

ORIGINAL ARTICLE

Potentially Inappropriate Medications (PIMs) in Elderly Hypertensive Inpatients using 2023 AGS Beers Criteria: A Cross-Sectional Study

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ABSTRACT

Polypharmacy and complex pharmacotherapy are common among older adults with hypertension and increase the risk of potentially inappropriate medications (PIMs). This study aimed to determine the prevalence, patterns, and predictors of PIM exposure among elderly hypertensive inpatients at Universitas Indonesia Hospital (RSUI) using the 2023 updated American Geriatrics Society (AGS) Beers Criteria®. A retrospective cross-sectional study was conducted using de-identified electronic medical records. Of 1,265 admissions screened between 2023 and 2024, 200 hypertensive inpatients aged ≥65 years met the inclusion criteria. Inpatient prescriptions were evaluated according to the 2023 AGS Beers Criteria and categorized accordingly. Logistic regression analysis was performed to identify independent predictors of PIM exposure. The mean age was 72.1 ± 6.46 years, and 55.0% were female; polypharmacy (≥5 medications) was highly prevalent (85.5%). Overall, 83.0% of patients received at least one Beers-listed medication, most commonly Category 3 (“use with caution”) PIMs (72.5%), followed by Category 1 (“avoid”) (26.0%) and Category 4 (23.5%). The most frequently prescribed PIMs were furosemide (55.5%), clonidine (24.5%), and hydrochlorothiazide (24.0%). In multivariable analysis, polypharmacy (≥5 medications) emerged as the sole independent predictor of PIM exposure (adjusted OR 3.30; 95% CI 1.17–9.32; $p = 0.024$). The high prevalence of cardiovascular-related PIMs is clinically concerning, as these agents may increase the risk of electrolyte disturbances, orthostatic hypotension, and hyperkalemia in elderly hypertensive inpatients, particularly those with reduced renal function. These findings underscore the importance of structured inpatient medication review, careful monitoring of high-risk cardiovascular regimens, and pharmacist-led deprescribing interventions during hospitalization.

Keywords: aged; Beers Criteria; hypertension; inpatients; potentially inappropriate medication

Introduction

Cardiovascular disease remains a major global health burden, and hypertension is a major contributor [1]. Hypertension (≥140/90 mmHg) affected over 1.39 billion adults (31.1%) in 2010 and is driven by several modifiable lifestyle factors [2]. Additional cardiovascular risk factors are present in over half of people with hypertension, and early-stage disease is often asymptomatic, allowing heart damage to go undetected [3].

Managing hypertension becomes more difficult as the population ages. An estimated 2.1 billion adults worldwide will be 60 years of age or older by 2050 [4]. Indonesia's elderly population increased, and it is anticipated that this tendency will continue, and by 2035, there will be 48.2 million older adults (15.77%) [5]. However, the challenge of hypertension management in older adults extends beyond demographic ageing. Elderly patients frequently present with multimorbidity and require multiple concurrent medications, leading to polypharmacy and increased risk of drug-drug interactions [6–8]. Furthermore, age-related alterations in pharmacokinetics and pharmacodynamics, such as reduced renal clearance, altered drug distribution, and heightened sensitivity to antihypertensive agents, predispose older adults to hypotension, electrolyte disturbances, and adverse drug reactions [9,10]. Together, these

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clinical and physiological factors complicate blood pressure control and increase the risk of medication-related harm.

In Indonesia, hypertension is highly prevalent and is still not properly diagnosed, treated, and controlled, reflecting gaps in awareness and long-term management [11]. In 2018, Basic Health Research reported that the prevalence of hypertension rose from 25.8% to 34.1%, indicating a substantial and growing burden among the population [12]. Within this context, medication safety in older adults becomes particularly important.

Potentially inappropriate medication (PIM) use remains a significant concern in geriatric pharmacotherapy. PIM exposure is associated with clinically important adverse outcomes in older adults, including falls related to orthostatic hypotension, acute kidney injury in the setting of reduced renal reserve, electrolyte imbalance, and increased hospitalization risk [13,14]. International evidence confirms that PIM exposure remains widespread among older populations across care settings [15]. These risks are especially relevant in elderly hypertensive patients receiving complex cardiovascular regimens. To support safer prescribing in older adults, several explicit screening tools have been developed, among which the American Geriatrics Society (AGS) Beers Criteria are widely applied due to their strong evidence base and regular updates [14].

Indonesian studies have reported substantial PIM prevalence among older adults in primary care, outpatient, and hospital settings, with polypharmacy consistently identified as a major predictor of inappropriate prescribing [16–20]. However, data remain limited for elderly hypertensive inpatients, a high-risk subgroup frequently exposed to intensive cardiovascular pharmacotherapy during hospitalization.

Universitas Indonesia Hospital (RSUI), a tertiary teaching hospital in West Java, manages medically complex patients with substantial comorbidity burden and extensive medication exposure. Evaluating PIM use within this institutional setting provides insight into real-world prescribing practices in Indonesian tertiary care and may help identify actionable targets for improving inpatient medication safety. Moreover, no RSUI-specific study has applied the updated 2023 AGS Beers Criteria to assess PIM exposure in elderly

hypertensive inpatients. Therefore, this study aimed to determine the prevalence and pattern of PIM use and to evaluate associated factors (age group, sex, comorbidity burden, and polypharmacy) among hypertensive inpatients aged ≥ 65 years at RSUI. We hypothesized that PIM exposure in this cohort would be significantly associated with age, sex, comorbidity burden, and polypharmacy.

METHODS

Study Design and Setting

This study was conducted at Universitas Indonesia Hospital (RSUI), a tertiary teaching hospital in Depok, West Java, Indonesia, using a retrospective cross-sectional methodology. The study evaluated prescribing patterns and potentially inappropriate medication use during inpatient care using de-identified electronic medical records of hospitalized patients.

Study Population

Patients were eligible if they were at least 65 years old, had a documented diagnosis of hypertension, had taken at least one antihypertensive drug while in the hospital, and were hospitalized for less than eight days. Patients receiving palliative or terminal care, or those with incomplete key data, were excluded.

Sample Size and Patient Selection

A total of 1,265 inpatient admissions were assessed for eligibility during the study period. Of these, 200 patients met the inclusion criteria and were included in the final analysis. All eligible patients identified during the study period were included in the analytic dataset.

Data Collection

A standardized data collection form was used to retrieve clinical and demographic information from the electronic medical records, including age, gender, primary diagnosis of comorbid conditions, and duration of hospital stay. Comorbidities were identified based on documented physician diagnoses recorded in admission and discharge summaries within the electronic medical record. Relevant laboratory results, such as renal function tests, were also recorded. Creatinine clearance (CrCl) was estimated using the Cockcroft–Gault equation [21]. Medication-related information for all prescriptions during hospitalization was collected.

Polypharmacy was defined as the concurrent use of five or more drugs, and comorbidities were determined from physician-documented diagnoses.

Outcome Assessment

Medications prescribed during hospitalization were assessed for potentially inappropriate medications (PIMs) using the American Geriatrics Society (AGS) 2023 updated Beers Criteria [14]. The Beers Criteria classify PIMs into five categories: (1) medications considered as potentially inappropriate; (2) medications potentially inappropriate in patients with certain diseases or syndromes; (3) medications to be used with caution; (4) potentially inappropriate drug–drug interactions; and (5) medications whose dosages should be adjusted based on renal function. Patients receiving at least one Beers-listed medication from any category were considered to have PIM exposure.

Statistical Analysis

IBM SPSS Statistics version 30 was used to analyze the data. For both continuous and categorical variables, descriptive analyses were carried out. The findings are presented as means and standard deviations, as well as numbers and percentages, where applicable. Binary logistic regression was used to further investigate the relationship between PIM usage and explanatory variables (age group, gender, comorbidity group, and polypharmacy status) in order to find independent predictors of PIM use. A p-value of less than 0.05 was deemed statistically significant, and regression coefficients (adjusted odds ratios) with 95% confidence intervals (CIs) were shown.

Ethics

The study protocol was approved by the Universitas Indonesia Hospital Research Ethics Committee with number (S-086/KETLIT/RSUI/III/2025). Because only de-identified retrospective data were used, the requirement for individual informed consent was waived. All procedures were conducted in accordance with the principles of the Declaration of Helsinki.

RESULT AND DISCUSSION

After screening 1,265 hypertensive inpatient admissions between 2023 and 2024, 200 patients aged

≥65 years who met eligibility criteria were included in the final analysis. The demographic and clinical characteristics of the study population are summarized in **Table 1**. The mean age was 72.1 ± 6.46 years, and 55.0% were female. Polypharmacy (≥5 medications) was highly prevalent (85.5%), with a mean of 9.11 ± 3.64 medications per patient. The mean creatinine clearance (CrCl) was 43.64 ± 14.10 mL/min, indicating reduced renal function in a substantial proportion of patients, and the mean length of stay was 5.41 ± 1.31 days. These findings reflect a medically complex inpatient cohort characterized by multimorbidity and extensive pharmacotherapy exposure.

Using the 2023 AGS Beers Criteria, 83.0% (166/200) of patients received at least one potentially inappropriate medication (PIM) during hospitalization. The distribution of PIM exposure according to demographic and clinical characteristics is presented in

Table 1. Characteristics of the study population (n = 200)

Variables	n (%) / Mean ± SD
Age (years)	
Mean ± SD	72.1 ± 6.46
65–74	130 (65.0)
75–84	59 (29.5)
≥85	11 (5.5)
Sex	
Male	90 (45.0)
Female	110 (55.0)
Comorbidity group	
1–2 comorbidities	52 (26.0)
≥3 comorbidities	148 (74.0)
Polypharmacy (≥5 medicines)	
No	29 (14.5)
Yes	171 (85.5)
Other clinical variables (Mean ± SD)	
Length of stay (days)	5.41 ± 1.31
Creatinine clearance (mL/min)	43.64 ± 14.10
Total number of medicines	9.11 ± 3.64

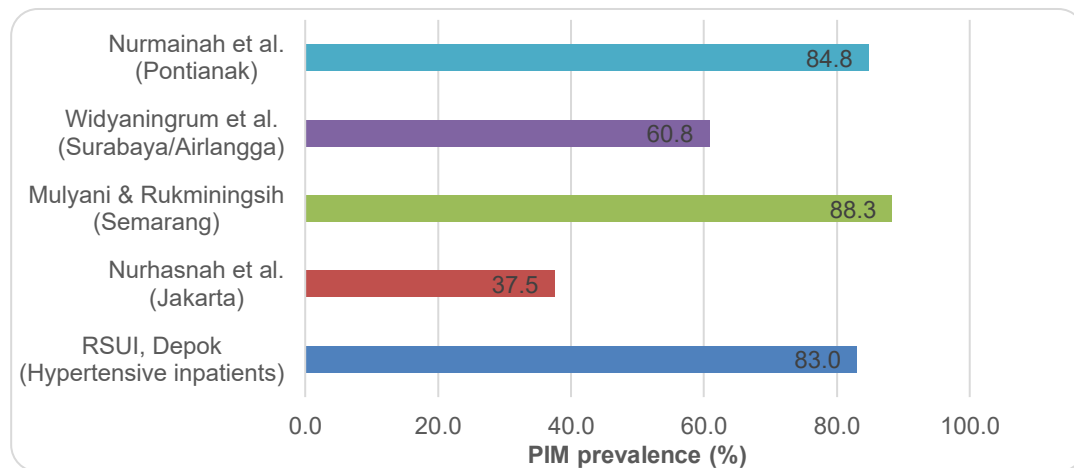


Figure 1. Comparison of potentially inappropriate medication (PIM) prevalence across Indonesian studies using the Beers criteria.

Table 2. Although PIM prevalence was broadly similar across age groups and sex, it was notably higher among patients with polypharmacy, reinforcing the well-established association between medication burden and inappropriate prescribing in older adults [15,22].

The overall PIM prevalence observed in this study is consistent with recent hospital-based findings reporting high Beers-defined PIM exposure among older inpatients, particularly in populations characterized by multimorbidity and intensive pharmacotherapy [23,24]. Differences across studies are expected due to variations in care settings, disease-specific cohorts, and the version of the Beers Criteria applied [25,26]. A

comparative overview of PIM prevalence across Indonesian studies applying the Beers Criteria is presented in **Figure 1**.

When PIMs were classified according to Beers' categories (**Table 3**), Category 3 ("use with caution") was the most frequent (72.5%), followed by Category 1 ("avoid") (26.0%) and Category 4 (clinically important drug–drug interactions) (23.5%). Category 5 (renal function–based recommendations) accounted for 6.0%, while Category 2 (drug–disease interactions) was uncommon (1.5%). Because individual patients could receive multiple PIMs across different categories, total percentages exceed 100%. The proportional distribution of PIMs across Beers categories is illustrated in **Figure 2**.

The predominance of Category 3 PIMs aligns with findings from other inpatient cohorts applying recent Beers updates, where monitoring-sensitive medications constitute a substantial proportion of identified PIMs [24,27]. This pattern suggests that inappropriate prescribing in hospitalized elderly hypertensive patients may frequently reflect issues related to monitoring and

Table 2. Distribution of PIM exposure by patient characteristics (n = 200)

Variable	Category	Total participant n (%)	Participants with PIMs n (%)
Overall PIM status	No	34 (17.0)	—
	Yes	166 (83.0)	—
Age group	65–74	130 (65.0)	106 (81.5)
	75–84	59 (29.5)	51 (86.4)
	≥85	11 (5.5)	9 (81.8)
Sex	Male	90 (45.0)	77 (85.6)
	Female	110 (55.0)	89 (80.9)
Comorbidity group	1–2	52 (26.0)	42 (80.8)
	≥3	148 (74.0)	124 (83.8)
Polypharmacy	No (<5)	29 (14.5)	20 (69.0)
	Yes (≥5)	171 (85.5)	146 (85.4)

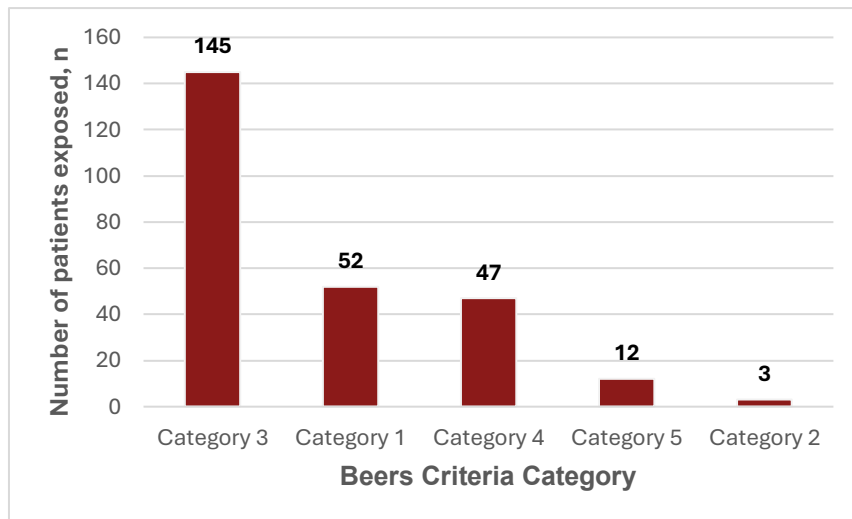


Figure 2. Distribution of PIMs by Beers Criteria category

dose optimization rather than absolute contraindication.

At the medication level, the most frequent Category 3 agents were furosemide (55.5%) and hydrochlorothiazide (24.0%), reflecting substantial diuretic exposure in older hypertensive inpatients (**Table 3**). The relative frequency of the most commonly prescribed PIMs is depicted in **Figure 3**. According to the 2023 AGS Beers Criteria, diuretics are flagged because of their potential to precipitate or worsen hyponatremia and SIADH in older adults, particularly those with impaired renal function [14].

In the inpatient setting, laboratory monitoring is feasible; however, practical challenges remain.

Electrolyte disturbances may be multifactorial, laboratory surveillance may vary across teams, and adverse drug effects may be attributed to underlying disease rather than medication exposure. Therefore, the high frequency of diuretic-related PIMs in this cohort should be interpreted as a monitoring-sensitive prescribing issue rather than automatic inappropriate use. These

findings support the implementation of structured medication review processes and standardized sodium and renal function monitoring protocols, particularly in patients with polypharmacy [15].

Within Category 1 (“avoid”), clonidine (24.5%) and immediate-release nifedipine (1.0%) were identified (**Table 3**). These medications are discouraged in older adults because clonidine may cause central nervous system adverse effects, bradycardia, and orthostatic hypotension, whereas immediate-release nifedipine may cause marked hypotension and myocardial ischemia. These findings emphasize the importance of preferring longer-acting antihypertensive agents with

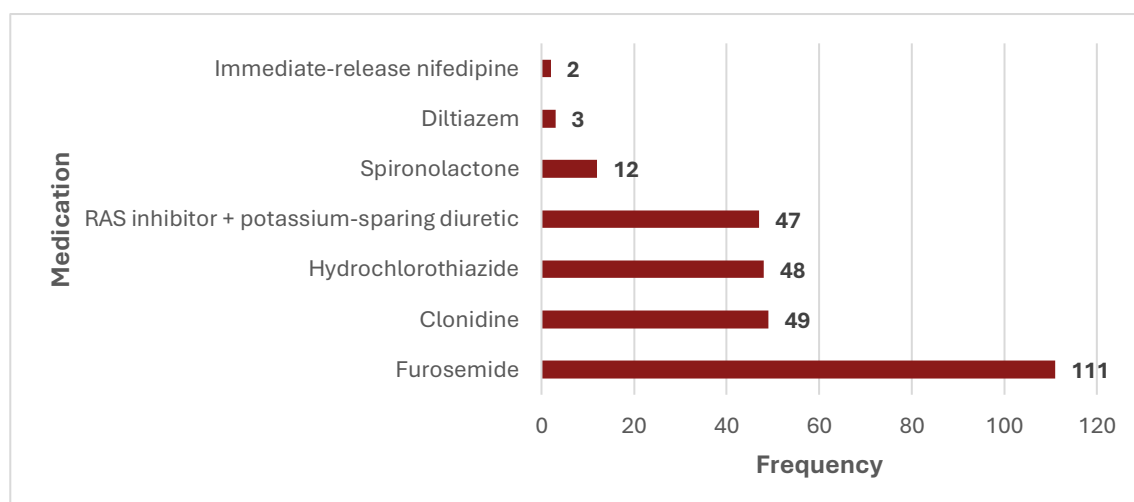


Figure 3. Most frequently prescribed potentially inappropriate medications identified using the 2023 AGS Beers Criteria among older hypertensive inpatients

Table 3. PIMs according to the 2023 AGS Beers Criteria categories

Beers category	Medications	n exposed	% of total	Recommendation (Beers 2023)	Quality of evidence	Strength of recommendation
Category 1: Medications considered as potentially inappropriate	Clonidine	49	24.5	Avoid.	Low	Strong
	Nifedipine (immediate release)	2	1.0	Avoid.	High	Strong
Category 2: Potentially inappropriate in certain diseases/syndromes	Diltiazem	3	1.5	Avoid	Moderate	Strong
Category 3: Medications to be used with caution	Furosemide	111	55.5	Use with caution	Moderate	Strong
	Hydrochloro thiazide	48	24.0	Use with caution	Moderate	Strong
Category 4: Potentially inappropriate drug-drug interactions	RAS inhibitor + potassium-sparing diuretic	47	23.5	Avoid routinely using ≥2 RAS inhibitors, or a RAS inhibitor + potassium-sparing diuretic concurrently in CKD stage 3a or higher.	Moderate	Strong
Category 5: Medications whose dosages should be adjusted based on renal function	Spirolactone when CrCl <30 mL/min	12	6.0	Avoid.	Moderate	Strong

Note: A patient may meet criteria for more than one category; therefore, category totals can exceed 100%.

Abbreviations: CrCl = Creatinine clearance, RAS = Renin-Angiotensin System

more predictable pharmacodynamic profiles and highlight the need for careful review of centrally acting antihypertensives in elderly inpatients.

Clinically important drug-drug interactions (Category 4) were primarily driven by combinations of a renin-angiotensin system (RAS) inhibitor plus a potassium-sparing diuretic (23.5%). This combination increases the risk of hyperkalemia, particularly among older adults with reduced renal function.

Hyperkalemia in this population may lead to cardiac conduction abnormalities, life-threatening arrhythmias, muscle weakness, and sudden clinical

deterioration. Given that the mean CrCl in this cohort was 43.64 mL/min, impaired renal clearance likely amplified susceptibility to electrolyte disturbances. The 2023 AGS Beers Criteria specifically caution against such combinations in older adults and recommend careful monitoring of renal function and serum potassium [14].

Accordingly, routine renal function assessment and potassium monitoring should be integral components of inpatient medication review for elderly hypertensive patients receiving RAS-modulating therapies.

In multivariable logistic regression analysis (**Table**

4), polypharmacy emerged as the sole independent predictor of PIM exposure (adjusted OR 3.30; 95% CI 1.17–9.32; $p = 0.024$). Age group, sex, and comorbidity burden were not statistically significant after adjustment.

This finding is consistent with contemporary literature demonstrating that increasing medication count is a strong and independent determinant of Beers-listed medication exposure [15,22,23]. The results suggest that medication burden may represent a more actionable intervention target than demographic characteristics alone.

From a clinical perspective, these findings support prioritizing structured medication review during hospitalization for elderly hypertensive patients prescribed ≥ 5 medications. Pharmacist-led medication reconciliation and deprescribing interventions have been shown to reduce inappropriate prescribing and medication-related harm in older adults with polypharmacy [28,29].

This study provides RSUI-specific data on PIM exposure among elderly hypertensive inpatients using the updated 2023 AGS Beers Criteria. By incorporating clinically relevant variables such as polypharmacy and renal function, the analysis offers practical insight into modifiable risk factors for medication safety in older adults.

However, several limitations should be acknowledged. As a retrospective single-center study relying on electronic medical records, the findings may have limited generalizability to other institutions with different patient demographics or prescribing practices.

Documentation completeness may have affected comorbidity and medication classification. Additionally, the Beers Criteria serve as an explicit screening tool and do not account for individualized clinical rationale; therefore, some medications identified as PIMs may have been clinically justified. Finally, the study did not evaluate clinical outcomes such as falls, acute kidney injury, readmission, or mortality, precluding causal inference. Future prospective and multicenter studies incorporating outcome assessment are warranted to determine whether reducing PIM exposure translates into improved clinical outcomes in elderly hypertensive inpatients.

CONCLUSION

Potentially inappropriate medication use was highly prevalent among elderly hypertensive inpatients at Universitas Indonesia Hospital and was largely driven by cardiovascular pharmacotherapy, including diuretics, clonidine, immediate-release nifedipine, and high-risk renin-angiotensin system combinations, particularly in patients with reduced renal function. Polypharmacy emerged as the sole independent predictor of PIM exposure, highlighting medication burden as a practical and modifiable target for intervention.

These findings support the implementation of structured inpatient medication review protocols, with particular emphasis on electrolyte and renal function monitoring for diuretics and RAS-modulating therapies, avoidance or substitution of non-preferred antihypertensive agents where feasible, and pharmacist-led medication reconciliation and deprescribing initiatives for patients prescribed five or more medications.

Future prospective and interventional studies are warranted to evaluate whether targeted medication review strategies can reduce PIM exposure and translate into measurable improvements in clinical outcomes, such as reduced falls, electrolyte disturbances, hospital readmissions, and overall medication-related harm in elderly hypertensive populations.

Table 4. Logistic regression analysis of factors associated with PIM exposure

Predictor	aOR	95% CI	p value
Age 65–74 vs ≥ 85	0.76	0.14–4.02	0.746
Age 75–84 vs ≥ 85	1.25	0.21–7.33	0.802
Male vs female	1.60	0.73–3.48	0.241
Comorbidity 1–2 vs ≥ 3	1.31	0.51–3.37	0.576
Polypharmacy (≥ 5) vs no	3.30	1.17–9.32	0.024

Model notes: Omnibus test $p = 0.241$; Hosmer–Lemeshow $p = 0.799$; Nagelkerke $R^2 = 0.055$.

CONFLICT OF INTEREST

The authors have no conflicts of interest regarding this investigation.

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