Die Pharmazie

Pharmazie **2026**; 81(7): 53161
https://doi.org/10.31083/Pharmazie53161

Research Article

Pharmaceutical Interventions During Inpatient Care in a French Geriatric Hospital

Diana Lopez-Leret[1,†], Joël Schlatter[1,*,†]

[1]Pharmacy, Hospital of Paul Doumer – Assistance Publique des Hôpitaux de Paris, 60140 Labruyère, France
*Correspondence: joel.schlatter@aphp.fr (Joël Schlatter)
[†]These authors contributed equally.

Academic Editors: Thilo Bertsche and Walter E. Müller
Submitted: 21 April 2026 Revised: 15 June 2026 Accepted: 24 June 2026 Published: 24 July 2026

Abstract

Background: Since aging is associated with pharmacokinetic and pharmacodynamic changes, polypharmacy is particularly harmful in older adults. Meanwhile, clinical pharmacists contribute to safer prescribing by applying their clinical expertise during medication review. Therefore, this study aimed to characterize potential drug-related problems through the analysis of routine pharmaceutical interventions. **Methods:** Data were collected from the electronic health record between 2019 and 2025; potentially inappropriate medications and high-risk medications were identified. Drug-related problems were categorized according to the Pharmaceutical Care Network Europe classification. **Results:** Pharmacists performed 12,856 pharmaceutical interventions, of which prescribers accepted 65%. The mean patient age was 87.5 years (range, 65–113 years), and 60.2% of patients were female. Among all pharmaceutical interventions, 1779 involved a potentially inappropriate medication. The most frequent causes of drug-related problems were related to dose selection (39.8%), drug selection (14.3%), treatment duration (10.1%), and treatment safety (9.3%). The most commonly targeted drug categories were the nervous system (24.7%), the digestive tract and metabolism (21.5%), blood and hematopoietic organs (19.8%), and the cardiovascular system (13.6%). **Conclusions:** Pharmaceutical interventions that prevent prescribing errors in older adults are essential in clinical practice. Understanding potential drug-related problems and the nature of pharmaceutical interventions can help ensure safe pharmacotherapy by alerting prescribers and caregivers to major medication-related risks.

Keywords: pharmaceutical interventions; patient safety; aged; drug therapy; medication errors

1. Introduction

Polypharmacy, defined as the concurrent use of five or more medications, is common among older adults and often reflects the need to manage multimorbidity and the associated complications. In a recent systematic review, the overall prevalence of polypharmacy and hyper-polypharmacy in the older adult population worldwide was 39.1% and 13.3%, respectively [1,2]. Hyper-polypharmacy, defined as the use of 10 or more medications, increased more than threefold between 1995 (4.9%) and 2010 (17.2%) [3]. Meanwhile, the prevalence of polypharmacy in older adults across 27 European countries varies from around 25% to 51.8%, depending on age group and region [4]. In France, the prevalence is 28.7% among individuals aged 65–74 years, 21.1% among those aged 75–84 years, and 35.8% among those aged ≥85 years [4]. Polypharmacy is particularly harmful in older adults because advancing age is often associated with significant pharmacokinetic and pharmacodynamic changes [5,6]. Specifically, structural and functional changes affect renal and hepatic clearance, the volume of distribution of lipid-soluble drugs, and sensitivity to several drug classes [5]. Thus, to provide accurate medication management, the quality of prescriptions for older patients requires a solid understanding of pharmacokinetics and pharmacodynamics, including drug interactions and potential adverse effects in this population. The World Health Organization published a technical report on "medication safety in polypharmacy", identifying the scale of avoidable harm caused by unsafe medication practices and medication errors [7]. To ensure medication safety, appropriate prescribing and a risk–benefit analysis of each medicine are the first steps. Failures stemming from limited prescriber knowledge or excessive workload may lead to medication errors, whether or not the medication causes harm [8]. In a retrospective, descriptive analysis of French pharmacovigilance data, prescribing-related medication errors accounted for 11% of error stages, the second most frequent stage reported [8]. To optimize medication use, the expertise of each pharmacist in medication review can reduce adverse drug reactions, helping prescribers optimize regimens and discontinue medications deemed inappropriate [9,10,11,12]. Pharmaceutical interventions are recommendations made by clinical pharmacists regarding medication therapy, such as detecting drug–drug interactions, identifying potential adverse effects, and discontinuing drugs based on clinical, paraclinical, and biological data [13]. Therefore, this study aimed to describe pharmaceutical interventions for inpatient treatment among older adults at a French geriatric hospital.

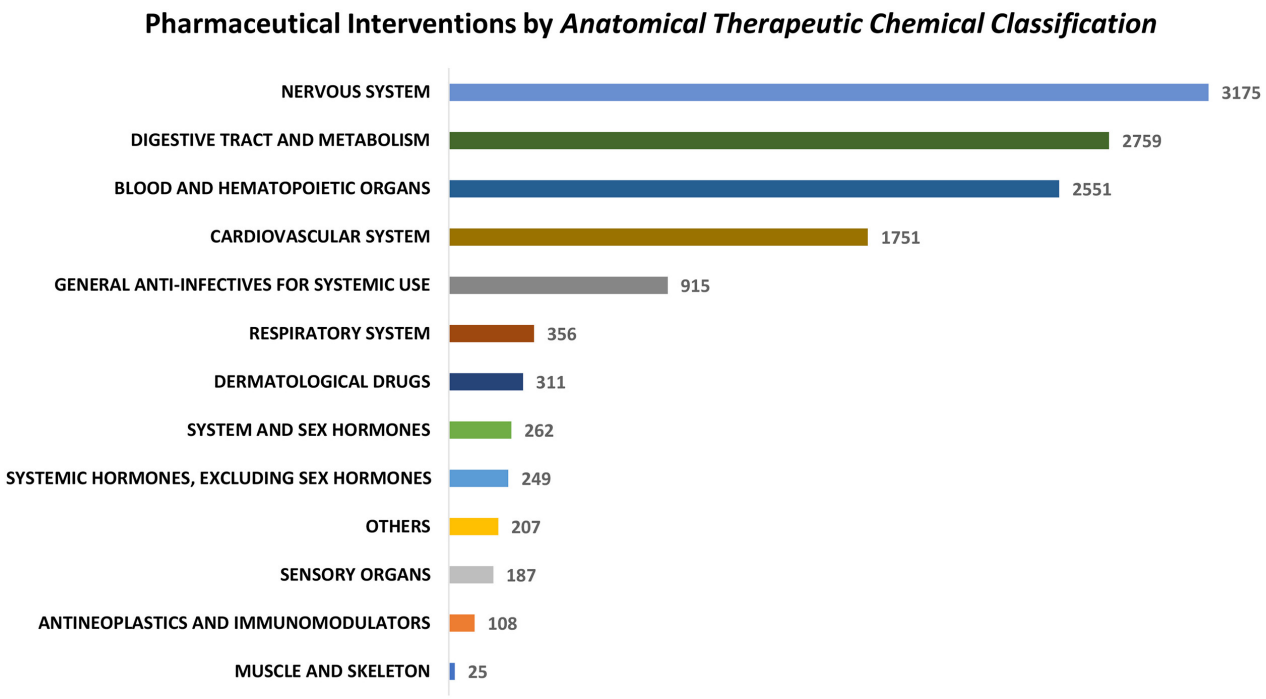

Fig. 1. Total number of pharmaceutical interventions categorized according to the Anatomical Therapeutic Chemical (ATC) classification system.

2. Materials and Methods

2.1 Study Design

This single-center retrospective study was conducted at the Paul Doumer Hospital, a 193-bed academic geriatric hospital. Medical record data were extracted from the electronic health record between March 2019 and October 2025, with anonymization and data protection measures compliant with the Declaration of Helsinki [14]. To provide a relevant pharmaceutical analysis, a patient profile was established that considered demographic factors, comorbidities, prescribed medications, and laboratory data. After assessment of the patient profile, the focus was on the pharmacotherapeutic analysis of the prescription, including medication adaptation (galenic forms, doses, frequencies, and duration), therapeutic duplication, drug interactions, and inappropriate indications. Potentially inappropriate medications, as identified in the American Geriatrics Society Beers Criteria, were identified [15]. Moreover, high-risk medications were also identified. High-risk medications were defined as drugs that substantially increase the risk of significant patient harm when used in error, with consequences that are particularly severe for patients [16]. The top 15 high-risk medications include digoxin, antiarrhythmics, methotrexate, hypnotics and sedatives, immunosuppressants, dual platelet therapy, insulin, antipsychotics, carbamazepine, lithium, anticoagulants, oral hypoglycemic drugs, phenytoin, opioids, and chemotherapeutic drugs [17,18]. Drug-related problems were categorized according to the Pharmaceutical Care Network Europe classification, independently evaluated by two pharmacists. Global pharmaceutical interventions by the clinical pharmacist were integrated and validated in real time within the electronic medical record and were visible to the prescriber, who could accept or reject the pharmaceutical recommendations. All patients hospitalized during the study period were included. Multiple pharmaceutical interventions performed on the same patient were included.

2.2 Analysis

The baseline characteristics of patients are described as the mean ± standard deviation (SD). Data analyses were conducted using GraphPad Prism version 6.01 (GraphPad Software, Boston, MA, USA).

3. Results

Between March 2019 and October 2025, clinical pharmacists made 12,856 pharmaceutical interventions for a total of 3685 patients, with 65% accepted by prescribers, 2% refused, and 33% without response. Temporal analysis showed an overall increase in pharmaceutical interventions during the study period. A total of 2123 interventions were recorded in 2020. After decreases in 2021 (856 interventions) and 2022 (947 interventions), the number of interventions increased markedly from 2023 onwards, reaching 2376 in 2023 and 3608 in 2024. In 2025, 2946 interventions were recorded as of October. Overall, these findings indicate a progressive expansion of clinical pharmacy activities within the geriatric hospital and a growing integration of pharmacists into patient care, with the highest ac-

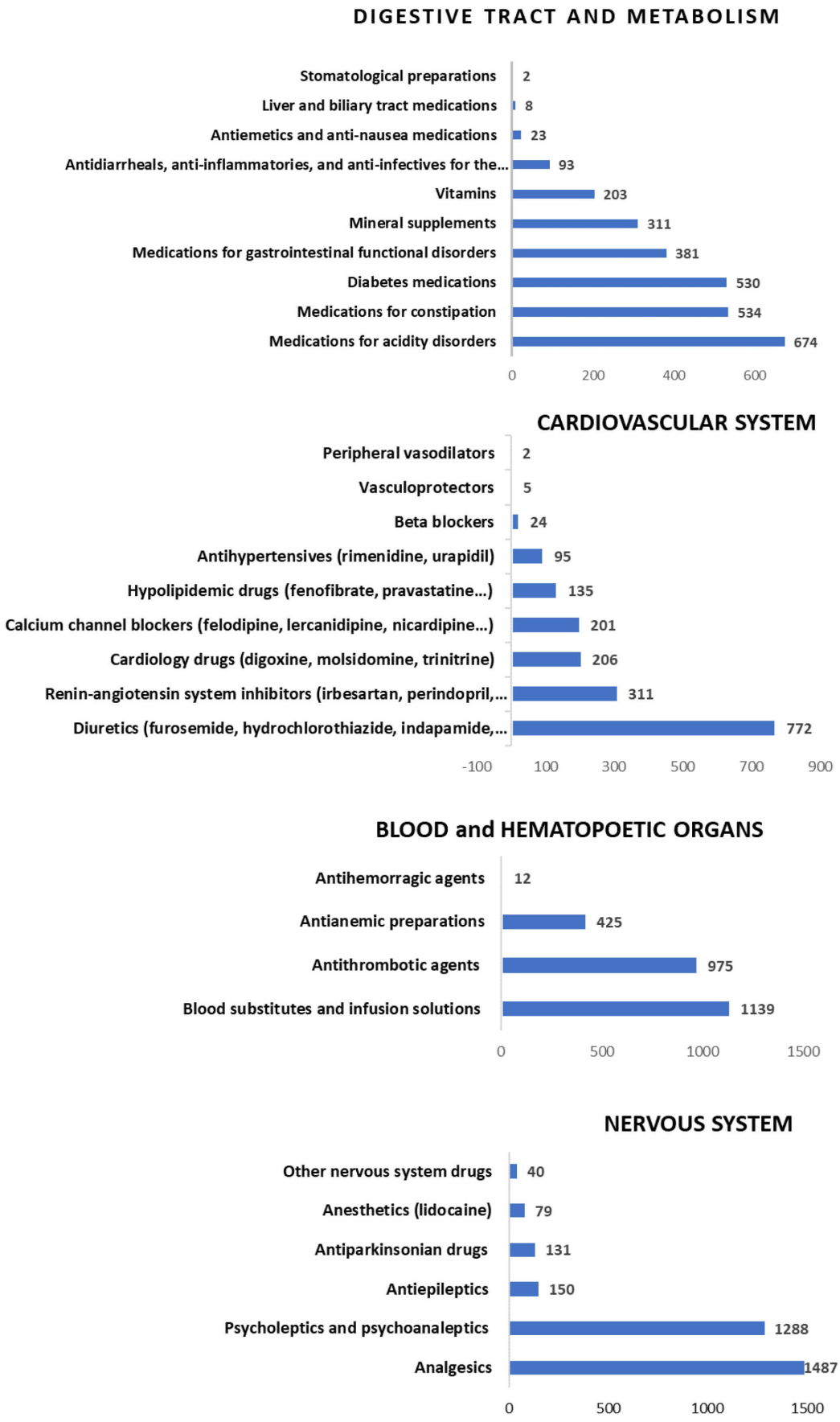

Fig. 2. Number of pharmaceutical interventions by major drug categories.

Table 1. Top 20 drugs targeted by pharmaceutical interventions.

Rank	Drugs	ATC code	Pharmaceutical interventions (n, %)
1	Glucose	Irrigating solutions (B05B)	938 (7.3)
2	Furosemide	High-ceiling diuretics (C03C)	583 (4.5)
3	Lansoprazole	Drugs for peptic ulcer and gastro-esophageal reflux disease (A02B)	541 (4.2)
4	Paracetamol	Other analgesics and antipyretics (N02B)	509 (4.0)
5	Metoclopramide	Propulsives (A03F)	317 (2.5)
6	Nefopam	Other analgesics and antipyretics (N02B)	276 (2.1)
7	Morphine	Opioids (N02A)	254 (2.0)
8	Potassium chloride	Potassium (A12B)	251 (2.0)
9	Laxative (sodium phosphate)	Drugs for constipation (A06A)	239 (1.9)
10	Tramadol	Opioids (N02A)	233 (1.8)
11	Fer	Iron preparations (B03A)	231 (1.8)
12	Econazole	Antifungals for topical use (D01A)	220 (1.7)
13	Mianserin	Antidepressants (N06A)	215 (1.7)
14	Enoxaparin	Antithrombotic agents (B01A)	172 (1.3)
15	Escitalopram	Antidepressants (N06A)	170 (1.3)
16	Fluindione	Antithrombotic agents (B01A)	164 (1.3)
17	Folic acid	Vitamin B12 and folic acid (B03B)	162 (1.3)
18	Apixaban	Antithrombotic agents (B01A)	159 (1.2)
19	Sitagliptin	Blood glucose lowering drugs (A10B)	158 (1.2)
20	Perindopril	ACE inhibitors (C09A)	154 (1.2)

ATC, Anatomical Therapeutic Chemical.

tivity level observed in 2024. The mean patient age was 87.5 years (SD, 8.2), with an age range of 65–113 years; 60.2% of patients were female. The mean number of medications per patient was 8.5 ± 6.8, and the mean number of pharmaceutical interventions per patient was 4.8 ± 5.5. The mean number of pharmaceutical interventions per patient was 4.9 ± 5.8 in women and 4.7 ± 4.8 in men. No significant difference was observed between sexes regarding the number of pharmaceutical interventions per patient (Mann–Whitney U test, $p = 0.497$). The most commonly targeted drug categories were the nervous system (n = 3175, 24.7%), the digestive tract and metabolism (n = 2759, 21.5%), blood and hematopoietic organs (n = 2551, 19.8%), and the cardiovascular system (n = 1751, 13.6%) (Fig. 1).

The nervous system category was divided into analgesics (n = 1487) and psycholeptics and psychoanaleptics (n = 1288) (Fig. 2).

The digestive tract and metabolism category was divided into medications for acidity disorders (n = 674), medications for constipation (n = 534), diabetes medications (n = 533), and medications for gastrointestinal functional disorders (n = 381) (Fig. 2). The blood and hematopoietic organs category was divided into blood substitutes and infusion solutions (n = 1139), antithrombotic agents (n = 975), anemia preparations (n = 425), and antihemorrhagic agents (n = 12) (Fig. 2). The cardiovascular system category was divided into diuretics (n = 772), renin–angiotensin system inhibitors (n = 311), cardiology drugs (n = 206), and calcium channel blockers (n = 201) (Fig. 2).

The 10 most common types of drugs identified by clinical pharmacists were glucose (n = 938, 7.3%), furosemide (n = 583, 4.5%), lansoprazole (n = 541, 4.2%), paracetamol (n = 509, 4.0%), metoclopramide (n = 317, 2.5%), nefopam (n = 276, 2.1%), morphine (n = 254, 2.0%), oral potassium (n = 251, 2.0%), laxative (n = 239, 1.9%), and tramadol (n = 233, 1.8%) (Table 1).

Among all pharmaceutical interventions, 1779 (13.8%) involved a potentially inappropriate medication, as defined by the American Geriatrics Society Beers Criteria for patients aged 65 years and older [15]. Key points of pharmaceutical interventions related to potentially inappropriate medications are detailed in Table 2.

The pharmaceutical interventions identified numerous clinically significant medication-related issues, including contraindications, major dosing errors, drug–drug interactions, duplication of therapy, and lack of appropriate monitoring (Table 2). Comments by pharmacists were classified according to the Pharmaceutical Care Network Europe Drug-Related Problem classification [19]. According to this classification, the most frequent causes of drug-related problems were dose selection (39.8%), drug selection (14.3%), treatment duration (10.1%), and treatment safety (9.3%) (Table 3).

Several prescribed drugs were formally contraindicated in the context of severe renal impairment, such as nitrofurantoin and other renally eliminated agents. Hypokalemia in the presence of digoxin created a major risk of digoxin toxicity and malignant arrhythmias. Moreover,

Table 2. Potentially inappropriate medications and examples of pharmaceutical interventions.

Drug	Rationale	Examples of pharmaceutical interventions
Nitrofurantoin (n = 24)	Potential for pulmonary toxicity, hepatotoxicity, and peripheral neuropathy, especially with long-term use; safer alternatives are available	Nitrofurantoin is contraindicated in patients with GFR <45, no justification for the choice of antibiotic, comment regarding the recommended dosage
Clonazepam (n = 8)	The use of benzodiazepines exposes users to risks of abuse, misuse, and addiction. Concomitant use of opioids may result in profound sedation, respiratory depression, coma, and death	Synergy of anticholinergic effects with other prescriptions with risks of falls for example; no indication documented in the patient record
Primidone (n = 2)	High rate of physical dependence, tolerance to sleep benefits, increased risk of overdose at low dosage	Decrease in plasma concentration of finasteride by enzyme-inducing agents
Trihexyphenidyl (n = 7)	Not recommended for prevention or treatment of extrapyramidal symptoms due to antipsychotics; more effective agents available for the treatment of Parkinson's disease	Please confirm the association with the extended-release form. Medication is not divisible; dose insufficient for therapeutic effect
Rivaroxaban (n = 126)	At doses used for long-term treatment of VTE or nonvalvular atrial fibrillation, rivaroxaban appears to have a higher risk of major bleeding and GI bleeding in older adults than other DOACs, particularly apixaban	Incorrect dosage for the indication; insufficient dosage for prevention of PE (15 mg/day when adjusted for renal function vs. 20 mg/day otherwise); duplicate prescriptions (two lines of rivaroxaban); potential decrease in efficacy when combined with carbamazepine (enzyme inducer); for GFR 13 mL/min/1.73 m^2, FDA guidelines recommend 15 mg/day with close monitoring
Warfarin (n = 129)	Compared with DOACs, warfarin has higher risks of major bleeding (particularly intracranial bleeding) and similar or lower effectiveness for the treatment of nonvalvular atrial fibrillation and VTE	INR 7.92: discontinuation of treatment and consideration of vitamin K supplementation; absence of INR control; duplicate prescriptions (two lines of warfarin); possible risk of bleeding with concomitant sulfamethoxazole; paracetamol use may alter INR; evening prescribing enables dosage adjustment or omission if the morning INR is abnormal
Metoclopramide (n = 317)	Can cause extrapyramidal effects, including tardive dyskinesia; the risk may be greater in frail older adults and with prolonged exposure	Please adjust dosage based on kidney function (decrease of 50% if moderate or severe, 75% if extreme); treatment should be limited to a maximum of 5 days; please consider that the patient weighs 45.2 kg (maximum recommended daily dose is 0.5 mg/kg); metoclopramide + levodopa is contraindicated due to mutual antagonism; contraindicated in Parkinson's disease; three lines of metoclopramide prescription
Lansoprazole (n = 541)	Risk of *C. difficile* infection, pneumonia, GI malignancies, bone loss, and fractures	Please consider patient anemia; lansoprazole may reduce vitamin B12 absorption; methotrexate toxicity may increase due to reduced elimination; please correct the dose (15 mg and not 15 tablets); please specify a treatment duration; absence of indication; absence of re-evaluation
Gliclazide (n = 50)	Sulfonylureas have a higher risk of cardiovascular events, all-cause mortality, and hypoglycemia than alternative agents. Sulfonylureas may increase the risk of cardiovascular death and ischemic stroke	Contraindicated in severe renal failure (GFR <30 mL/min/1.73 m^2); the maximum dose of gliclazide is 120 mg once daily with breakfast; combining two long-acting hypoglycemic sulphonamides leads to a higher risk of hypoglycemia and is not clinically justified
Insulin (n = 94)	Higher risk of hypoglycemia without improvement in hyperglycemia management regardless of care setting	Two lines of drug prescription; please confirm the prescription for two fast-acting insulins; please confirm more than one injection per day for the glargine insulin; prescribe the protocol validated in the software because the nurse does not have the information needed for administration

Table 2. Continued.

Drug	Rationale	Examples of pharmaceutical interventions
Digoxin (n = 22)	Use in atrial fibrillation: should not be used as a first-line agent. Use in heart failure: evidence for benefits and harms of digoxin is conflicting and of lower quality. Decreased renal clearance of digoxin may lead to an increased risk of toxic effects	Hypokalemia enhances the toxicity of digoxin; in older patients, the dosage should generally be reduced to 0.125 mg per day because of physiological decline in renal function and greater sensitivity to digoxin; in older patients with renal failure, plasma digoxin levels should be measured to adjust the dosage, especially toward the end of the first week
Paroxetine (n = 84)	Highly anticholinergic, sedating, and can cause orthostatic hypotension	Avoiding administration in the evening, as paroxetine may cause insomnia and agitation; tramadol + paroxetine carries a risk of serotonin syndrome; gradual discontinuation of treatment with a reduction in the daily dose by 10 mg (0.5 tablets) per week, administration once daily; caution with pizotifen, which has an anti-serotoninergic effect
Clorazepate (n = 10)	The use of benzodiazepines exposes users to risks of abuse, misuse, and addiction	Error of dosage (800 mg/d)
Haloperidol (n = 33)	Increased risk of stroke and greater rate of cognitive decline and mortality in individuals with dementia	Elevated risk of ventricular arrhythmias in combination with drugs that can prolong the QTc interval; dose of 16.5 mg: in older patients, the maximum recommended dose is 5 mg/day

GFR, glomerular filtration rate; VTE, venous thromboembolism; GI, gastrointestinal; DOACs, direct oral anticoagulants; FDA, Food and Drug Administration; INR, international normalized ratio; QTc, corrected QT.

Table 3. Classification of pharmaceutical interventions according to the Pharmaceutical Care Network Europe (PCNE) Drug-Related Problem (DRP) classification.

Primary domain	Code PCNE	Description	Number
Drug selection (The cause of the (potential) DRP is related to the selection of the drug (by patient or health professional))	C1.1	Inappropriate drug according to guidelines/formulary	812 (6.3%)
	C1.3	Inappropriate combination of drugs, or drugs and herbal medications, or drugs and dietary supplements	645 (5.0%)
	C1.4	Inappropriate duplication of therapeutic group or active ingredient	391 (3.0%)
	Total		**1848 (14.3%)**
Drug form (The cause of the DRP is related to the selection of the drug form)	C2.1	Inappropriate drug form/formulation (for this patient)	60 (0.5%)
Dose selection (The cause of the DRP is related to the selection of the dose or dosage)	C3.1	Drug dose too low	1528 (11.9%)
	C3.2	Drug dose of a single active ingredient too high	2623 (20.4%)
	C3.3	Dosage regimen not frequent enough	964 (7.5%)
	Total		**5115 (39.8%)**
Treatment duration (The cause of the DRP is related to the duration of treatment)	C4.1	Duration of treatment too short	241 (1.9%)
	C4.2	Duration of treatment too long	1059 (8.2%)
	Total		**1300 (10.1%)**
Drug use process (The cause of the DRP is related to the way the patient gets the drug administered by a health professional or other carer, despite proper dosage instructions (on label/list))	C6.1	Inappropriate timing of administration or dosing intervals by a health professional	712 (5.5%)
	C6.2	Drug under-administered by a health professional	426 (3.3%)
	Total		**1138 (8.8%)**
Patient related (The cause of the DRP is related to the patient and his behaviour (intentional or non- intentional))	C7.1	Patient intentionally uses/takes less drug than prescribed or does not take the drug at all for whatever reason	108 (0.8%)
Other causes	C9.1	No or inappropriate outcome monitoring	994 (7.7%)

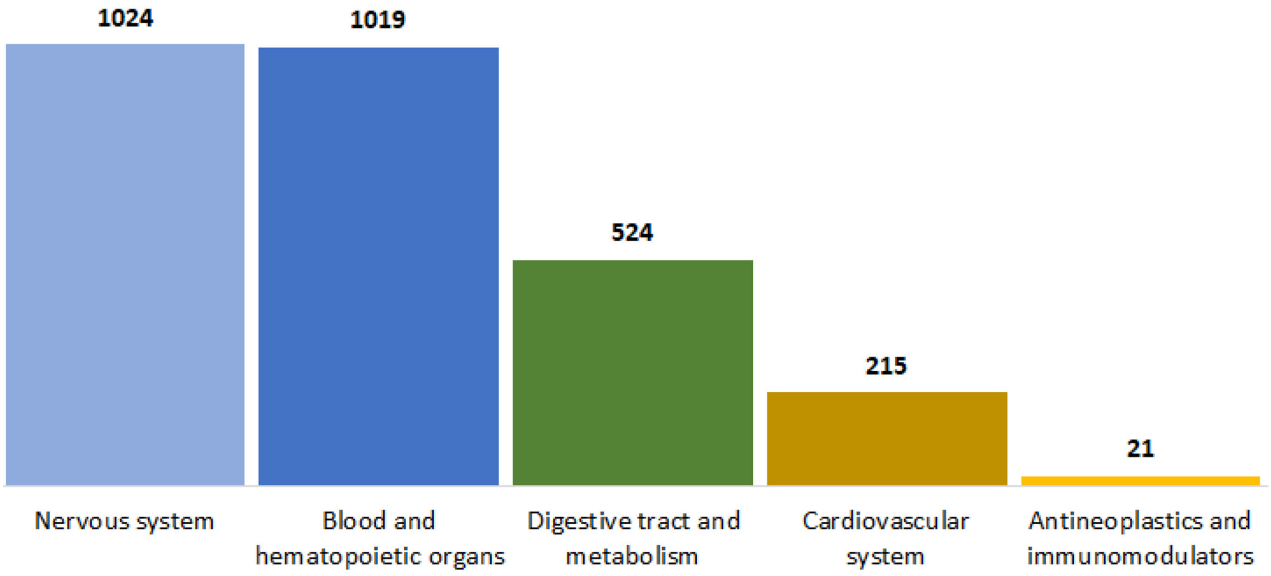

Fig. 3. Number of pharmaceutical interventions related to high-risk medications by drug category.

relevant dosing errors were observed because treatments were not adapted to renal function, advanced age, or low body weight. Among the identified drug interactions, carbamazepine, a potent enzyme inducer, is known to reduce the efficacy of several concomitant treatments, including finasteride. Combining tramadol and paroxetine might cause life-threatening serotonin syndrome. Many duplicate prescriptions were found, some medications appearing two or three times on the same prescription. Numerous treatments had no documented indication, expected duration, or follow-up. Regarding high-risk medications, 2803 pharmaceutical interventions were recorded, accounting for 21.8% of all interventions. The distribution of pharmaceutical interventions by category is shown in Fig. 3.

The major categories were the nervous system (n = 1024, 36.5%) and blood and hematopoietic organs (n = 1019, 36.4%) including analgesics (n = 903; fentanyl, morphine, nefopam, oxycodone, tramadol), psycholeptics (clorazepate, diazepam, loxapine, midazolam, scopolamine), and antithrombotic agents (n = 912; acenocoumarol, apixaban, clopidogrel, dabigatran, enoxaparin, fluindione, heparin, rivaroxaban, warfarin, potassium chloride for injection). For the digestive tract and metabolism, the high-risk drug category included diabetes medications (insulin and oral antidiabetic drugs). In the cardiovascular system, digoxin was the most commonly identified substance among pharmaceutical interventions. In the antineoplastics and immunomodulators category, pharmaceutical interventions focused on methotrexate.

4. Discussion

Polypharmacy among older adults (65 years or older) is a global concern, with prevalence estimates in European countries ranging from 25.0% to 51.8%, including 28.7% in France [4]. The use of multiple medications carries documented adverse drug events, particularly in older adults who present physiological changes such as impairment of pharmacokinetics and pharmacodynamics, reduction in liver and kidney function, and loss of muscle mass [3,20]. Thus, older adults are more exposed to medication-related harms, of which 17% are preventable. Medication-related adverse events were most frequently observed during prescribing (53%), monitoring (36%), and administration (22.2%). Therefore, clinical pharmacist interventions are effective in detecting and preventing prescription errors [21,22]. In a recent study, clinical pharmacist interventions reduced prescribing errors by 89.5% [21].

This retrospective study assessed prescribing errors detected following pharmaceutical interventions. Results showed that prescribers accepted 65% of pharmaceutical interventions and did not respond to 33%. Several factors could explain this 33% non-response rate, including high clinical workloads or excessive numbers of electronic notifications. The lack of response may represent missed opportunities to optimize medication and improve patient safety. Further work should focus on investigating the determinants of non-response and developing strategies to strengthen communication and collaboration between pharmacists and prescribers. Acceptance of pharmaceutical interventions has been reported to range from 48.6% to 80.8% [11,23,24,25]. Acceptance rates appear to vary by type of pharmaceutical intervention, with higher rates for addition, switch, discontinuation, or administration-mode optimization [25]. Recommendations related to drug monitoring appear to be less well accepted, as cited in the literature [25]. Among the 12,856 pharmaceutical interventions, 13.8% were related to potentially inappropriate medications and 21.8% to high-risk medications. The most commonly targeted drug categories were the nervous system

(24.7%), the digestive tract and metabolism (21.5%), blood and hematopoietic organs (19.8%), and the cardiovascular system (13.6%). Medications most commonly found in pharmaceutical interventions included analgesics, glucose-lowering medications, antithrombotics, and antipsychotics. These categories, most frequently associated with pharmaceutical interventions, were also observed in the literature [25,26]. Therefore, clinical pharmacists need to be particularly vigilant when reviewing prescriptions in these areas, particularly regarding high-risk medications. Reducing harm from high-risk medications has been identified as an international health priority. The US National Action Plan for Adverse Drug Event Prevention was developed to improve medication safety and patient outcomes by reducing harms associated with anticoagulants (*i.e.*, bleeding), glucose-lowering medications (*i.e.*, hypoglycemia), and opioids (*i.e.*, accidental overdose, oversedation, respiratory depression) [27]. Pharmacists have a key role in identifying, through their pharmaceutical interventions, potentially high-risk medication use in older adults using the American Geriatrics Society Beers and STOPP tools [15,28,29].

The prevalence of medications that affect the nervous system, the cardiovascular system, antiplatelet agents, and antidiabetic drugs among the prescribed treatments likely reflects the burden of chronic diseases and multimorbidity among very old hospitalized patients. These classes of drugs are often associated with a narrow therapeutic index and a high risk of adverse effects. In particular, anticoagulants can lead to major bleeding, antidiabetic drugs to severe hypoglycemia, and opioids and psychotropic drugs to excessive sedation, delirium, and falls; meanwhile, digoxin can cause life-threatening toxicity in cases of renal failure.

In the study, the most common types of drug-related problems identified through pharmaceutical interventions were related to dosage selection (39.8%), including "drug dose too high", selection of the drug (14.3%), including inappropriate drug according to guidelines, and the duration of treatment (10.1%). These results are consistent with those reported in the literature [26,30,31]. In a recent publication, clinical pharmacists identified in pharmaceutical interventions as drug-related problems "non-conformity to guidelines" (57.7%), including "non-conformity of drug choice compared to the Formulary", "overdosage" (11.1%), and "improper administration" (9.1%) [26]. Clinical pharmacists, in their daily practice, encounter prescriptions for drugs that are not referenced in the hospital. In France, substitution proposals are authorized under national legislation, in accordance with the Public Health Code [32].

The pharmaceutical interventions identified in this study highlighted high doses of medication or overdosage as one of the main drug-related risks. Similar findings emerged from previous studies, with rates ranging from 10.8% to 25.6% [25,26,30,31]. The major cause of this drug-related problem was prescriptions that were not adjusted according to renal function, frequently altered in older adults, particularly for drugs with renal elimination or those that are nephrotoxic. The high proportion of issues related to dosage selection observed in our study can be explained by age-related physiological changes, including reduced renal clearance, altered pharmacokinetics, frailty, and low body weight, all of which require careful individualization of dosage. These results suggest that medication reviews conducted by clinical pharmacists are particularly valuable in geriatrics, where prescribing errors can quickly lead to clinically significant adverse effects, prolonged hospitalization, functional decline, or readmission. Pharmaceutical interventions targeting drug-related problems may help reduce adverse drug events, optimize medication use, and potentially improve clinical outcomes, such as hospital length of stay and readmission rates.

No association was found between patient sex and the frequency of pharmaceutical interventions. Women and men experienced a similar number of interventions during hospitalization, suggesting that the need for pharmacist intervention was primarily driven by clinical and pharmacotherapeutic factors rather than sex-related differences.

Limitations

The findings of this study have several limitations. First, the study was conducted at a single French geriatric hospital, which may limit the applicability of these results to other healthcare systems or countries with different regulations. Second, the classification used was based solely on the identification of drug-related problems, and the potential clinical impacts of pharmaceutical interventions were not assessed. Another limitation is that this study did not examine pre-prescription interventions involving communication between pharmacists and physicians, nor did the study evaluate the consequences for patients resulting from medication errors. Moreover, two pharmacists independently evaluated Pharmaceutical Care Network Europe classifications. However, inter-rater reliability was not formally assessed, which represents a methodological limitation. Future studies should include formal measures of agreement, such as Cohen's kappa, to strengthen methodological rigor.

5. Conclusions

This study highlights the importance of pharmaceutical interventions in preventing prescribing errors in older adults, a population in which polypharmacy is highly prevalent. Understanding potential drug-related problems and pharmaceutical interventions is essential to ensuring safe pharmacotherapy by alerting prescribers and caregivers to major medication-related risks. Future studies are needed to directly assess the impact of pharmaceutical interventions on patient-centered outcomes, including adverse drug events, length of hospital stay, functional status, and readmission rates.

Availability of Data and Materials

All data reported in this paper will also be shared by the lead contact upon request.

Author Contributions

DLL designed the research study, performed the research. DLL and JS analyzed the data. JS wrote the manuscript. Both authors contributed to editorial changes in the manuscript. Both authors read and approved the final manuscript. Both authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

Anonymization and data protection compliant were in accordance with the Helsinki Declaration. This retrospective observational study was reviewed by the our local Ethic Committee of Paul Doumer Hospital, which determined that formal ethical approval was not required because the study involved the retrospective analysis of routinely collected anonymized data and did not modify patient management. This exemption is consistent with French regulations.

Acknowledgment

Not applicable.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Wang Z, Liu T, Su Q, Luo H, Lou L, Zhao L, et al. Prevalence of Polypharmacy in Elderly Population Worldwide: A Systematic Review and Meta-Analysis. Pharmacoepidemiology and Drug Safety. 2024; 33: e5880. https://doi.org/10.1002/pds.5880

[2] Masnoon N, Shakib S, Kalisch-Ellett L, Caughey GE. What is polypharmacy? A systematic review of definitions. BMC Geriatrics. 2017; 17: 230. https://doi.org/10.1186/s12877-017-0621-2

[3] Davies LE, Spiers G, Kingston A, Todd A, Adamson J, Hanratty B. Adverse Outcomes of Polypharmacy in Older People: Systematic Review of Reviews. Journal of the American Medical Directors Association. 2020; 21: 181–187. https://doi.org/10.1016/j.jamda.2019.10.022

[4] Bonanno EG, Figueiredo T, Mimoso IF, Morgado MI, Carrilho J, Midão L, et al. Polypharmacy Prevalence Among Older Adults Based on the Survey of Health, Ageing and Retirement in Europe: An Update. Journal of Clinical Medicine. 2025; 14: 1330. https://doi.org/10.3390/jcm14041330

[5] Mangoni AA, Jackson SHD. Age-related changes in pharmacokinetics and pharmacodynamics: basic principles and practical applications. British Journal of Clinical Pharmacology. 2004; 57: 6–14. https://doi.org/10.1046/j.1365-2125.2003.02007.x

[6] Pazan F, Wehling M. Polypharmacy in older adults: a narrative review of definitions, epidemiology and consequences. European Geriatric Medicine. 2021; 12: 443–452. https://doi.org/10.1007/s41999-021-00479-3

[7] World Health Organization. Medication Safety in Polypharmacy (WHO/UHC/SDS/2019.11). 2019. Available at: https://apps.who.int/iris/bitstream/handle/10665/325454/WHO-UHC-SDS-2019.11-eng.pdf?ua=1 (Accessed: 21 April 2026)

[8] Laroche ML, Guillaumin M, Grau M, Vettoretti L, Valnet-Rabier MB. Medication errors in older patients: a pharmacovigilance perspective. Drugs & Therapy Perspectives. 2024; 40: 276–289. https://doi.org/10.1007/s40267-024-01090-9

[9] Isop LM, Neculau AE, Kramers CK, Dima L. Polypharmacy Intervention Studies in Older Adults: Challenges in Proving Benefits in Hard Clinical Outcomes. American Journal of Therapeutics. 2025; 32: e458–e466. https://doi.org/10.1097/MJT.0000000000002010

[10] Ruiz-Ramos J, Hernández MH, Juanes-Borrego AM, Milà R, Mangues-Bafalluy MA, Mestres C. The Impact of Pharmaceutical Care in Multidisciplinary Teams on Health Outcomes: Systematic Review and Meta-Analysis. Journal of the American Medical Directors Association. 2021; 22: 2518–2526. https://doi.org/10.1016/j.jamda.2021.05.038

[11] Stuhec M, Gorenc K, Zelko E. Evaluation of a collaborative care approach between general practitioners and clinical pharmacists in primary care community settings in elderly patients on polypharmacy in Slovenia: a cohort retrospective study reveals positive evidence for implementation. BMC Health Services Research. 2019; 19: 118. https://doi.org/10.1186/s12913-019-3942-3

[12] Chan M, Plakogiannis R, Stefanidis A, Chen M, Saraon T. Pharmacist-Led Deprescribing for Patients With Polypharmacy and Chronic Disease States: A Retrospective Cohort Study. Journal of Pharmacy Practice. 2023; 36: 1192–1200. https://doi.org/10.1177/08971900221097246

[13] Allenet B, Juste M, Mouchoux C, Collomp R, Pourrat X, Varin R, et al. De la dispensation au plan pharmaceutique personnalisé: vers un modèle intégratif de pharmacie clinique. Le Pharmacien Hospitalier et Clinicien. 2019; 54: 56–63. https://doi.org/10.1016/j.phclin.2018.12.003

[14] World Medical Association. World Medical Association Declaration of Helsinki: Ethical Principles for Medical Research Involving Human Subjects. JAMA. 2013; 310: 2191–2194. https://doi.org/10.1001/jama.2013.281053

[15] By the 2023 American Geriatrics Society Beers Criteria® Update Expert Panel. American Geriatrics Society 2023 updated AGS Beers Criteria® for potentially inappropriate medication use in older adults. Journal of the American Geriatrics Society. 2023; 71: 2052–2081. https://doi.org/10.1111/jgs.18372

[16] World Health Organization. Medication without harm. 2023. Available at: https://iris.who.int/server/api/core/bitstreams/1eacccb6-838e-4787-bfd9-4bdeb4debfcf/content (Accessed: 21 April 2026)

[17] Dumitrescu I, Casteels M, De Vliegher K, Van Der Linden L, Van Leeuwen E, Dilles T. High-Risk Medication in Home Care Nursing: A Delphi Study. Journal of Patient Safety. 2022; 18: 435–443. https://doi.org/10.1097/PTS.0000000000001023

[18] Dumitrescu I, Casteels M, De Vliegher K, Hubens C, Dilles T. Home Care Patient's Experiences and Medication Burden Related to High-Risk Medication Use: A Cross-Sectional Study. International Journal of Older People Nursing. 2025; 20: e70003. https://doi.org/10.1111/opn.70003

[19] PCNE Pharmaceutical Care Network Europe. The definition of drug-related problems. 2020. Available at: https://pcne.org/wp-content/uploads/2026/01/PCNE_classification_V9-1-en-2026.pdf (Accessed: 21 April 2026)

[20] Faramarzi Nasab N, Rezaeian S, Ezadi S, Khatony A. Prevalence and Determinants of Polypharmacy: A Cross-Sectional Study Among Elderly Patients With Cardiovascular Diseases in Outpatient Clinics. Scientifica. 2025; 2025: 6641747. https://doi.org/10.1155/sci5/6641747

[21] Abu-Naser D. Impact of Clinical Pharmacist Interventions in Prescribing Errors in Hospitalized Diabetic Patients with Major Polypharmacy. Hospital Pharmacy. 2021; 56: 392–399. https://doi.org/10.1177/0018578720985428

[22] Ciapponi A, Fernandez Nievas SE, Seijo M, Rodríguez MB, Vietto V, García-Perdomo HA, et al. Reducing medication errors for adults in hospital settings. The Cochrane Database of Systematic Reviews. 2021; 11: CD009985. https://doi.org/10.1002/14651858.CD009985.pub2

[23] Doffou E, Coulibaly A, Abrogoua PD. Analysis of pharmaceutical interventions related to outpatient treatment of chronic heart failure. Annales Pharmaceutiques Francaises. 2025; 83: 739–747. https://doi.org/10.1016/j.pharma.2025.01.004 (In French)

[24] Somers A, Robays H, De Paepe P, Van Maele G, Perehudoff K, Petrovic M. Evaluation of clinical pharmacist recommendations in the geriatric ward of a Belgian university hospital. Clinical Interventions in Aging. 2013; 8: 703–709. https://doi.org/10.2147/CIA.S42162

[25] Bedouch P, Sylvoz N, Charpiat B, Juste M, Roubille R, Rose FX, et al. Trends in pharmacists' medication order review in French hospitals from 2006 to 2009: analysis of pharmacists' interventions from the Act-IP© website observatory. Journal of Clinical Pharmacy and Therapeutics. 2015; 40: 32–40. https://doi.org/10.1111/jcpt.12214

[26] Alkanj A, Godet J, Johns E, Gourieux B, Michel B. Deep learning classification of drug-related problems from pharmaceutical interventions issued by hospital clinical pharmacists during medication prescription review: a large-scale descriptive retrospective study in a French university hospital. European Journal of Hospital Pharmacy: Science and Practice. 2025; 32: 324–328. https://doi.org/10.1136/ejhpharm-2024-004139

[27] Ducoffe AR, Baehr A, Peña JC, Rider BB, Yang S, Hu DJ. Adverse Drug Event Prevention: 2014 Action Plan Conference. American Journal of Medical Quality: the Official Journal of the American College of Medical Quality. 2016; 31: 476–485. https://doi.org/10.1177/1062860615588105

[28] Sluggett JK, Harrison SL, Ritchie LA, Clough AJ, Rigby D, Caughey GE, et al. High-Risk Medication Use in Older Residents of Long-Term Care Facilities: Prevalence, Harms, and Strategies to Mitigate Risks and Enhance Use. The Senior Care Pharmacist. 2020; 35: 419–433. https://doi.org/10.4140/TCP.n.2020.419

[29] O'Mahony D, Cherubini A, Guiteras AR, Denkinger M, Beuscart JB, Onder G, et al. STOPP/START criteria for potentially inappropriate prescribing in older people: version 3. European Geriatric Medicine. 2023; 14: 625–632. https://doi.org/10.1007/s41999-023-00777-y

[30] Tasaka Y, Tanaka A, Yasunaga D, Asakawa T, Araki H, Tanaka M. Potential drug-related problems detected by routine pharmaceutical interventions: safety and economic contributions made by hospital pharmacists in Japan. Journal of Pharmaceutical Health Care and Sciences. 2018; 4: 33. https://doi.org/10.1186/s40780-018-0125-z

[31] Saldanha V, Randall Martins R, Lima SIVC, Batista de Araujo I, Gouveia Oliveira A. Incidence, types and acceptability of pharmaceutical interventions about drug related problems in a general hospital: an open prospective cohort. BMJ Open. 2020; 10: e035848. https://doi.org/10.1136/bmjopen-2019-035848

[32] Journal officiel de la République française. Arrêté du 21 février 2023 relatif au Renouvellement et à L'adaptation des prescriptions par les pharmaciens exerçant au sein des pharmacies à usage intérieur en application de L'article L 5126-1 du code de la santé publique. 2023. Available at: https://www.legifrance.gouv.fr/loda/id/JORFTEXT000047241696 (Accessed: 21 April 2026)