Shaping geriatric practice: evaluating Beers, PRISCUS, and European Union(7) criteria for optimal patient care. A retrospective study

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Abstract

Medications whose risk of adverse drug events exceeds their expected clinical benefit when given to older patients are called potentially inappropriate medications (PIMs). The geriatric population represents about 10% of the world population and 7% of the Indian population and consumes 40% of prescription and 35% of all over-the-counter drugs. That is why it is necessary to evaluate the use of PIMs in the geriatric population.

This study aimed to evaluate prescriptions for PIMs by using three pre-validated and internationally used criteria, namely the Beers criteria (2019), the European Union (EU)(7) list (2015), and the PRISCUS list (2010). A retrospective observational study began after obtaining written approval from the institutional review board. Demographic and clinical profiles and patients' complete prescriptions were recorded, and the Beers criteria (2019), the EU(7) (2015) list, and the PRISCUS list (2010) were applied. A $p<0.05$ was considered statistically significant. A total of 345 patients, with a mean age of 71.48 years, were included in the study. Vitamin D3 (56.81%) was frequently prescribed as medicine. According to the Beers, EU(7), and PRISCUS criteria, PIMs were 311 (11.26%), 272 (9.85%), and 105 (3.80%), respectively. Pantoprazole [20.57% Beers and 23.52% EU(7)] and glimepiride [15.43% Beers and 17.64% EU(7)] were the most inappropriate drugs. According to the PRISCUS list, piroxicam (21.9%) and etoricoxib (19.04%) were the inappropriate drugs. According to the Beers, EU(7), and PRISCUS criteria, total inappropriate prescriptions containing at least one PIM are 183 (52.04%), 174 (50.43%), and 88 (25.5%), respectively. The number of prescriptions with inappropriate medication is highly correlated with the total number of drugs prescribed per prescription ($p<0.01$) and the total number of fixed-dose combinations ($p<0.01$). Maximum PIMs were found with the Beers criteria and minimum PIMs with the PRISCUS list. This study shows that the prescription of PIMs ranges from 25.5 to 52.04%. The EU(7) list had the highest sensitivity (63.66%), while the PRISCUS list had the highest specificity (98.48%) to detect PIMs with the Beers criteria taken as a reference.

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Introduction

Geriatric drug prescribing is a fundamental part of care for the elderly, and prescribing medicines for this patient population has become a significant public health issue worldwide. Several features of geriatric care influence drug prescription for these people, making the selection of appropriate drug therapy a difficult and complex process.[1]

The geriatric population represents just over 10% of the population worldwide and 7% of the Indian population,[2] but consumes 40% of prescription drugs and 35% of all over-the-counter medicines.[3] Reduced absorption, distribution, metabolism, elimination, receptor sensitivity, concomitant drug use, and the presence of multiple comorbidities are some of the distinctive pharmacokinetic and pharmacodynamic changes attributed to aging.[4] Because of these changes, the geriatric population is more likely to develop adverse reactions and drug-drug interactions (80.8%).[5] Inappropriate medication can lead to significant morbidity as well as a clinical and economic burden on patients and society.

Therefore, inappropriate prescribing for elderly people has become an important public health issue worldwide.[1]

Medications whose risk of adverse drug events (ADEs) exceeds their expected clinical benefit when given to elderly patients and which can be replaced by better-tolerated alternatives are called potentially inappropriate medications (PIMs).[6] Inappropriate prescriptions can also lead to adverse drug reactions, anti-microbial resistance, suboptimal therapeutic response to the drug, and unnecessary wastage of the patient's time in treatment.[7]

A number of criteria have been published over the past two decades to help identify inappropriate prescribing. Most of these prescribing indicators are related to overprescribing and suboptimal prescribing, and only a few focus on underprescribing of indicated drugs. Additional interventions to improve prescribing in older adults include comprehensive geriatric assessment, clinical pharmacologist assessment and prescriber education, and computer-assisted prescribing through clinical decision support systems.[8]

There are various approaches to identifying inappropriate medication in the elderly, such as the patient-in-focus listing approach (PILA), the drug-oriented listing approach (DOLA), and DOLA+. PILA requires in-depth patient information; DOLA provides a set of options that are primarily negative or only negative and does not require specific patient knowledge. The only way DOLA+ differs from DOLA is that it includes recommendations linked to specific indications, so understanding the indications is necessary.[9]

There are several criteria available to evaluate PIMs, such as the Beers criteria (2019), the screening tool to alert to the right treatment and screening tool for older persons' prescriptions criteria (2023), the fit for the aged Chinese criteria (2017), the Amsterdam tool (2015), the European Union (EU)(7) list (2015), the PRISCUS list (2010), *etc*. Here, we aim to evaluate prescriptions for PIMs by using three widely used and highly sensitive criteria: the Beers criteria (2019) from the American Geriatric Society, the EU(7) (2015) list from the European list of PIMs, and the PRISCUS list (2010) from the German list of PIMs.

Materials and Methods

After obtaining written approval from the institutional review board, we conducted a retrospective observational study to evaluate prescriptions for PIMs by using the Beers criteria (2019), the EU(7) list (2015), and the PRISCUS list (2010).

Based on a 34% prevalence of inappropriate prescriptions and a 5% precision rate, the calculated sample size was 345 (Equation 1):

$$n=Z^2 P(1-P)/d^2 \quad \text{(Eq. 1)}$$

where the level of confidence (Z) is Z=3.84, the prevalence (P) is P=34% and the precision rate (d) is d=5%.

We included patients over 65 years of age attending the geriatric unit of a tertiary care teaching hospital from February 2021 to September 2022. Demographic details, clinical profiles, and complete prescriptions of all the patients were recorded. Three drug-oriented tools, namely the Beers criteria, the EU(7) list, and the PRISCUS list were used to assess the appropriateness of prescribed medicines. The Beers criteria and EU(7) list are DOLA+ tools, whereas the PRISCUS list is a DOLA tool.

While these criteria share the goal of identifying PIMs, they have different scopes, development processes, and international applicability. The Beers criteria (2019) are widely recognized and used internationally, while the PRISCUS list (2010) and the EU(7) list (2015) have more specific regional focuses (Germany and Europe, respectively).

The complete data was entered in Microsoft Excel 2021 and SPSS version 26.0 (IBM, Armonk, NY, USA), and appropriate statistical tests were applied. A $p<0.05$ was considered statistically significant, obtained from 2-tailed tests. The normality of the data was assessed by the Kolmogorov-Smirnov test. The Pearson correlation coefficient was used to correlate the number of PIMs with a variety of parameters, like the total number of drugs prescribed, age, and number of fixed-dose combinations.

Beers criteria

The Beers criteria for finding inappropriate medicines were first developed in 1991. Since then, many updates have been made to the list. The American Geriatrics Society (AGS) made the most recent update in 2019. The AGS Beers criteria are a particular list of PIMs that, in most cases or in some situations, such as in certain diseases or disorders, are generally to be avoided by older people.[10] The Beers criteria consist of several sections: medications to be avoided in the elderly (section 1), medications to be avoided in combination with specific diseases or syndromes (section 2), medications to be used with caution (section 3), and potentially clinically important drug interactions to be avoided (section 4).

European Union(7)-potentially inappropriate medication list

This is a European PIM list based on various national PIM lists that was published in 2015. The list includes dosage and time limitations for some medications and provides therapeutic alternatives and dose adjustment guidance.[11,12]

PRISCUS list

The German PRISCUS list was published in 2010 and last updated in 2011. The list offers suggestions for alternative treatments and what must be done if PIM use is unavoidable. It aims to improve prescribing quality and medication safety for the elderly.[12,13]

Results

We analyzed a total of 345 prescriptions written for geriatric patients. Male patients were 198 (57.39%), while female patients were 147 (42.60%). The majority of the patients were in the 65-69 age range. The patients' mean age was 71.48±5.66 years. Table 1 lists the five most frequent diagnoses made in our patients. The most frequent diagnosis was hypertension. The patients received a prescription for, on average, 6.41±4.35 medicines. Vitamin D3 was prescribed most frequently in patients (196), followed by atorvastatin (149), aspirin (130), metformin (128), and telmisartan (113).

Prescriptions that contained at least one inappropriate medication were considered "inappropriate prescriptions". The number of inappropriate and appropriate prescriptions according to all three cri-

Table 1. Most frequent diagnosis observed.

Diagnosis	Frequency (%)
Hypertension	228 (66)
Type 2 diabetes mellitus	132 (38)
Osteoarthritis knee	77 (22)
Dyslipidaemia	54 (15)
Hypothyroidism	51 (14)

teria is depicted in Figure 1. Out of 345 prescriptions, 183 came out to be inappropriate according to the Beers criteria, 174 according to the EU(7) list, and 88 according to the PRISCUS list. There were 100 and 102 inappropriate prescriptions, according to Beers criteria and the EU(7) list, respectively, that contained at least one inappropriate medication. The number of PIMs in all three criteria is shown in Figure 2.

Out of the total medicines prescribed to 345 patients, 311 medicines were inappropriate according to the Beers criteria (2019), 272 according to the EU(7) list (2015), and 105 according to the PRISCUS list (2010). The most common inappropriate medications and their frequency based on all three criteria are shown in Table 2. Pantoprazole, a proton pump inhibitor (PPI), was the most often prescribed inappropriate drug according to the Beers criteria (2019) (64, 20.57%) and the EU(7) list (2015) (64, 23.52%). The most inappropriate medication, as determined by the PRISCUS list (2010), is the selective COX-2 inhibitor piroxicam (23, 21.90%).

According to the Beers criteria, some medications were to be taken with caution in the elderly population based on their organ/system function. Diuretics like torsemide in 28 patients, hydrochlorothiazide in 21 patients, spironolactone in 11 patients, and chlorthalidone in 9 patients were to be used with caution. Escitalopram (22), tramadol (16), carbamazepine (1), dabigatran (1), duloxetine (1), and dextromethorphan (4) are other medications that were recommended to our patients and should be taken with caution.

A Venn diagram of overlapping PIMs from the three criteria is shown in Figure 3. The Beers criteria (2019) and the PRISCUS list (2010) share a maximum of seven PIMs in common, whereas the PRISCUS list (2010) and the EU(7) list (2015) share just one PIM. The EU(7) list (2015), and the Beers criteria (2019) shared five PIMs. Alprazolam, lorazepam, nifedipine, and zolpidem were the four inappropriate medications that met all three criteria.

We did not find any medications that should be avoided in combination with specific diseases or syndromes or potentially clinically important drug interactions to be avoided according to the Beers criteria (sections 2 and 4).

Table 3 shows there is a positive correlation between the number of drugs prescribed and the number of total fixed drug combinations

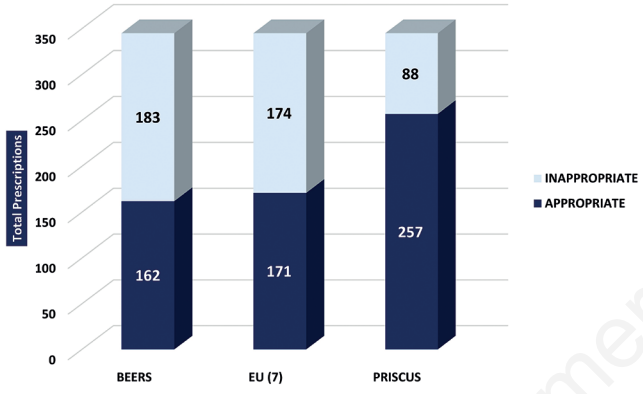

Figure 1. Total number of appropriate and inappropriate prescriptions (out of 345). EU, European Union.

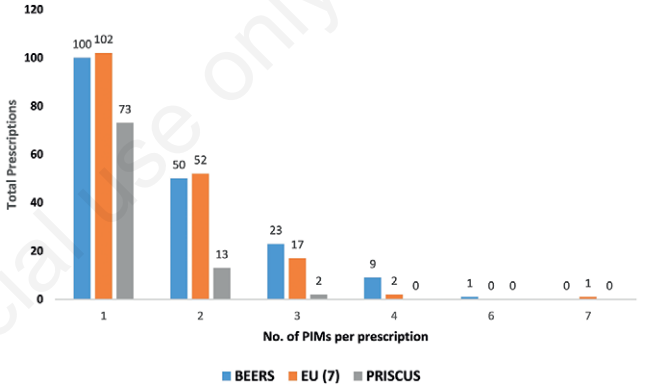

Figure 2. Number of potentially inappropriate medications per prescription in all three criteria. PIMS, potentially inappropriate medications; EU, European Union.

Table 2. Top five inappropriate medications according to all three criteria.

Beers criteria (2019) (311) (n, %)	EU(7) list (2015) (272) (n, %)	PRISCUS list (2010) (105) (n, %)
Pantoprazole (64, 20.57)	Pantoprazole (64, 23.52)	Piroxicam (23, 21.90)
Glimepiride (48, 15.43)	Glimepiride (48, 17.64)	Etoricoxib (20, 19.04)
Rabeprazole (37, 11.89)	Clonazepam (24, 8.82)	Cremaffin (12, 11.42)
Clonazepam (24, 7.71)	Zolpidem (21, 7.72)	Lorazepam (9, 8.57)
Zolpidem (21, 6.75)	Etoricoxib (20, 7.35)	Nitrofurantoin (8, 7.61)

Table 3. Correlation of various parameters with all three criteria.

	Value	Beers (2019)	EU(7) (2015)	PRISCUS (2010)
Number of drugs prescribed	r	0.444	0.430	0.287
	p	<0.01**	<0.01**	<0.01**
Age	r	0.059	-0.008	0.057
	p	0.271	0.876	0.295
Total number of FDC	r	0.420	0.399	0.172
	p	<0.01**	<0.01**	<0.01**

EU, European Union; FDC, fixed-dose combination; r, Pearson correlation coefficient; **correlation is significant at the 0.01 level (2-tailed).

with the number of PIMs in all three criteria. Table 4 describes the reasons for the inappropriateness of the top five inappropriate medicines based on the three criteria we used.

A total of 2760 drugs were prescribed to 345 patients. Using the Beers criteria (2019) as the reference point, the EU(7) list (2015) had a sensitivity of 63.66% and a specificity of 96.97%, and the PRISCUS list (2010) had a sensitivity of 21.86% and a specificity of 98.48% to detect PIMs (Table 5).

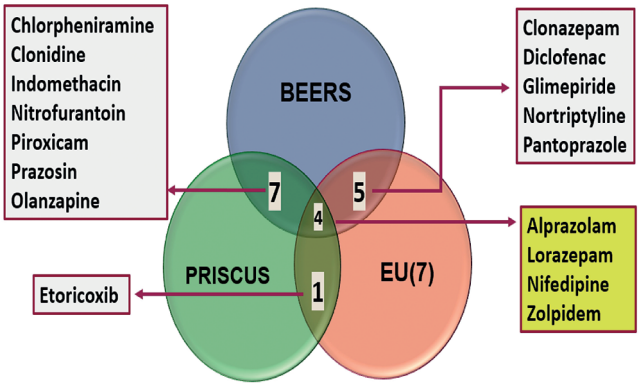

Figure 3. Overlapping potentially inappropriate medications from all three criteria. EU, European Union.

Discussion

PIMs are drugs whose risk of an ADE when administered to older patients outweighs their anticipated clinical benefit and that can be switched with better-tolerated alternatives.[6] These medications may cause ADEs, such as falls, cognitive impairment, and drug interactions. The use of PIMs is a significant public health concern, as they are often prescribed to vulnerable populations, such as elderly patients or those with multiple chronic conditions. To minimize the risks associated with PIMs, healthcare providers should use evidence-based guidelines to prescribe medications, conduct comprehensive medication reviews, and engage in shared decision-making with patients to identify the most appropriate treatment options.[14]

In our study, the total number of drugs prescribed in 345 prescriptions was 2760. After a screening of all the prescriptions and prescribed medications, PIMs were found to be highest in the Beers criteria (2019) (11.2%), followed by the EU(7) list (2015) (9.85%) and the PRISCUS list (2010) (3.80%).

Krüger *et al.* also performed a prescription audit of geriatric prescriptions and had similar findings.[12] Krüger *et al.* found PPIs (15.7%) and non-steroidal anti-inflammatory drugs (18.7%) to be the most common PIMs in the EU(7) list (2015).[12] In our study, pantoprazole (a PPI) was the most commonly prescribed PIM according to the Beers (2019) and the EU(7) (2015) criteria.

Fick *et al*. studied the prevalence of PIM use, which varied from 24.1% according to the 2003 Beers criteria and 25.9% according to the 2015 AGS Beers criteria to 57.2% according to

Table 4. Reason for inappropriateness of the top ten medicine according to the three criteria.

Drug	Reason of inappropriateness	Remedial steps/alternate medicine
Pantoprazole	Risk of *Clostridium difficile* infection and bone loss and fracture	Avoid for longer duration
Glimepiride	Higher risk of severe prolonged hypoglycemia	Metformin, insulin, gliclazide
Rabeprazole	Risk of *Clostridium difficile* infection and bone loss and fracture	Avoid for longer duration
Clonazepam	Delirium, falls, fractures; increased emergency room visits/hospitalizations; motor vehicle crashes	Levetiracetam, gabapentin, lamotrigine, valproic acid
Zolpidem	Delirium, falls, fractures; increased emergency room visits/hospitalizations; motor vehicle crashes, delayed reaction time	Short or intermediate acting benzodiazepines
Etoricoxib	Gastrointestinal bleeding or peptic ulcer, cardiovascular contraindications	Paracetamol, (weak) opioids (tramadol, codeine), weak NSAID (*e.g.*, ibuprofen)
Piroxicam	Gastrointestinal bleeding or peptic ulcer	Paracetamol, (weak) opioids (tramadol, codeine), weak NSAID (*e.g.*, ibuprofen)
Cremaffin	Pulmonary side effects if aspirated	Lactulose
Lorazepam	Delirium, falls, fractures); increased emergency room visits/hospitalizations; motor vehicle crashes	Short or intermediate acting benzodiazepines
Nitrofurantoin	Potential for pulmonary toxicity, hepatoxicity, and peripheral neuropathy	Other antibiotics (*e.g.*, cephalosporins, cotrimoxazole, trimethoprim

NSAID, nonsteroidal anti-inflammatory drugs.

Table 5. Sensitivity and specificity of the European Union(7) list (2015) and the PRISCUS list (2010).

		Beers* (2019)		Sensitivity**	Specificity***
		Inappropriate	Appropriate		
EU(7) (2015)	Inappropriate	198 (A)	74 (B)	63.66%	96.97%
	Appropriate	113 (C)	2375 (D)		
PRISCUS (2010)	Inappropriate	68 (A)	37 (B)	21.86%	98.48%
	Appropriate	243 (C)	2412 (D)		

A, true positive; B, false positive; C, false negative; D, true negative; *Beers criteria (2019) chosen as a reference tool because it is the most widely used criteria to detect potentially inappropriate medications; **sensitivity was calculated using this formula: $\frac{TP\,(A)}{TP\,(A)+FN\,(C)} \times 100$; ***specificity was calculated using this formula: $\frac{TN\,(D)}{TN\,(D)+FP(B)} \times 100$.

the EU(7) list (2015).[14] In our study, we found that the prescribing of PIMs reaches 25.5% according to the PRISCUS list (2010), 50.46% according to the EU(7) list (2015), and 53.04% according to the Beers criteria (2019).

Important risk factors for PIMs in prescriptions were the total number of prescribed medications and age. The positive association between polypharmacy and the risk of PIM prescription has been well documented in several studies, though the results are not constant. In fact, polypharmacy has been found to be the only factor having a positive association with PIMs in the meta-analysis of a systematic review analyzing studies that estimated the association between risk factors and PIM prescription.[15] In our study, the patients received a prescription for, on average, 6.41±4.35 medicines, which might have contributed to PIMs.

Several studies showed that geriatric medicine service approaches, pharmacist involvement in patient care, and computerized decision support can improve the appropriateness of prescribing for elderly patients in different settings.[1] According to the available literature, the presence of multiple comorbidities is usually considered a risk factor for PIM prescription.[15] In our study, 66% of patients had hypertension, followed by type 2 diabetes mellitus (38%), osteoarthritis knee (22%), dyslipidemia (15%), and hypothyroidism (14%).

The least number of inappropriate medicines (105) were found with the PRISCUS list (2010), which is similar to another study carried out by Lisowska *et al*.[9]

PPIs are considered inappropriate because the risks of *Clostridium difficile* infection, bone loss, and fractures are high when they are used for longer durations.[10] Similarly, piroxicam, a nonsteroidal anti-inflammatory drug, which is the most inappropriate medicine according to the PRISCUS list (2010), carries the risk of gastrointestinal bleeding or peptic ulcer.[12] The second most prevalent inappropriate medicine in the Beers criteria (2019) and the EU(7) (2015) list is glimepiride, a longer-acting sulfonylurea that can cause hypoglycemia in older adults.[10,11] Nitrofurantoin, a urinary antiseptic, was observed as a frequent PIM according to the PRISCUS list (2010), carrying a risk of liver damage, pulmonary toxicity, and neuropathy when used for a longer duration. Alprazolam, lorazepam, nifedipine, and zolpidem fall into the category of PIMs under all three criteria. The altered sensitivity of the geriatric population to benzodiazepines can lead to increased cognitive impairment, delirium, falls, and fractures. The z-agent among them, *i.e.*, zolpidem, when prescribed at a dose of more than 5 mg per day, carries a similar risk as seen with the benzodiazepine group of drugs. Nifedipine (a short-acting calcium channel blocker) used in the elderly increases the risk of myocardial infarction due to reflex tachycardia.[10,11,13]

Section 3 of the Beers criteria (2019) displays drugs that should be used with caution by elderly people. In our study, that list mostly includes the diuretic class of drugs, which may cause hyponatremia or the syndrome of inappropriate antidiuretic hormone secretion.[10]

The sensitivity of the Beers criteria (2019) varies across different studies and populations, ranging from approximately 43 to 95%, and the specificity from approximately 73 to 98%. This indicates that the Beers criteria (2019) can accurately identify medications that are not PIMs in the population under study; hence, we have taken it as a reference tool to identify the sensitivity and specificity of the EU(7) (2015) and PRISCUS (2010) lists.

Studies assessing the sensitivity of the EU(7) list (2015) have reported values ranging from approximately 39 to 79% and the specificity of the list ranging from approximately 79 to 94%. In our study, the sensitivity and specificity of the EU(7) list (2015) came out to be 63.66% and 96.97%, respectively. The sensitivity of the PRISCUS list (2010) ranges from 57 to 81% and the specificity from 67% to 97%. In our study, the sensitivity and specificity of the PRISCUS list came out to be 21.86% and 98.48%, respectively.

Patients can respond differently to medications due to factors like genetics, metabolism, and other underlying health conditions. The DOLA might not fully account for these individual variations, potentially leading to inappropriate recommendations for certain patients. Another limitation of our study is that none of these criteria has been developed specifically for the Indian community. Also, other tools to identify PIMs could have been used. The strength of the study is that it has been conducted for a shorter duration with an adequate sample size.

Certain approaches can be adapted to reduce the prevalence of inappropriate prescribing (Figure 4). Geriatric prescribers should undergo annual training for the identification of inappropriate

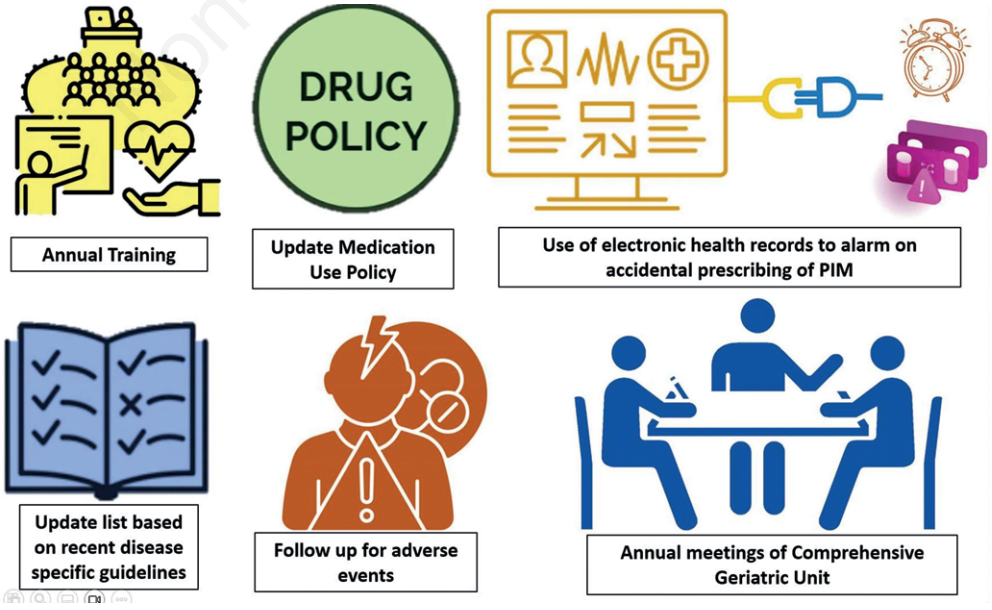

Figure 4. Approaches to reduce the prevalence of inappropriate prescribing. PIM, potentially inappropriate medications.

medications. PIM criteria can be embedded with recent disease-specific guidelines. Geriatric prescribers should regularly review and update medication use policies and protocols based on current guidelines and evidence-based medicine. Every geriatric prescription and patient should be followed for any adverse event, based on clinical experience. The PIM list can be modified. In addition, physician order entry systems and electronic health records can be utilized, which can automatically raise alarms about the accidental prescribing of PIMs. The comprehensive geriatric assessment unit can have annual meetings where each member of the team can give his/her unique expertise regarding any particular medicine. Also, deprescribing medicines should be considered when they are no longer needed.

Conclusions

Our findings reveal significant variations in the identification of PIMs among these criteria. Beers criteria identified the highest number of PIMs, while the PRISCUS list (2010) identified the fewest instances. The prevalence of PIM prescriptions ranged from 25.5% to 53.04% across the different criteria.

Specific medications, including alprazolam, lorazepam, nifedipine, and zolpidem, consistently fell within the category of PIMs, according to all three criteria. Additionally, our study highlights concerns regarding the long-term use of PPIs, commonly prescribed for gastrointestinal prophylaxis, due to associated risks such as *C. Difficile* infection and potential bone loss.

In conclusion, our evaluation of prescriptions using these three widely accepted criteria sheds light on the prevalence of PIMs and emphasizes the importance of employing multiple criteria to comprehensively assess medication appropriateness, especially in geriatric populations where medication safety is paramount.

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