Xu T. The prevalence and risk factors of potentially inappropriate medication use in older Chinese inpatients with multimorbidity and polypharmacy: a cross-sectional study. *Ann Transl Med.* 2021;9(18):1483. doi:10.21037/atm-21-4238
12. Davidoff AJ, Miller GE, Sarpong EM, Yang E, Brandt N, Fick DM. Prevalence of potentially inappropriate medication use in older adults using the 2012 beers criteria. *J Am Geriatr Soc.* 2015;63(3):486–500. doi:10.1111/jgs.13320
13. Saeed D, Carter G, Parsons C. Interventions to improve medicines optimisation in frail older patients in secondary and acute care settings: a systematic review of randomised controlled trials and non-randomised studies. *Int J Clin Pharm.* 2022;44(1):15–26. doi:10.1007/s11096-021-01354-8
14. Patterson SM, Cadogan CA, Kerse N, et al. Interventions to improve the appropriate use of polypharmacy for older people. *Cochrane Database Syst Rev.* 2014;10:CD008165. doi:10.1002/14651858.CD008165.pub3
15. By the 2023 American Geriatrics Society Beers Criteria® Update Expert Panel. American Geriatrics Society 2023 updated AGS beers criteria® for potentially inappropriate medication use in older adults. *J Am Geriatr Soc.* 2023;71(7):2052–2081. doi:10.1111/jgs.18372
16. Clark CM, Shaver AL, Aurelio LA, et al. Potentially inappropriate medications are associated with increased healthcare utilization and costs. *J Am Geriatr Soc.* 2020;68(11):2542–2550. doi:10.1111/jgs.16743
17. Hospitalization and death associated with potentially inappropriate medication prescriptions among elderly nursing home residents. Available from: <https://pubmed.ncbi.nlm.nih.gov/15642877/>. Accessed October 11, 2023.
18. Al Odhayani A, Tourkmani A, Alshehri M, Alqahtani H, Mishriky A. Potentially inappropriate medications prescribed for elderly patients through family physicians. *Saudi J Biol Sci.* 2017;24(1):200–207. doi:10.1016/j.sjbs.2016.05.006
19. Shaver AL, Clark CM, Hejna M, Feuerstein S, Wahler RG, Jacobs DM. Trends in fall-related mortality and fall risk increasing drugs among older individuals in the United States, 1999–2017. *Pharmacoepidemiol Drug Saf.* 2021;30(8):1049–1056. doi:10.1002/pds.5201
20. Sample size calculator by Raosoft, Inc. Available from: <http://www.raosoft.com/samplesize.html>. Accessed January 15, 2024.
21. Cockcroft-Gault Formula. National kidney foundation. Available from: https://www.kidney.org/professionals/kdoqi/gfr_calculatorcoc. Accessed January 15, 2024.
22. Awad A, Alhadab A, Albassam A. Medication-related burden and medication adherence among geriatric patients in Kuwait: a cross-sectional study. *Front Pharmacol.* 2020;11:1296. doi:10.3389/fphar.2020.01296
23. Alhawassi TM, Alatawi W, Alwhaibi M. Prevalence of potentially inappropriate medications use among older adults and risk factors using the 2015 American Geriatrics Society Beers criteria. *BMC Geriatr.* 2019;19(1):154. doi:10.1186/s12877-019-1168-1
24. Vieira de lima TJ, Garbin CAS, Garbin AJ, Sumida DH, Saliba O. Potentially inappropriate medications used by the elderly: prevalence and risk factors in Brazilian care homes. *BMC Geriatr.* 2013;13:52. doi:10.1186/1471-2318-13-52
25. Tang J, Wang K, Yang K, et al. A combination of Beers and STOPP criteria better detects potentially inappropriate medications use among older hospitalized patients with chronic diseases and polypharmacy: a multicenter cross-sectional study. *BMC Geriatr.* 2023;23(1):44. doi:10.1186/s12877-023-03743-2
26. Prescription of potentially inappropriate medication in older inpatients of an internal medicine Ward: concordance and overlap among the EU (7)-PIM list and beers and STOPP criteria. Available from: <https://pubmed.ncbi.nlm.nih.gov/34393774/>. Accessed October 11, 2023.
27. Jabri FF, Liang Y, Alhawassi TM, Johnell K, Möller J. Potentially inappropriate medications in older adults-prevalence, trends and associated factors: a cross-sectional study in Saudi Arabia. *Healthcare.* 2023;11(14):2003. doi:10.3390/healthcare11142003
28. Awad A, Hanna O. Potentially inappropriate medication use among geriatric patients in primary care setting: a cross-sectional study using the Beers, STOPP, FORTA and MAI criteria. *PLoS One.* 2019;14(6):e0218174. doi:10.1371/journal.pone.0218174
29. Al-Dahshan A, Kehyayan V. Prevalence and predictors of potentially inappropriate medication prescription among older adults: a cross-sectional study in the state of Qatar. *Drugs Real World Outcomes.* 2021;8(1):95–103. doi:10.1007/s40801-020-00220-9
30. Al-Azayzih A, Alamoori R, Altawalbeh SM. Potentially inappropriate medications prescribing according to Beers criteria among elderly outpatients in Jordan: a cross sectional study. *Pharm Pract.* 2019;17(2):1439. doi:10.18549/PharmPract.2019.2.1439
31. Nothelle SK, Sharma R, Oakes A, Jackson M, Segal JB. Factors associated with potentially inappropriate medication use in community-dwelling older adults in the United States: a systematic review. *Int J Pharm Pract.* 2019;27(5):408–423. doi:10.1111/ijpp.12541
32. AlZamil A, AlHoqail R, Alodhayani A. Barriers and attitudes of family and internal medicine residents toward geriatric patients: a cross-sectional analytical study. *Adv Med Educ Pract.* 2019;10:585–590. doi:10.2147/AMEP.S171376
33. Lee S, Yu YM, Han E, Park MS, Lee JH, Chang MJ. Effect of pharmacist-led intervention in elderly patients through a comprehensive medication reconciliation: a randomized clinical trial. *Yonsei Med J.* 2023;64(5):336–343. doi:10.3349/ymj.2022.0620
34. Stuhc M, Lah L. Clinical pharmacist interventions in elderly patients with mental disorders in primary care focused on psychotropics: a retrospective pre-post observational study. *Ther Adv Psychopharmacol.* 2021;11:20451253211011007. doi:10.1177/20451253211011007

35. Rababa M, Rababa'h A. Community-dwelling older adults' awareness of the inappropriate use of proton pump inhibitors. *BMC Geriatr.* 2020;20(1):431. doi:10.1186/s12877-020-01844-w
36. Wang P, Wang Q, Li F, Bian M, Yang K. Relationship between potentially inappropriate medications and the risk of hospital readmission and death in hospitalized older patients. *Clin Interv Aging.* 2019;14:1871–1878. doi:10.2147/CIA.S218849
37. Sheikh-Taha M, Dimassi H. Potentially inappropriate home medications among older patients with cardiovascular disease admitted to a cardiology service in USA. *BMC Cardiovasc Disord.* 2017;17(1):189. doi:10.1186/s12872-017-0623-1
38. Clarke K, Adler N, Agrawal D, et al. Reducing overuse of proton pump inhibitors for stress ulcer prophylaxis and nonvariceal gastrointestinal bleeding in the hospital: a narrative review and implementation guide. *J Hosp Med.* 2021;16(7):417–423. doi:10.12788/jhm.3637
39. Jaynes M, Kumar AB. The risks of long-term use of proton pump inhibitors: a critical review. *Ther Adv Drug Saf.* 2018;10:2042098618809927. doi:10.1177/2042098618809927
40. Spinewine A, Fialová D, Byrne S. The role of the pharmacist in optimizing pharmacotherapy in older people. *Drugs Aging.* 2012;29(6):495–510. doi:10.2165/11631720-000000000-00000
41. Kitapçı MT, Karakuş O, Işli F, Aksoy M, Güvel MC, Uluoğlu C. Evaluation of the potentially inappropriate cardiovascular medication prescription in elderly: a nationwide study in Turkey. *Anatol J Cardiol.* 2023;27(6):328–338. doi:10.14744/AnatolJCardiol.2023.2618
42. Guaraldo L, Cano FG, Damasceno GS, Rozenfeld S. Inappropriate medication use among the elderly: a systematic review of administrative databases. *BMC Geriatr.* 2011;11:79. doi:10.1186/1471-2318-11-79
43. Alwhaibi M. Potentially inappropriate medications use among older adults with comorbid diabetes and hypertension in an ambulatory care setting. *J Diabetes Res.* 2022;2022:1591511. doi:10.1155/2022/1591511
44. Alturki A, Alaama T, Alomran Y, Al-Jedai A, Almudaiheem H, Watfa G. 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
45. Nagai T, Nagaoka M, Tanimoto K, Tomizuka Y, Uei H, Nakanishi K. Relationship between potentially inappropriate medications and functional prognosis in elderly patients with distal radius fracture: a retrospective cohort study. *J Orthop Surg Res.* 2020;15(1):321. doi:10.1186/s13018-020-01861-w
46. Early NK, Fairman KA, Hagarty JM, Sclar DA. Joint effects of advancing age and number of potentially inappropriate medication classes on risk of falls in Medicare enrollees. *BMC Geriatr.* 2019;19(1):194. doi:10.1186/s12877-019-1202-3
47. Jungo KT, Streit S, Lauffenburger JC. Patient factors associated with new prescribing of potentially inappropriate medications in multimorbid US older adults using multiple medications. *BMC Geriatr.* 2021;21(1):163. doi:10.1186/s12877-021-02089-x
48. Abdelwahed AA, El-Dahiyat F, Aljawamis D, Al Ajimi J, Bin Rafeea KJ. Potentially inappropriate medications in older adults according to Beers criteria 2019: prevalence and risk factors. *Int J Clin Pract.* 2021;75(11):e14715. doi:10.1111/ijcp.14715
49. Bao Y, Shao H, Bishop TF, Schackman BR, Bruce ML. Inappropriate medication in a national sample of US elderly patients receiving home health care. *J Gen Intern Med.* 2012;27(3):304–310. doi:10.1007/s11606-011-1905-4
50. Ryan R, Santesso N, Lowe D, et al. Interventions to improve safe and effective medicines use by consumers: an overview of systematic reviews. *Cochrane Database Syst Rev.* 2014;2014(4):CD007768. doi:10.1002/14651858.CD007768.pub3
51. Mucherino S, Casula M, Galimberti F, et al. The effectiveness of interventions to evaluate and reduce healthcare costs of potentially inappropriate prescriptions among the older adults: a systematic review. *Int J Environ Res Public Health.* 2022;19(11):6724. doi:10.3390/ijerph19116724