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Potentially inappropriate medications for geriatric patients in Bahrain: prevalence, predictors, and implications for practice

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Abstract

Background The global increase in the older adult population necessitates a comprehensive understanding of medication management to mitigate the risks associated with potentially inappropriate medications (PIMs). These medications are of particular concern due to their association with adverse drug reactions, increased hospitalization, and increased healthcare costs. This study aimed to determine the prevalence and risk factors associated with PIM use among older adult patients attending primary health care centers in Bahrain.

Methods This cross-sectional study was conducted in 2022 in 27 primary healthcare centers across Bahrain. The study included patients aged 65 years or older. A computer based simple random sample was obtained, and the Beers criteria 2023 was utilized to assess medication appropriateness. Anonymous data was retrieved from electronic medical records and analyzed via univariate, and logistic regression analyses.

Results Among the 595 older adult patients studied, the average age was 71.7 years, with 54.5% ($n=324$) being female. Most of the patients were married (70.8%, $n=421$). More than half of the patients (51.3%, $n=305$) received at least one PIM, with gliclazide (37%, $n=113$), pantoprazole (29.8%, $n=91$), and rabeprazole (27.9%, $n=85$) being the most prevalent prescribed PIM. Univariate analyses revealed that PIM rates were significantly higher among females ($p=0.001$) and patients with comorbidities such as diabetes mellitus ($p<0.001$), essential hypertension ($p<0.001$), and hyperlipidaemia ($p<0.001$). Logistic regression analysis revealed that age (OR = 1.09, $p<0.001$), female sex (OR = 1.645, $p=0.012$), and diabetes mellitus (OR = 1.696, $p=0.029$) were significant predictors of PIM use.

Conclusion This study highlights the significant burden of PIM use among older adult patients in Bahrain, with more than half of the participants receiving at least one PIM. These findings underscore the urgent need for targeted interventions, particularly among female patients, those with chronic conditions such as diabetes mellitus, and patients taking five or more medications. These insights contribute to the broader understanding of geriatric pharmacotherapy and offer a foundation for policy development aimed at optimizing medication safety in aging populations.

Keywords Aged, Beers criteria, Potentially inappropriate medications, PIM list

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Introduction

Medication safety is an essential and challenging aspect of patient care that aims to optimize clinical outcomes and reduce adverse drug events (ADEs) [1]. ADEs are undesirable clinical manifestations that result from medication use and include adverse drug reactions (ADRs) and medication errors (MEs) [2, 3]. ADRs are harmful reactions that occur at normal doses used in humans for prophylaxis, diagnosis, or therapy, whereas MEs involve any preventable event that may result in inappropriate medication use or patient harm [2, 4].

Owing to age-related physiological changes, changes in pharmacokinetic and pharmacodynamic processes, multiple comorbidities, and complex medication regimens, medication safety challenges grow more pronounced among older patients [5]. Furthermore, polypharmacy, the concurrent use of five or more medications, is a common finding among older patients that substantially elevates the likelihood of ADEs among older patients [6, 7]. Therefore, the use of potentially inappropriate medications (PIMs), drugs with high risk-to-benefit ratios for older adults, has garnered significant attention among this group of patients. Consequently, identifying, and mitigating PIMs is a cornerstone of geriatric pharmacotherapy optimization [8].

Several studies assessed the percentage of older patients who were on PIMs. In the United States, 30–35% of older patients were on at least one PIM in the period between 2007 and 2012 [9, 10]. A slightly lower percentage (29%) was reported in a study of approximately one million older patients in the United Kingdom [11], while a higher prevalence was reported in Ireland and Japan (36% and 40%) [12, 13]. In China and Australia, the prevalence of PIM use among older patients was 50.1% and 60%, respectively [14, 15]. In the Middle Eastern countries including Kuwait, Saudi Arabia, and Qatar, the studies reported that more than half of older patients were on at least one PIM (53%, 57.6%, and 60% respectively [16–18]. Higher rates of PIM were reported in Jordan (62%) and Lebanon (80%) [19, 20]. All these studies indicate that the usage of PIMs by older patients is a worldwide problem with significant implications.

Furthermore, several studies have assessed the predictors of PIM use among older patients. These studies revealed that advanced age [20], polypharmacy [21–23], and the presence of comorbidities such as heart failure, hypertension, diabetes, and cancer [24, 25] significantly increase the risk of PIM use among older adult patients.

Various tools including the Beers' criteria, the Screening Tool of Older Persons' Prescriptions and Screening Tool to Alert to Right Treatment (STOPP/START) criteria, and the Medication Appropriateness Index (MAI) were used to assess the extent of PIMs among older patients. Of all tools, the Beers criteria is a widely recognized and extensively validated tool that is used to identify PIMs [25, 26]. It provides a comprehensive list of medications that should generally be avoided or used with caution due to their associated risks, such as adverse drug reactions. It is particularly valuable in guiding healthcare providers to improve the safety and quality of pharmacotherapy in older adult patients, especially those with multiple comorbidities or who are at risk of PIM use [27, 28].

As the global older adult population is projected to reach 2 billion by 2050, a parallel increase in the prevalence of PIMs is expected [29, 30]. This high prevalence of PIM is associated with higher hospitalization rates [31–33], higher mortality and morbidity outcomes [34, 35], and higher costs among older adults [36–39]. Therefore, efforts are made to minimize the prevalence and impacts of PIM among old patients. Despite these efforts, there remains a gap in research analyzing PIM use among older adults in many Middle Eastern countries including Bahrain. Hence, this study aimed to determine the prevalence and predictors of PIM among older adults in Bahrain.

Methods

Study design & setting

Between March and April 2022, a cross-sectional study was undertaken among older adult patients under the care of primary healthcare centers in Bahrain. The country comprises of 27 primary health centers spread across 4 health regions. All older adult patients attending these centers during the specified period were considered eligible for participation.

Approval for the research was secured from the Research and Ethics Committees of Primary Healthcare in Bahrain. During this timeframe, a total of 15,666 older adult patients sought care at primary healthcare centers in Bahrain.

Population, sample size calculation & sampling technique

A sample size of 385 was targeted based on the basis of the estimated older adult population in Bahrain ($n = 48{,}053$), with a 95% confidence interval, 5% precision level, and an anticipated PIM prevalence of 50% [40]. A computer-based random sample was then selected from the pool of 15,666 patients.

Selection criteria

Patients aged 65 years and above who were attending primary care centers during the selected period were included. For patients who made multiple visits within this period, data from their initial visit was retrieved from electronic records. In addition, certain medications, such as topical agents and nonprescription medications,

were excluded from the assessment, along with herbals and vitamins.

Data was obtained from patients' electronic medical records (EMR).

Definitions and criteria

The Beers criteria, developed by the American Geriatrics Society, provides a list of PIMs that should generally be avoided in older adults (aged ≥ 65 years) owing to the high risk of adverse effects [41]. The criterion is updated regularly, with the 2023 edition being used for this study. The Beers Criteria carefully consider medications that pose a high risk of adverse effects, have limited effectiveness in older adults, involve drug-disease or drug-drug interactions that may exacerbate the patient's condition, and include dosage and duration limitations for certain medications. The grouping of participants into 'appropriate' and 'inappropriate' medication users was based on well-defined criteria outlined by the 2023 Beers Criteria. Medications were classified into five categories: (1) potentially unsuitable medications, (2) medications potentially unsuitable for patients with specific diseases or syndromes, (3) medications warranting careful use, (4) potentially inappropriate drug-drug interactions, and (5) medications requiring dosage adjustments based on renal function [41]. Each classification was assessed based on the quality of evidence and strength of recommendation. Medications that did not fall into any of these categories were classified as 'appropriate.' Ambiguous or borderline cases were carefully reviewed within this framework, adhering to the overarching principle of weighing the risks versus the benefits of the medication. Discrepancies in medication classification were independently evaluated by two board-certified family physicians, and a third family physician adjudicated cases where disagreements arose.

Comorbidities diagnoses were obtained from the EMR. Diagnoses were based on the 10th edition of the International Classification of Diseases (ICD-10).

Data collection tool

A comprehensive data collection tool was developed, consisting of four parts: the first part gathered sociodemographic information and baseline characteristics; the second part assessed comorbidities (e.g., diabetes mellitus, essential hypertension, hyperlipidaemia, cerebrovascular accident, chronic kidney disease); the third part documented all the medications available at the primary care centers, including their names and categories according to the Anatomical Therapeutic Chemical classification system, and the inappropriateness level of medication prescribed was assessed via the Beers 2023 criteria.

Statistical analysis & selection criteria

Statistical analyses encompassed computing frequencies and percentages for categorical variables and means with standard deviations for continuous variables. Participants were divided into two groups based on medication use: inappropriate and appropriate. T-tests were utilized to compare mean differences between independent groups, whereas the chi-square test was used to compare categorical variables. Normality tests were conducted which revealed normal distribution of continuous data, thus not warranting the use of non-parametric tests (ex. Mann-Whitney U test) nor the mention of median and IQR (interquartile range) values. The minimum expected cell count assumption was met in all analyses. Logistic regression analyses were performed, and the results are presented as odds ratios (OR) with 95% confidence intervals (CI). Data analysis was conducted using IBM SPSS Statistics, Version 28.0, with a *P*-value of less than 0.05 considered statistically significant.

Results

The study included 595 patients, the majority of whom were female (324, 54.5%). The average age was 71.74 ± 6.21 years. Most patients were Bahraini (573, 96.3%) and married (421, 70.8%). The most common comorbidities were essential hypertension (400, 67.2%), hyperlipidaemia (361, 60.7%), and diabetes mellitus (324, 54.5%). The average number of medications taken per patient was approximately 5 (4.72) ± 3.23 (range 1.49–7.95 medications). Table 1 shows the sociodemographic, clinical characteristics, and the most prescribed medications among the participants.

PIMs were identified in 305 patients (51.3%), with the majority having 1 PIM (74.1%). The most frequently prescribed medications were metformin (43.4%), atorvastatin (34.6%), and perindopril (26.7%).

Among patients with polypharmacy, most received 1 PIM (74.1%, $n = 305$), while some received 2 PIMs (22.6%) and a minority received 3 PIMs (3.3%). The most frequently identified PIMs were gliclazide (37%), pantoprazole (29.8%), and rabeprazole (27.9%). Table 2 shows the frequency and types of PIMs.

The univariate analysis revealed a greater prevalence of PIM use among females than among males ($p < 0.001$). Patients who had diabetes mellitus ($p < 0.001$), hypertension ($p < 0.001$), dyslipidaemia ($p < 0.001$), and cardiovascular diseases ($p = 0.002$) were found to have a higher prevalence of PIM than their counterparts. Moreover, other comorbidities such as asthma ($p = 0.043$), psychiatric disorders ($p = 0.018$), and hypothyroidism ($p = 0.003$) also correlated with a high PIM prevalence.

Table 3 shows the statistical significance of the associations between social demographics, comorbidities, and

Table 1 Sociodemographic and clinical characteristics of older adult patients attending primary care centers in Bahrain (TN = 595)

Characteristics		*n* (%)
Sex	Male	271 (45.5)
	Female	324 (54.5)
Age, mean ± SD		71.7 ± 6.2
Nationality	Bahraini	573 (96.3)
	Non-Bahraini	22 (3.7)
Marital Status	Single	22 (3.7)
	Married	421 (70.8)
	Divorced	33 (5.5)
	Widowed	119 (20.0)
Comorbidities	Essential hypertension	400 (67.2)
	Hyperlipidaemia	361 (60.7)
	Diabetes Mellitus	324 (54.5)
	Hypothyroidism	76 (12.8)
	Cardiovascular diseases	60 (10.1)
	Asthma	44 (7.4)
	Psychiatric disorders	24 (4.0)
Medications	Metformin	258 (43.4)
	Atorvastatin	206 (34.6)
	Perindopril	159 (26.7)
	Amlodipine	159 (26.7)
	Valsartan	146 (24.5)
	Aspirin	144 (24.2)

Table 2 Potentially inappropriate medications (n, %) among older adult patients attending primary care centers

Potentially inappropriate medications (PIM)		*n* (%) TN = 595
PIM Prescribed TN = 595	Yes	305(51.3)
	No	290(48.7)
Number of PIM TN = 305	1	226 (74.1)
	2	69 (22.6)
	3	10 (3.3)
Most frequently prescribed medications TN = 305	Gliclazide	113 (37.0)
	Pantoprazole	91 (29.8)
	Rabeprazole	85 (27.9)
	Omeprazole	23 (7.5)
	Esomeprazole	21 (6.9)
	Amitriptyline	15 (4.9)
	Diclofenac acid	14 (4.6)
	Glimepiride	10 (3.3)

PIMs among older adult patients attending primary care centers.

Logistic regression analysis revealed that sex (OR = 1.645, $P = 0.012$), age (OR = 1.09, $P < 0.001$), diabetes mellitus (OR = 1.696, $P = 0.029$) and number of medications (OR = 0.610, $P < 0.001$) were predictors of PIM use. Table 4 shows the results of the logistic regression analysis of PIM risk factors.

Table 3 Association between social demographics, comorbidities, and PIMs (n, %) among older adult patients attending primary care centers

		PIM present TN = 305, (*n*, %)	No PIM TN = 290, (*n*, %)	*P* value
Sex	**Male**	119 (43.9)	152(56.1)	**0.001**
	Female	186 (57.4)	138(42.6)	
Age		71.78 ± 6.12	71.69 ± 6.32	0.859
Nationality	**Bahraini**	294 (51.3)	279(48.7)	0.904
	Non-Bahraini	11 (50)	11(50)	
Marital Status	**Single**	12 (54.5)	10(45.5)	0.739
	Married	210 (49.9)	211(50.1)	
	Divorced	17 (51.5)	16(48.5)	
	Widowed	66 (55.5)	53(44.5)	
Comorbidities	**Diabetes Mellitus**	196 (60.5)	128(39.5)	**< 0.001**
	Essential hypertension	236 (59)	164(41)	**< 0.001**
	Hyperlipidaemia	219 (60.7)	142(39.3)	**< 0.001**
	Cardiovascular diseases	42 (70)	18(30)	**0.002**
	Asthma	29 (65.9)	15(34.1)	**0.043**
	Psychiatric disorders	18 (75)	6(25)	**0.018**
	Hypothyroidism	51 (67.1)	25(32.9)	**0.003**
Polypharmacy status	**Polypharmacy**	214 (72.3)	82(27.7)	**< 0.001**
	No Polypharmacy	91 (30.4)	208(69.6)	
Number of medications		6.24 ± 2.98	3.12 ± 2.67	**< 0.001**

Table 4 Logistic regression for PIM risk stratification among older adult patients attending to primary care centers

	Odds ratio (95% confidence interval)	*P* value
Sex	1.645 (1.117–2.421)	**0.012**
Age	1.019 (1.012–1.026)	**< 0.001**
Diabetes Mellitus	1.696 (1.055–2.727)	**0.029**
Essential hypertension	1.487 (0.910–2.431)	0.113
Hyperlipidaemia	1.286 (0.799–2.069)	0.300
Cardiovascular diseases	0.975 (0.498–1.911)	0.942
Asthma	0.969 (0.437–2.146)	0.938
Psychiatric disorders	0.485 (0.169–1.391)	0.178
Hypothyroidism	0.832 (0.454–1.524)	0.552
Polypharmacy status	0.906 (0.466–1.763)	0.771
Number of medications	0.610 (0.523–0.712)	**< 0.001**

Discussion

This study aimed to determine PIM prevalence and associated risk factors among older adult patients in Bahrain. The study revealed that more than half of the older adult patients suffered from PIM, with a higher prevalence among female patients, those with comorbidities such as diabetes mellitus, and those subjected to polypharmacy. The study also revealed that gliclazide, pantoprazole, and rabeprazole were the most common PIMs.

The prevalence of PIMs among older adult patients attending primary care centers in Bahrain was comparable to that reported by local and international figures. For example, several studies reported rates varying between 30% and 80% [9–20]. In contrast, some studies reported a lower prevalence of PIM than our study did, whereas others observed a higher prevalence. Possible reasons for this variability include different inclusion and exclusion criteria, including age and specific comorbidities, along with complex medication regimens, the involvement of multiple healthcare providers, and a higher prevalence of other comorbidities, such as diabetes or hypertension.

This study found that gliclazide, a common oral hypoglycaemic agent, was the most frequently prescribed PIM, which may explain the higher PIM rate among patients with diabetes mellitus compared to their counterparts. Additionally, proton pump inhibitors (PPIs) such as pantoprazole, rabeprazole, omeprazole, and esomeprazole are highly prevalent, which is consistent with other studies that identified PPIs as commonly prescribed PIMs [21, 23, 41].

In line with the literature, our findings revealed that age, sex, diabetes status, and the number of medications are significant predictors of PIM prevalence [17]. Across numerous studies, polypharmacy has been consistently identified as a primary determinant of PIM use [21, 22, 24, 42, 43]. However, while polypharmacy is significant, some research argues that it should not be viewed solely as a predictor of PIM use [44, 45]. Chronic conditions often necessitate individualized and complex prescribing patterns, which are essential for effective disease management. Therefore, the presence of multiple medications does not inherently indicate inappropriate prescribing; rather, the focus should be on evaluating the appropriateness of each medication within the context of the patient's overall treatment plan [15, 46].

Conversely, several variables did not maintain their significance in further analysis, indicating that their initial association with PIMs diminished when the broader context of patient health was considered. This trend was observed in conditions such as cardiovascular diseases, hypertension, hyperlipidaemia, psychiatric disorders, hypothyroidism, polypharmacy, and asthma, which were significant in the univariate analysis but not in the subsequent analyses. The inconsistency in these results is reflected in other studies exploring similar risk factors [15, 47]. For instance, hypertension initially appeared to be significantly associated with PIMs, but this connection weakened upon further analysis, suggesting that the observed PIM incidence may be influenced more by the overall burden of chronic conditions and the resulting need for complex medication regimens, rather than by hypertension alone. This aligns with published research, which suggests that the link between hypertension and PIMs may be less direct, with the potential for inappropriate prescribing being more closely tied to the cumulative effect of managing multiple coexisting conditions, which often necessitates a multifaceted therapeutic approach [48].

Addressing the issue of PIM requires an approach that combines system-level interventions with individualized patient care. Regular medication reviews by a multidisciplinary team should be integrated into routine clinical practice, particularly during care transitions such as hospital discharge or admission to long-term care facilities [49] Integrating clinical decision support systems (CDSS) into EMRs can further enhance these efforts by providing real-time alerts to prescribers, flagging PIMs, suggesting safer alternatives, and identifying potential drug-drug interactions [50].

One of the foremost strengths of this study was the comprehensive and detailed data collection process, which included the use of a random sampling method. This study utilized data from electronic medical records across Bahrain and effectively employed the Beers Criteria to identify PIMs, providing robust and representative insights into the older adult population—a demographic often underrepresented in previous studies. The findings, while valuable, may have slightly underestimated the prevalence of PIM use due to the exclusion of certain older adult groups, such as those who were homebound, in long-term care facilities, and or non-attendees in the designated study period.

Additionally, a key limitation of this study is that healthcare provider behavior and patient adherence to medications were not assessed or factored into the analysis. These variables could influence prescribing practices and medication usage patterns, potentially impacting the overall prevalence of PIMs observed in the study.

Conclusion

In summary, this study revealed a high prevalence of PIM among older adults in primary care centers in Bahrain especially among female patients, those with chronic conditions such as diabetes mellitus, and patients taking five or more medications.

Urgent actions including regular medication reviews by a multidisciplinary team, and the integration of clinical decision support systems (CDSS) into EMR are needed to mitigate the risk of PIMs among this population. Further studies are warranted to analyze medication patterns among the entire older adult population including those those who are homebound, in long-term care facilities, and or non-attendees to primary healthcare centers.

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Author contributions
M.A conceptualized and designed the study. O.M, F.O., M.F. performed the data collection and statistical analysis. All authors interpreted the results and drafted the manuscript. M.A. contributed to the critical revision of the manuscript for important intellectual content. All authors read and approved the final manuscript.

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Data availability
The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request. Due to the nature of this study, which involves patient electronic medical records, public sharing of the dataset is restricted to protect individual privacy and confidentiality. However, de-identified data may be provided under certain conditions in compliance with ethical and legal guidelines.

Declarations

Ethics approval and consent to participate
This study was conducted in full accordance with the principles of the Declaration of Helsinki. Ethical approval was obtained from the Primary Healthcare Centers Research Ethics Committee in Bahrain. All participants' data were anonymized, and no personally identifiable information was collected. Since this study was based on retrospective data from electronic medical records, the requirement for written informed consent was waived by the Ethics Committee. The research team ensured that patient confidentiality was maintained throughout the study.

Informed consent
Informed consent was not applicable for this study as it involved the retrospective analysis of anonymized electronic medical records. Since no personally identifiable data, such as biomedical, clinical, or biometric information, was collected, the requirement for informed consent was waived by the Primary Healthcare Centers Research Committee in Bahrain. All participants' privacy and confidentiality were strictly maintained throughout the research process. The study did not involve any vulnerable populations or individuals where consent could not be fully informed. If required, further documentation and evidence of this process can be provided to the Editor.

Clinical trial number
Not applicable.

Competing interests
The authors declare no competing interests.

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References

1. Soon HC, Geppetti P, Lupi C, Kho BP. Medication safety. In: Donaldson L, Ricciardi W, Sheridan S, Tartaglia R, editors. Textbook of patient safety and clinical risk management. Cham: Springer; 2021. https://doi.org/10.1007/978-3-030-59403-9_31.
2. Nebeker JR, Barach P, Samore MH. Clarifying adverse drug events: A clinician's guide to terminology, documentation, and reporting. Ann Intern Med. 2004;140:795–801.
3. Cohen MM, Kimmel NL, Benage MK, Cox MJ, Sanders N, Spence D, Chen J. Medication safety program reduces adverse drug events in a community hospital. Qual Saf Health Care. 2005;14(3):169–74. https://doi.org/10.1136/qshc.2004.010942. PMID: 15933311; PMCID: PMC1744034.
4. Coleman JJ, Pontefract SK. Adverse drug reactions. Clin Med (Lond). 2016;16(5):481–5. https://doi.org/10.7861/clinmedicine.16-5-481. PMID: 27697815; PMCID: PMC6297296.
5. Barry HE, Hughes CM. An Update on Medication Use in Older Adults: a Narrative Review. Curr Epidemiol Rep. 2021;8(3):108–115. https://doi.org/10.1007/s40471-021-00274-5. Epub 2021 Jul 20. PMID: 34306966; PMCID: PMC8294219.
6. Masnoon N, Shakib S, Kalisch-Ellett L, Caughey GE. What is polypharmacy? A systematic review of definitions. BMC Geriatr. 2017;17(1):230. https://doi.org/10.1186/s12877-017-0621-2. PMID: 29017448; PMCID: PMC5635569.
7. Alawainati M, Habib F, Ateya E, Dakheel E, Al-Buainain M, Prevalence. Characteristics and determinants of polypharmacy among elderly patients attending primary healthcare centres in Bahrain: A cross-sectional study. Sultan Qaboos Univ Med J. 2024;24(1):63–9. https://doi.org/10.18295/squmj.9.2023.052. Epub 2024 Feb 28. PMID: 38434473; PMCID: PMC10906769.
8. Lam Y. Potentially inappropriate medications in the elderly. Brown Univ Psychopharmacol Update. 2023;34. https://doi.org/10.1002/pu.31059.
9. Fick DM, Semla TP, Steinman M, et al. American geriatrics society 2019 updated AGS beers Criteria® for potentially inappropriate medication use in older adults. J Am Geriatr Soc. 2019;67(4):674.
10. Jirón M, Pate V, Hanson LC, et al. Trends in prevalence and determinants of potentially inappropriate prescribing in the united States: 2007 to 2012. J Am Geriatr Soc. 2016;64(4):788–97. https://doi.org/10.1111/jgs.14077.
11. Kongkaew C, Noyce PR, Ashcroft DM. Hospital admissions associated with adverse drug reactions: a systematic review of prospective observational studies. BMC Geriatr. 2014;14:72. https://doi.org/10.1186/1471-2318-14-72.
12. Hamano J, Tokuda Y. Inappropriate prescribing among elderly home care patients in Japan: prevalence and risk factors. J Prim Care Community Health. 2014;5(2):90–6. https://doi.org/10.1177/2150131913518346.
13. Cahir C, Fahey T, Teeling M, Teljeur C, Feely J, Bennett K. Potentially inappropriate prescribing and cost outcomes for older people: a National population study. Br J Clin Pharmacol. 2010;69(5):543–52. https://doi.org/10.1111/j.1365-2125.2010.03628.x. PMID: 20573091; PMCID: PMC2856056.
14. Zhao X, Li L, Guo X, Wang J, Yan Y, Le Y. Potentially Inappropriate Medication Use Among Older Patients with Diabetes in a Chinese Community. Exp Clin Endocrinol Diabetes. 2023;131(10):548–553. https://doi.org/10.1055/a-2123-0734. Epub 2023 Jul 4. PMID: 37402408.
15. Reeve E, Shakib S, Hendrix I, Roberts MS, Wiese MD. The benefits and harms of deprescribing. Med J Aust. 2014;201(7):386-9. https://doi.org/10.5694/mja13.00200. PMID: 25296058.
16. 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. https://doi.org/10.1186/s12877-019-1168-1. PMID: 31142286; PMCID: PMC6542098.
17. 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. https://doi.org/10.1007/s40801-020-00220-9. Epub 2020 Nov 17. PMID: 33205232; PMCID: PMC7984128.
18. Alhawassi TM, Alatawi W, Abuelizz H et al. Inappropriate prescribing in older adults: the Saudi case. PLoS One. 2019;14(6). https://doi.org/10.1371/journal.pone.0218174. Kuwait.
19. Obeidat R, Mofleh R, Alsakran L, et al. Inappropriate prescribing in older adults: Jordan perspective. Pharm Pract (Granada). 2020;18(1):1439. https://doi.org/10.18549/PharmPract.2020.1.1439.
20. Saab YB, Hachem A, Sinno S et al. Inappropriate medication use in elderly patients. Res Square. 2021. https://www.researchsquare.com/article/rs-318181/v1.
21. de Lima JD, Teixeira IA, Silva FO, Deslandes AC. The comorbidity conditions and polypharmacy in elderly patients with mental illness in a middle income country: a cross-sectional study★. IBRO Rep. 2020;9:96–101. PMID: 33336105; PMCID: PMC7733142.
22. 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. https://doi.org/10.1155/2022/1591511. PMID: 35586116; PMCID: PMC9110241.
23. Sangaleti CT, Lentsck MH, Silva DCD, Machado A, Trincaus MR, Vieira MCU, Pelazza BB, Colombo FMC. Polypharmacy, potentially inappropriate medications and associated factors among older adults with hypertension in primary care. Rev Bras Enferm. 2023;76(Suppl 2):e20220785. https://doi.org/10.1590/0034-7167-2022-0785. PMID: 38088658; PMCID: PMC10704688. Suppl 2.
24. Bazargan M, Smith JL, King EO. Potentially inappropriate medication use among hypertensive older African-American adults. BMC Geriatr. 2018;18(1):238. https://doi.org/10.1186/s12877-018-0926-9. PMID: 30290768; PMCID: PMC6173851.
25. 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. https://doi.org/10.1371/journal.pone.0218174. PMID: 31194800; PMCID: PMC6563997.
26. Grace A, Briggs R, Kieran R, Corcoran R, Romero-Ortuño R, Coughlan T, O'Neill D, Collins R, Kennelly S. A comparison of beers and STOPP criteria in assessing potentially inappropriate medications in nursing home residents attending the emergency department. J Am Med Dir Assoc. 2014;15(11):830–4. https://doi.org/10.1016/j.jamda.2014.08.008.
27. Miaz B, Nunes M, Mancinetti M, Balmer P. [Polypharmacy: the method and tools for medication review]. Revue Medicale Suisse. 2021;17 749:1489–94.
28. Deliens C, Deliens G, Filleul O, Pepersack T, Awada A, Piccart M, Praet J, Lago L. Drugs prescribed for patients hospitalized in a geriatric oncology unit: potentially inappropriate medications and impact of a clinical pharmacist. J Geriatric Oncol. 2016;7(6):463–70. https://doi.org/10.1016/j.jgo.2016.05.001.
29. Beard JR, Officer A, de Carvalho IA et al. The World Report on Ageing and Health: A Policy Framework for Healthy Ageing. World Health Organization. 2015:1-260. PMID: 27184411.
30. Qato DM, Wilder J, Schumm LP, et al. Changes in prescription and Over-the-Counter medication and dietary supplement use among older adults in the united States, 2005 vs 2011. JAMA Intern Med. 2016;176(4):473–82. PMID: 2699870.
31. Vatcharavongvan P, Puttawanchai V. Elderly patients in primary care are still at risks of receiving potentially inappropriate medications. J Prim Care Community Health. 2021;12. https://doi.org/10.1177/21501327211035088.
32. Varavithya V, Tirapat C, Rojpibulstit P, et al. Potentially inappropriate medication use and the hospitalization rate among Thai elderly patients: a retrospective cohort study. Eur J Clin Pharmacol. 2022;78:847–55. https://doi.org/10.1007/s00228-021-03269-9.
33. Sato I, Yamamoto Y, Kato G, et al. Potentially inappropriate medication prescribing and risk of unplanned hospitalization among the elderly: A Self-Matched, Case-Crossover study. Drug Saf. 2018;41:959–68. https://doi.org/10.1007/s40264-018-0676-9.
34. Bories M, Bouzillé G, Cuggia M, Le Corre P. Drug–Drug interactions in elderly patients with potentially inappropriate medications in primary care, nursing home and hospital settings: A systematic review and a preliminary study. Pharmaceutics. 2021;13(2):266.
35. Wang F, Xu G, Rong C, Wu X. Association between potentially inappropriate medication and adverse drug reactions in hospitalized elderly patients. J Clin Pharm Ther. 2021;46:1139–47. https://doi.org/10.1111/jcpt.13413.
36. Alhawassi TM, Krass I, Bajorek BV et al. Prevalence and factors associated with polypharmacy in older people: A systematic review. PLoS One. 2014;9(12). PMID: 25479234.
37. Obreli-Neto PR, Nobili A, de Oliveira Baldoni A, et al. Adverse drug reactions caused by drug-drug interactions in elderly outpatients: a prospective cohort study. J Clin Pharm Ther. 2012;37(6):674–81. PMID: 22775479.
38. Heider D, Matschinger H, Meid AD, et al. Health service use, costs, and adverse events associated with potentially inappropriate medication in old age in Germany: retrospective matched cohort study. Drugs Aging. 2017;34:289–301. https://doi.org/10.1007/s40266-017-0441-2.
39. Clark CM, Shaver AL, Aurelio LA, Feuerstein S, Wahler RG Jr, Daly CJ, Jacobs DM. Potentially inappropriate medications are associated with increased healthcare utilization and costs. J Am Geriatr Soc. 2020;68:2542–50. https://doi.org/10.1111/jgs.16743.
40. Ministry of Health Kingdom of Bahrain, Estimated Population Census MOH. 2020. https://www.moh.gov.bh/Content/Files/Publications/statistics/HS2020/PDF/CH-02-census_2020-2.pdf
41. 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):2052–81. https://doi.org/10.1111/jgs.18372.
42. Rodrigues DA, Plácido AI, Tavares AB, Azevedo D, Mateos-Campos R, Figueiras A, Herdeiro MT, Roque F. Potentially inappropriate medication prescribing in older adults according to EU(7)-Potentially inappropriate medication list: A nationwide study in Portugal. Curr Ther Res Clin Exp. 2022;97:100681. https://doi.org/10.1016/j.curtheres.2022.100681. PMID: 35937773; PMCID: PMC9350873.
43. Idrisnur S, Abdu N, Yohannes F, Tewelde T, Russom N, Tesfamariam EH. Potentially inappropriate use of medication and its determinants among ambulatory older adults in six community chain pharmacies in Asmara, Eritrea: A Cross-Sectional study using the 2023 American geriatric society beers Criteria®. Clin Interv Aging. 2024;19:1177–87. https://doi.org/10.2147/CIA.S466649. PMID: 38974511; PMCID: PMC11227139.
44. Fujie K, Kamei R, Araki R, et al. Prescription of potentially inappropriate medications in elderly outpatients: a survey using 2015 Japanese guidelines. Int J Clin Pharm. 2020;42:579–87. https://doi.org/10.1007/s11096-020-00967-9.
45. Maher RL, Hanlon J, Hajjar ER. Clinical consequences of polypharmacy in elderly. Expert Opin Drug Saf. 2014;13(1):57–65. https://doi.org/10.1517/14740338.2013.827660. Epub 2013 Sep 27. PMID: 24073682; PMCID: PMC3864987.
46. Varghese D, Ishida C, Patel P et al. Polypharmacy. [Updated 2024 Feb 12]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK532953/
47. Gu J, Li SJ, Yu A, Xing Z, Kong J, Yang J, Wang YH. Prescription of potentially inappropriate medicines and comparison with lists of essential medicines for treatment of chronic disorders in older patients. Arch Gerontol Geriatr. 2023;109:104939. Epub 2023 Jan 26. PMID: 36746015.
48. Su L, Mittal R, Ramgobin D, Jain R, Jain R. Current management guidelines on hyperlipidemia: the silent killer. J Lipids. 2021;2021:9883352. https://doi.org/10.1155/2021/9883352. PMID: 34394993; PMCID: PMC8363437.
49. Rodrigues DA, Plácido AI, Mateos-Campos R, Figueiras A, Herdeiro MT, Roque F. Effectiveness of interventions to reduce potentially inappropriate medication in older patients: A systematic review. Front Pharmacol. 2022;12:777655. https://doi.org/10.3389/fphar.2021.777655. PMID: 35140603; PMCID: PMC8819092.
50. Monteiro L, Maricoto T, Solha I, Ribeiro-Vaz I, Martins C, Monteiro-Soares M. Reducing potentially inappropriate prescriptions for older patients using computerized decision support tools: systematic review. J Med Internet Res. 2019;21. https://doi.org/10.2196/preprints.15385.

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