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Prevalence and factors associated with preventable drug-related emergency department visits ($DRED_p$) in elderly patients

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Abstract

Background The prevalence of emergency department (ED) visits among the elderly is high and increasing. While emergency services for the elderly involve many factors, drug-related problems (DRPs) that can worsen patient conditions are less frequently discussed. This study investigates the prevalence of preventable drug-related ED visits ($DRED_p$) and the characteristics of DRPs in elderly ED patients through a comprehensive medication review.

Methods A cross-sectional study was conducted at a non-trauma ED of a university-affiliated tertiary-care hospital. All adult patients aged 60 years and older who were on medications and visited the ED were included. A clinical pharmacist conducted comprehensive medication reviews for each patient. Patients were classified as experiencing drug-related ED visits (DRED) if their primary reason for the visit was associated with a DRP, as determined by both the physician and pharmacist. DRPs attributed to medication errors were categorized as preventable, while other DRPs were assessed for preventability using modified Schumock and Thornton criteria.

Results The study involved 351 patients with a mean age of 75.5 years (SD 9.3) and an equal male-to-female ratio of ED visits. The median number of comorbidities was five (IQR 3–6), with about half of the patients taking ten or more medications. The interdisciplinary team classified 43 patients (12.3%) as $DRED_p$, accounting for 58.1% of the 74 (21.1%) drug-related ED visits. All medication errors categorized as causing harm (level E and higher) occurred within the $DRED_p$ group, constituting approximately half of all $DRED_p$ (22 cases, 51.2%). Approximately two-thirds of drug-related ED visits were associated with adverse drug events (ADEs), predominantly involving antithrombotics, oral hypoglycemic agents, and antineoplastics. Multivariable analysis identified that ED visits involving potentially inappropriate medications (PIMs) according to the STOPP criteria and the presence of multiple comorbidities (six or more concurrent diseases) were significantly associated with $DRED_p$.

Conclusions About one in ten elderly patients visited the ED due to preventable DRPs. The majority of DRPs leading to ED visits were ADEs. Both the prescription of PIMs and the presence of multiple comorbidities were significantly associated with $DRED_p$.

Keywords Elderly, Emergency department visit, Drug-related problems, Adverse drug events

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Background

Over time, the emergency department (ED) has become increasingly integral in managing the medical needs of older adults and providing acute care for elderly patients with urgent or multifaceted health issues [1, 2]. In all nations, including Thailand, the prevalence of ED visits among the elderly is currently high and expected to continue rising [2, 3], with rates escalating with age [4]. Those aged 80 and above experienced more than a threefold increase in visit prevalence compared to younger elderly individuals, and approximately one in three of these visits resulted in hospital admission [5]. Due to advancing age, changes in health behavior, and physiological changes across all organ systems, elderly individuals are more likely to suffer from multiple chronic conditions requiring treatment [6]. Consequently, this population tends to use more medications and have more complex drug regimens compared to the general population. Polypharmacy (PP: 5–9 medications) and excessive polypharmacy (EPP: ≥ 10 medications) [7] are particularly prevalent among the elderly, which increases their susceptibility to adverse drug events (ADEs), medication errors (MEs), drug interactions, and medication nonadherence. These factors may also contribute to a decline in functional capacity [8, 9].

A systematic review of the literature found that frequent utilization of emergency services among the elderly is associated with various factors, including a history of admissions to EDs and hospitals, residing in rural areas adjacent to city centers, low income, extensive drug prescriptions, and a history of cardiovascular disease [10]. An additional, yet less frequently discussed, contributing factor is drug-related problems (DRPs), which cause adverse treatment outcomes and potentially worsen patient conditions. Prior studies have reported the prevalence of DRPs in elderly patients visiting ED to range from 12.2% to 16.14%, primarily attributable to ADEs [11–14], with 76% of DRPs being deemed preventable [13]. Despite these findings, research on this patient demographic in Southeast Asia remains limited, and there is a notable absence of studies explicitly examining drug-related ED visits among older adults in Thailand. The objective of this study is to investigate the prevalence of preventable drug-related emergency department visits ($DRED_p$) and the characteristics of DRPs in elderly ED patients through a comprehensive medication review.

Methods

Study design and setting

This cross-sectional descriptive study was conducted at the non-trauma ED of a 1500-bed urban, university-affiliated tertiary-care hospital. This ED treats more than 80,000 new patient encounters per year and serves as a referral hospital from other urban hospitals and community hospitals for the surrounding neighborhood. The study received approval from the Institutional Review Board (COA No. 0182/2024). Written informed consent was obtained from all participants.

Study population

The study included all non-traumatic adult patients aged 60 years and older who were on medications and visited the ED between 7:30 a.m. and 3:30 p.m. on weekdays from February 12, 2024, to April 30, 2024. Patients who were able to communicate effectively or had relatives available to provide the necessary information were eligible. Patients were excluded if they had end-stage malignancies with palliative treatment, inaccessible patient information, or were discharged or transferred before information recording was completed.

The sample size was calculated using a single proportion formula [15], assuming 26% as the expected proportion of the population with preventable drug-related ED visits, based on previous literature [16]. A significance level (alpha) of 0.05 was used at a 95% confidence interval (CI), and an additional 10% was included to account for patients who might provide incomplete information. The final calculated sample size was 330.

Data collection

All patients underwent a comprehensive medication review by the first author. Data were gathered from electronic health records and detailed interviews with the patients or their caregivers. The information included patient demographics, comorbidities, current medication usage (including supplements, over-the-counter medications, and prescription drugs regularly taken prior to the emergency department visit), history of drug allergies and adverse effects, chief complaints, medications dispensed during the emergency department visit, principle diagnosis by the treating physician, and the visit outcomes. Furthermore, DRPs and recommendations were collected from pharmacists' written notes in case record form.

Underlying diseases and primary diagnoses at ED was classified using the International Classification of Diseases and Related Health Problems, tenth revision (ICD-10) [17]. Drug classes were defined using the Anatomical Therapeutic Chemical (ATC) codes provided by the WHO Collaboration Centre for Drug Statistics Methodology [18]. The Pharmaceutical Care Network Europe (PCNE) classification system version 9.1 was utilized to categorize issues (such as treatment effectiveness or safety), causes (like lack of indication for a drug, dosage too high, or prolonged treatment duration), and interventions [19].

Definitions and case identification

DRPs are defined as any detrimental event or circumstance related to drug therapy that disrupts or may disrupt desired health outcomes [19]. Our study collected all DRPs in patients visiting the ED and categorized them into two types: harmful DRPs and hidden DRPs. Harmful DRPs were identified as the primary reasons for patients visiting the ED based on their chief presenting complaints. In contrast, hidden DRPs were not the main reasons for the ED visit but could potentially result in adverse outcomes in the future.

Patients who had at least one harmful DRP were categorized as drug-related emergency department visits (DRED).

The decision of whether the visit to the ED was related to a drug was made by the agreement of the ED physician and clinical pharmacist at the ED. In instances of disagreement, the researcher sought consultation from another medical professor within the emergency department, requiring a two-thirds majority opinion to determine whether a drug-related issue was the primary reason for admission to the emergency department. However, both DRED and non-drug-related emergency department visits (NDRED) were able to have hidden DRPs. In our study, $DRED_p$ is when all harmful DRPs can be prevented; if some harmful DRPs are not avoidable, they are nonpreventable ($DRED_{np}$).

DRPs were identified in the study patients by using a structured action plan. Initially, the trigger tool was utilized [20], which involves directives to discontinue, adjust dosage (increase or decrease), add, or change medications. This method aimed to detect adverse events related to the presenting complaints in the ED. Secondly, the Screening Tool to Alert to Right Treatment (START) and Screening Tool of Older Persons' Prescriptions (STOPP) criteria [21] were used as screening tools to detect medication errors among elderly patients. Thirdly, potential drug interactions were checked using Micromedex® or Lexicomp® Drug Interactions mobile apps, focusing on drug pairs categorized as major (D) or contraindicated (X). Lastly, dosage adjustments for elderly patients were determined based on Lexicomp®'s Geriatric Dosage and relevant standard practice guidelines.

To ascertain whether the issue was drug-related, the evaluation considered the following factors: (1) known drug actions as detailed in drug monographs or literature and (2) the temporal correlation between the event and the timing of drug administration. To determine the causal relationship between the culprit drug and the adverse drug reaction (ADR), the Naranjo algorithm was applied. Each ADR was categorized based on its score: definite (≥ 9), probable (5–8), possible (1–4), or doubtful (≤ 0) [22].

All DRPs attributed to ME were categorized as preventable. The severity of ME was assessed using the classification system established by the National Coordinating Council for Medication Error Reporting and Prevention (NCC MERP) [23]. According to this system, categories E and above indicate harmful or life-threatening errors. Conversely, DRPs not linked to ME were assessed for preventability using the modified Schumock and Thornton criteria [24]. A DRP meeting one or more of these criteria was deemed preventable.

Outcomes measure

The primary objective of this study was to measure the prevalence of $DRED_p$ among elderly patients through comprehensive medication reviews and categorize the types of DRPs using the PCNE classification system (version 9.1). The secondary objectives were to identify factors associated with $DRED_p$, assess the proportion of hospital admissions and the length of stay related to $DRED_p$, and determine the rate of MEs (category E and above) causing harm to patients. Additionally, the study aimed to evaluate the prevalence of PP and EPP.

Statistical analyses

Descriptive analysis involved summarizing categorical variables using counts and percentages, and continuous variables using means and standard deviations. The normality of continuous variables was assessed using histograms. Pearson's Chi-square test was employed for categorical outcomes, while an independent t-test was used to compare numerical data between two independent groups, where applicable. Since certain numerical variables were not normally distributed, a Mann–Whitney U test was applied. The prevalence of $DRED_p$ was estimated by dividing the number of patients who visited the ED due to preventable DRPs by the total number of patients in the ED.

Factors associated with $DRED_p$ were also investigated using univariable logistic regression analyses. The factors tested included age, body mass index (BMI), history of alcohol consumption, number of prescribed medications, multimorbidity (≥ 6 comorbidities), ED visits involving potentially inappropriate medications (PIMs) according to STOPP criteria, use of insulin/warfarin/digoxin, and renal insufficiency (creatinine clearance < 50 mL/min by CG formula). To identify independent associations with $DRED_p$, all factors statistically significant at an α level of 0.2 in the univariable analyses were included in a multivariable logistic regression model using the stepwise method. Results from the logistic regression were presented as odds ratios (ORs) with 95% confidence intervals (CIs) and corresponding p-values. Data manipulation and analyses were undertaken using Microsoft Excel (Version

16.85, Microsoft Corp.,2024) and STATA (Version 18.0, StataCorp., 2023).

Results

Characteristics of the study population

During the study period, 474 non-traumatic elderly patients on medication and visited the ED were screened for eligibility, with 352 meeting the inclusion criteria. However, one patient was excluded due to incomplete data, leaving 351 enrolled. Demographic and clinical characteristics of the emergency visit cases are presented in Table 1. The median number of comorbidities was five. The most common combination of diseases was hypertension, dyslipidemia, and diabetes mellitus, which was present in 137 patients (39%). Approximately half of the patients ($n=177$, 50.4%) were taking ten or more medications. Furthermore, responsibility for drug administration before ED visits rested with the patients themselves in half of the cases ($n=183$, 52.1%). One-third of the patients had a history of adverse drug reactions or side effects.

The principal diagnoses by the ED physicians in our population vary widely (Supplementary 1), often include dyspnoea (6.8%), fever (5.7%), cerebral infarction (4.6%), syncope and collapse (4%), alteration of consciousness (3.7%), gastrointestinal hemorrhage, influenza and pneumonia (3.7%), and diseases of the circulatory system (3.7%). Approximately two-thirds of patients ($n=203$, 57.8%) were admitted to the hospital following their presentation at the ED.

Prevalence of preventable drug-related emergency department visits

Out of 351 patients classified by the interdisciplinary team, 43 (12.3%) visited the ED due to preventable DRPs (Fig. 1). These cases accounted for 58.1% of the 74 DREDs (21.1%). The remaining 277 patients (78.9%) had NDRED. No distinct differences in medication usage were observed between the DRED and NDRED groups (Supplementary Material 2).

Both $DRED_p$ and non-$DRED_p$ groups demonstrate comparable rates of PP and EPP. Furthermore, there is no discernible difference in hospitalization or hospital stay duration between them (Table 2). All medication errors categorized as level E and higher occurred within the $DRED_p$ group, constituting approximately half of all $DRED_p$ (22 patients, 51.2%).

Drug-related problems classification

Around half of the ED visit patients ($n=169$, 48.1%) experienced at least one DRP. A total of 253 DRPs were identified, with 171 categorized as hidden and 82 as harmful. Treatment effectiveness was the most common

Table 1 Demographic and drug-related characteristics of emergency visit cases

Characteristics	Total study population ($n=351$)
Age (years), mean (SD)	75.5 (9.3)
BMI (kg/m^2), mean (SD)	23.2 (4.6)
Gender, number (%) —Female	182 (51.9)
Number of comorbidities, median (IQR)	5 (3–6)
Comorbidity, number (%)	
– Hypertension (HTN)	253 (72.1)
– Dyslipidemia (DLP)	205 (58.4)
– Type II diabetes mellitus (T2DM)	159 (45.3)
– Gout/osteoarthritis /osteoporosis	81 (32.3)
– Chronic kidney disease (CKD)	79 (22.5)
– Ischemic heart disease (IHD)	74 (21.1)
– Atrial fibrillation and flutter	74 (21.1)
– Malignant neoplasm (unspecified)	73 (20.8)
– Old CVA	70 (20.0)
– Sleep disorder	28 (8.0)
– Chronic heart failure	24 (6.8)
– Asthma/COPD	25 (7.1)
– Alzheimer's disease/dementia	17 (4.8)
– Parkinson's disease	8 (2.3)
– Cirrhosis	8 (2.3)
Number of prescribed medications, mean (SD)	10 (4.7)
Responsible for drug administration before ED visit, number (%)	
– Patient	183 (52.1)
– Other (next of kin/carer/ nursing home)	168 (47.9)
History of ADR/SE, number (%)	104 (29.6)
Number of DRPs, number (%)	
– No DRP	182 (51.9)
– 1 DRP	108 (30.8)
– 2 DRPs	44 (12.5)
– ≥ 3 DRPs	17 (4.8)
Principal diagnoses at ED (ICD-10), number (%)	
– Dyspnoea	24 (6.8)
– Fever, unspecified	20 (5.7)
– Cerebral infarction	16 (4.6)
– Syncope and collapse	14 (4.0)
– Alteration of consciousness, unspecified	13 (3.7)
– Gastrointestinal hemorrhage, unspecified	13 (3.7)
– Influenza and pneumonia	13 (3.7)
– Diseases of the circulatory system	13 (3.7)
Condition after ED visit, number (%)	
– Hospital admission	203 (57.8)
• General ward	176 (86.7)
• ICU	16 (7.9)
• Observation ward	11 (5.4)
– Discharge	136 (38.8)
– Transfer	11 (3.1)
– Dead	1 (0.3)

SD Standard deviation, *IQR* Interquartile range, *DRP* Drug-related problem, *ADR* Adverse drug reaction, *SE* Side effect, *ED* Emergency department, *HTN* Hypertension, *DLP* Dyslipidemia, *T2DM* Type 2 Diabetes mellitus, *IHD* Ischemic heart disease, *CKD* Chronic kidney disease, *COPD* Chronic obstructive pulmonary disease, *CVA* Cerebrovascular accident, *ICU* Intensive care unit

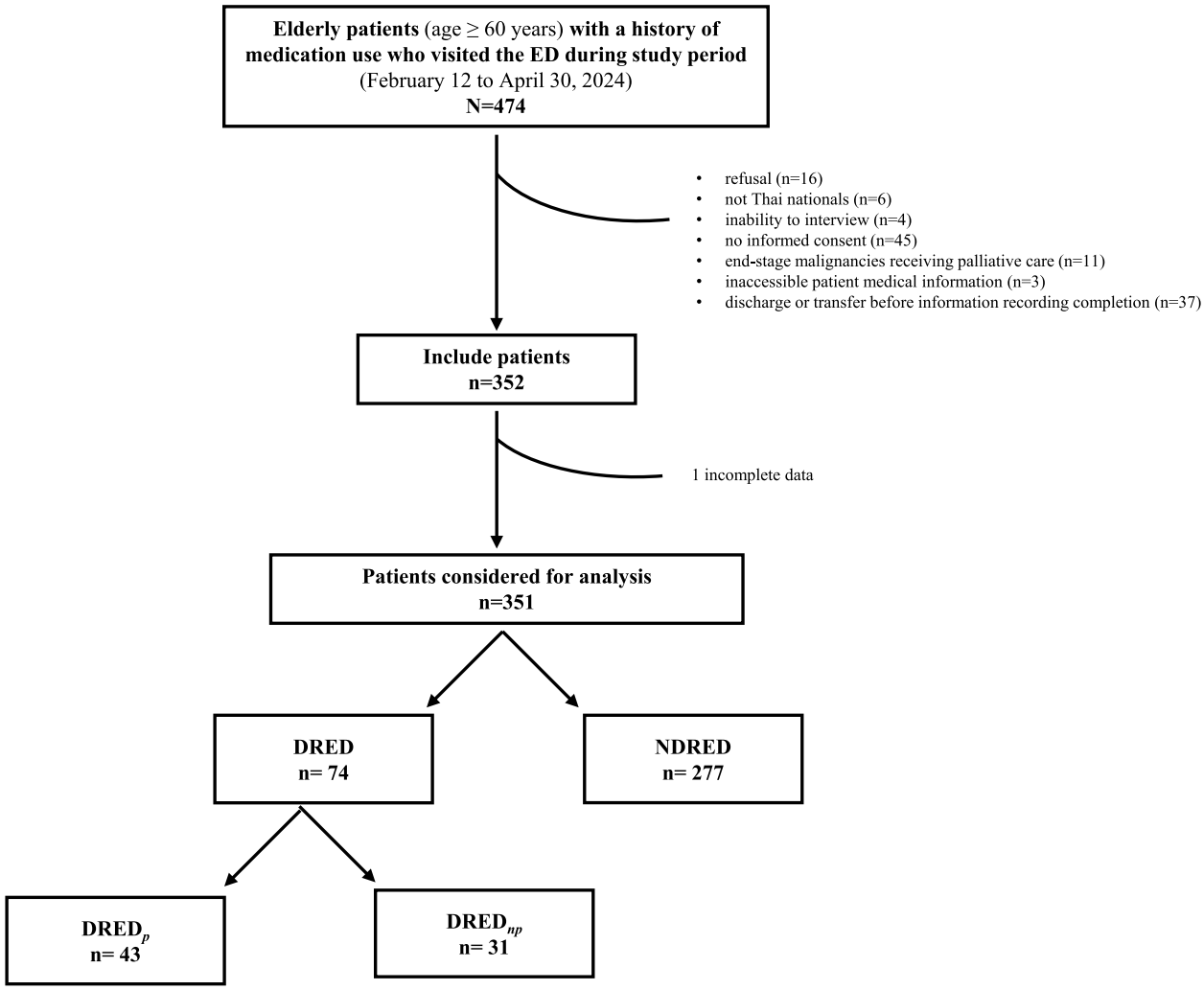

Fig. 1 Flow chart of the study

issue, comprising 133 DRPs (52.6%). This was followed by treatment safety at 44.7% and unnecessary treatment at 2.8%, as classified by the PCNE system. Remarkably, around two-thirds of the harmful DRPs were related to ADEs (Supplementary Material 3).

A total of 273 causes were identified for 253 DRPs, presented in Table 3. The predominant causes among these 253 DRPs were patient-related factors (31.5%), drug selection issues (26.7%), and other causes (24.9%). Within the patient-related category, the most frequent issue was patients taking less or none of the prescribed drug (25.7%), followed by patients taking more of the drug than prescribed (4%). In the inappropriate drug selection category, the majority of DRPs were due to inappropriate drugs being used according to guidelines or formulary (9.9%) and incomplete or missing drug treatment despite existing indications (7.1%). In the category of other causes, half of the cases had no obvious cause. 20 DRPs had two causes; half of the issues were related to drug selection.

In a study involving 253 DRPs, pharmacists predominantly suggested interventions, accounting for 88% of the patients. They informed prescribers and discussed the issues with them in approximately 56% of cases. Recommendations to pause or discontinue medication were made in 17.8% of DRPs. Over half of the DRPs received more than one intervention (51.8%). In 30% of cases, patient counseling was conducted, while communication with family members or caregivers occurred in 26.5%.

Drugs associated with harmful drug-related problems

In total, the harmful DRPs involved 108 medications: 41 aimed at treatment effectiveness and 67 focused on safety (Supplementary Material 3). Among the medications associated with treatment effectiveness issues, the *"C-Cardiovascular System"* category was the most

Table 2 Secondary outcome

Variable	Total ($n=351$) No. (%)	non-DRED$_p$ [‡] ($n=308$) No. (%)	DRED$_p$ ($n=43$) No. (%)	*p*-valuea
Non-polypharmacy: < 5 drugs	36 (10.3)	33 (10.7)	3 (7.0)	0.739
Polypharmacy: 5–9 drugs	138 (39.3)	121 (39.3)	17 (39.5)	
Excessive polypharmacy: ≥ 10 drugs	177 (50.4)	154 (50.0)	23 (53.5)	
Medication error (level E up)	22 (6.3)	0	22 (51.2)	
Hospitalization[*]	203 (57.8)	175 (56.8)	28 (65.1)	0.302
• non-ICU[†]	187 (92.1)	161 (92.0)	26 (92.9)	0.876
• ICU	16 (7.9)	14 (8.0)	2 (7.1)	
Hospital length of stay[**] (days), median (IQR)	5.06 (2.92–10.02)	5.22 (2.93–11.16)	3.97 (2.34–7.23)	0.562[b]

[a] Pearson's Chi-square

[b] Mann-whitney U test

[†] non-ICU (Observation ward + general ward)

[‡] non-DRED$_p$ (NDRED + DRED$_{np}$)

[*] defined as a stay in the hospital lasting more than 24 h

[**] only hospital admission cases

Table 3 Cause of DRPs according to the PCNE classification system version 9.1 [19]

Cause	Hidden DRPs ($n=171$) No. (%)	Harmful DRPs ($n=82$) No. (%)	All DRPs ($n=253$) No. (%)
C1: Drug selection			**73 (26.7)**
C1.1 Inappropriate drug according to guidelines/formulary	21 (12.3)	4 (4.9)	25 (9.9)
C1.2 No indication for drug	7 (4.1)	1 (1.2)	8 (3.2)
C1.3 Inappropriate combination of drug, or drugs and herbal medications, or drugs and dietary supplements	8 (4.7)	1 (1.2)	9 (3.6)
C1.4 Inappropriate duplication of therapeutic group or active ingredient	13 (7.6)	0	13 (5.1)
C1.5 No or incomplete drug treatment in spite of existing indication	10 (5.9)	8 (9.8)	18 (7.1)
C2: Drug form	2 (1.2)	0	**2 (0.8)**
C3: Dose selection			**15 (5.5)**
C3.1 Drug dose too low	5 (2.9)	2 (2.4)	7 (2.8)
C3.2 Drug dose of a single active ingredient too high	3 (1.8)	2 (2.4)	5 (2.0)
C3.5 Dose timing instructions wrong, unclear, or missing	3 (1.8)	0	3 (1.2)
C4: Treatment duration	1 (0.6)	0	**1 (0.4)**
C5: Dispensing	1 (0.6)	0	**1 (0.4)**
C6: Drug use			**27 (9.9)**
C6.2 Drug under-administered	7 (4.1)	1 (1.2)	8 (3.2)
C6.3 Drug over-administered	3 (1.8)	1 (1.2)	4 (1.6)
C6.4 Drug not administered at all	14 (8.2)	0	14 (5.5)
C7: Patient related			**86 (31.5)**
C7.1 Patient takes less or none of the drug	51 (29.8)	14 (17.1)	65 (25.7)
C7.2 Patient uses/takes more drugs than prescribed	7 (4.1)	3 (3.7)	10 (4.0)
C7.10 Patient unable to understand instructions properly	4 (2.3)	2 (2.4)	6 (2.4)
C9: Other causes			**68 (24.9)**
C9.1 No or inappropriate outcome monitoring (incl. TDM)	5 (2.9)	7 (8.5)	12 (4.7)
C9.2 Other cause	6 (3.5)	19 (23.2)	25 (9.9)
C9.3 No obvious cause	8 (4.7)	23 (28.1)	31 (12.3)
Two causes			**20 (7.9)**
Drug selection (***C1***) + others	8 (4.7)	4 (4.9)	12 (4.7)

prevalent, accounting for 19 medications. This category included beta-blockers, lipid-modifying agents, selective calcium channel blockers, ACE inhibitors, and antihypertensive agents acting on arteriolar smooth muscle. The *"A-Alimentary Tract and Metabolism"* category followed with 7 medications, including drugs for peptic ulcer and gastro-oesophageal reflux disease, blood glucose-lowering drugs excluding insulins, and insulins and analogs. Regarding safety, 67 medications were linked to ADEs. The most common ATC category was *"B-Blood and Blood Forming Organs,"* consisting entirely of 17 antithrombotic agents. The next most frequent category was *"A-Alimentary Tract and Metabolism,"* which included 15 medications, among them 8 blood glucose-lowering drugs and 4 insulins and analogs. The third most common categories were *"L-Antineoplastic and Immunomodulating Agents" and "C-Cardiovascular System,"* each with 9 medications. Specifically, the antineoplastic and immunomodulating agents included 3 plant alkaloids and other natural products, 3 other antineoplastic agents, and 3 immunosuppressants. The cardiovascular system drugs included 3 beta-blockers and 2 high-ceiling diuretics.

Factor associated with preventable drug-related emergency department visits

The univariable analysis revealed that six or more comorbid diseases, an ED visit with PIM, T2DM, two or more hypoglycemic agents, sulfonylurea use, and strong anticholinergic use, all had p-values < 0.2. These variables were, therefore, considered candidates for inclusion in the multivariable model. Our multivariable analysis showed that patients with multimorbidity (≥ 6 comorbid diseases) (OR = 1.97; 95% CI: 1.02–3.79) and those with ED visits involving PIM (OR = 2.89; 95% CI: 1.22 – 6.86) had an increased likelihood of being $DRED_p$. Table 4 presents our regression results for factors associated with $DRED_p$ in elderly patients.

Discussion

To the best of our knowledge, this is the first study to evaluate $DRED_p$ as the primary outcome and to focus on the elderly population in an ED setting. Our study revealed that among elderly patients who use medications and present to the ED, the prevalence of $DRED_p$ is 12.3%.

Few studies have examined DRED in older populations, and most of these have focused on adverse drug events. Previous articles have reported that the prevalence of DRED among elderly patients ranges from 12.2% to 16.14% [11–14]. Furthermore, identifying DRPs in patients with non-specific complaints appears more challenging than in the general ED population [12]. One study investigated DRED in the general population with an average age of over 60 years and reported a prevalence of ADE of 22.5% [25]. Our study found a DRED prevalence of approximately 21%, consistent with previous studies. Therefore, around one in five patients visiting the ED were classified as drug-related.

Approximately two-thirds of DRED in our study were associated with ADEs, aligning with the findings of Park et al. [13]. The predominant medications implicated in ADEs were antithrombotics, consistent with previous studies conducted in older populations [13, 26]. Additionally, we found that oral hypoglycemic agents and antineoplastics were common contributors to ADEs, as noted in earlier research [11, 13, 26]. Overall, the medications associated with ADEs in our study were similar to those identified in studies of emergency hospitalizations for ADEs in older patients, with warfarin, insulin, oral antiplatelet agents, and oral hypoglycemic agents implicated alone or in combination in 67% of cases [27].

Even though adverse effects were the most frequently registered cause of DRED in the previous studies, other drug-related issues, for instance, non-compliance, accounted for 7.6–15.4% [11, 13]. Our study found that 19.5% of harmful DRPs related to patients' behavior (non-compliance), which is higher than previous studies, may be due to the higher average number of pills taken per day and the fact that half of the patients self-administered their medications. Few studies mention about the drug selection problems or dosing problems. One study found that in DRED, the cause of drug choice problems is 12% and 21% from dose selection [12]. In contrast to our study, the drug selection problem is around 27%, while dose selection is around 6%.

Our findings revealed that 58.1% of DRED were preventable. Although research on this issue in elderly patients is limited, one study reported a preventability rate of 76% [13]. The differences between our study and previous ones may be due to varying evaluation criteria. Our results are consistent with earlier research on drug-related admissions, which reported that 57.3% to 61.5% of these incidents were potentially avoidable [28, 29]. Though it may not be feasible to prevent all instances of DRED, it is crucial to focus on enhancing overall recognition and documentation to mitigate preventable incidents [30].

Our final objective was to identify the variables associated with $DRED_p$ through multivariable analysis. The study revealed that ED visits involving PIMs according to the STOPP criteria, along with the presence of multiple comorbidities (defined as six or more concurrent diseases), were significantly associated with $DRED_p$ among the study participants.

Previous studies support that PIM prescriptions were identified as a predictive factor for ADEs, including

Table 4 Factors associated with $DRED_p$ among elderly patients

Variable	$DRED_p$		Univariable analysis**		Multivariable analysis***	
	NO ($n=308$) No. (%)	YES ($n=43$) No. (%)	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Age (year)						
- 60–74	152 (49.35)	18 (41.86)	REF			
- ≥ 75	156 (50.65)	25 (58.14)	1.35 (0.71, 2.58)	0.358	—	
BMI (kg/m^2)						
- 18.5–22.9	106 (34.42)	15 (34.88)	REF			
- < 18.5	44 (14.29)	5 (11.63)	0.80 (0.28, 2.34)	0.688		
- ≥ 23	158 (51.30)	23 (53.49)	1.03 (0.51, 2.06)	0.936	—	
Hx of alcohol						
- No	304 (98.70)	42 (97.67)	REF			
- Yes	4 (1.30)	1 (2.33)	1.81 (0.2, 16.58)	0.600	—	
Number of prescribed medications						
- < 15	256 (83.12)	33 (76.74)	REF			
- ≥ 15	52 (16.88)	10 (23.26)	1.49 (0.69, 3.21)	0.307	—	
Number of comorbidities						
- < 6	201 (65.26)	20 (46.51)	REF			
- ≥ 6	107 (34.74)	23 (53.49)	2.16 (1.14, 4.11)	0.019	1.97 (1.02, 3.79)	0.042
ED visit with PIM						
- No	285 (92.53)	34 (79.07)	REF			
- Yes	23 (7.47)	9 (20.93)	3.28 (1.40, 7.66)	0.006	2.89 (1.22, 6.86)	0.016
Use of insulin/digoxin/warfarin						
- NO	236 (76.62)	33 (76.74)	REF			
- YES	72 (23.38)	10 (23.26)	0.99 (0.47, 2.11)	0.986	—	
Renal insufficiency (CrCl* < 50 mL/min)						
- No	137 (51.70)	15 (40.54)	REF			
- Yes	128 (48.30)	22 (59.46)	1.57 (0.78, 3.16)	0.206	—	
T2DM						
- No	174 (56.49)	18 (41.86)	REF			
- Yes	134 (43.51)	25 (58.14)	1.80 (0.94, 3.44)	0.074	NS	
Number of oral hypoglycemic agents						
- < 2	265 (86.04)	32 (74.42)	REF			
- ≥ 2	43 (13.96)	11 (25.58)	2.12 (0.99, 4.52)	0.052	NS	
Sulfonylurea use						
- No	275 (89.29)	35 (81.40)	REF			
- Yes	33 (10.71)	8 (18.60)	1.90 (0.82, 4.45)	0.137	NS	
Strong anticholinergic use						
- No	261 (84.74)	31 (72.09)	REF			
- Yes	47 (15.26)	12 (27.91)	2.15 (1.03, 4.48)	0.041	NS	

BMI Body mass index, *PIM* Potentential inappropriate medication, *T2DM* Type 2 diabetes mellitus, *OR* Odds ratio, *CI* Confidence interval, *REF* Reference group

* Creatinine Clearance according to Cockcroft-Gault Formula

** *p*-value < 0.05; 95% CI (univariable analysis)

*** *p*-value < 0.2; 95% CI (stepwise multivariable analysis candidate), *NS* Not significant

ADR and ME, despite different PIM list criteria [26, 31]. However, in absolute terms, ADRs and MEs more often involved non-PIMs than PIMs [31]. Similarly, the study conducted by Budnitz et al. showed that most drug-related emergency department visits for ADEs in older adults were caused by commonly used drugs not classified as PIMs, such as insulin and oral anticoagulants [32]. This suggests that avoiding or deprescribing PIMs could enhance drug therapy safety. While focusing on PIM lists can help identify high-risk drugs, it is crucial not to underestimate the risks posed by other medications.

A study demonstrated that the presence of multiple comorbid conditions, defined as three or more concurrent diseases, was associated with an increased risk of ADEs due to medication-related issues in patients presenting to the ED [33]. Our research, however, defined multiple comorbidities as six or more concurrent diseases. Despite this definitional discrepancy, our findings similarly indicated that multiple comorbidities were correlated with DRPs resulting in ED visits, corroborating the conclusions of previous studies.

The recognition of the associated factors can trigger in-depth medical reviews to potentially discover the presence of adverse effects, non-compliance or incorrect drug dosage in the ED patients.

Our study has strengths. Firstly, data were collected prospectively, ensuring reliability by examining various information sources, including patient interviews, to obtain medication histories and detect DRPs. Additionally, we utilized an interdisciplinary team to determine the prevalence of drug-related ED visits, balancing any inter-professional and inter-individual differences of opinion. Thirdly, the DRPs were classified using the latest version of PCNE by two pharmacists, with disagreements resolved by consulting another expert pharmacist. Furthermore, we assessed the individual preventability of DRPs. Besides identifying harmful DRPs that led to ED visits, we also identified hidden DRPs that could potentially cause future harm. In cases of DRPs, pharmacists were involved in interventions for prescribers or patients/caregivers.

However, our study has some limitations. Primarily, it was conducted at a single urban tertiary care center, which may limit the generalizability of the findings to the entire population. Nonetheless, our hospital is representative of most academic urban EDs, supporting the applicability of our results to this setting. Furthermore, the short study period may have allowed seasonal effects to impact the prevalence of ADEs. Recruitment was limited to five days a week, following the pharmacy's working hours, rather than seven days a week, possibly introducing selection bias. Although drug histories were collected prospectively and sources were documented, some information may have been intentional or unintentional omissions, which must be considered.

Conclusion

Approximately one in ten elderly patients presented to the ED due to preventable DRPs. ADEs constitute a significant proportion of these DRPs, with antithrombotics, oral hypoglycemic agents, and antineoplastics frequently implicated. Prescribing PIMs, as defined by the STOPP criteria, and multiple comorbidities (six or more concurrent diseases) were significantly associated with $DRED_p$.

Abbreviations

ADE	Adverse drug event
ADR	Adverse drug reaction
ATC	Anatomical Therapeutic Chemical
BMI	Body mass index
CG	Cockcroft-Gault
CI	Confidence interval
CKD	Chronic kidney disease
COPD	Chronic obstructive pulmonary disease
CVA	Cerebrovascular accident
DLP	Dyslipidemia
DRED	Drug-related emergency department visits
$DRED_p$	Preventable drug-related emergency department visits
$DRED_{np}$	Nonpreventable drug-related emergency department visits
DRP	Drug-related problem
ED	Emergency department
EPP	Excessive polypharmacy
HTN	Hypertension
ICD-10	International Statistical Classification of Diseases and Related Health Problems 10th Revision
ICU	Intensive care unit
IHD	Ischemic heart disease
IQR	Interquartile range
ME	Medication error
NCC MERP	National Coordinating Council for Medication Error Reporting and Prevention
NDRED	Non-drug-related emergency department visits
OR	Odd ratio
PCNE	Pharmaceutical Care Network Europe
PIM	Potentially inappropriate medication
PP	Polypharmacy
SD	Standard deviation
SE	Side effect
START	The Screening Tool to Alert to Right Treatment
STOPP	The Screening Tool of Older Persons' Prescriptions
T2DM	Type 2 Diabetes mellitus

Supplementary Information

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Supplementary Material 1.

Supplementary Material 2.

Supplementary Material 3.

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Authors' contributions

PP, NA, and SV developed the study concept and design. KM conceived the study and also participated in its design. PP was responsible for acquiring subjects and data and conducting the intervention. NA and SV performed data verification. PP and NA analyzed and interpreted the data. PP drafted the manuscript, with all authors providing substantial revisions. All authors reviewed and approved the final version, taking collective responsibility for the entire content of the paper.

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Data availability

All relevant data are contained within the paper.
Our data has been collected in research unit database in authors' institute. In case of reviewers or editors request more to share, we will provide more information or access to the database.

Declarations

Ethics approval and consent to participate
The studies involving human participants were reviewed and approved by the Institutional Review Board (IRB) of the Faculty of Medicine, Chulalongkorn University (COA No. 0182/2024). Written informed consent was obtained from all participants. All methods adhered strictly to relevant guidelines and regulations.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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