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Original Research

Factors associated with adverse drug reactions among residents in nursing home

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Abstract

Background and Aim: Adverse drug reactions (ADRs) are a significant public health concern, especially in the elderly. Factors like multimorbidity, polypharmacy, frailty, and age-related changes in drug metabolism increase variability in drug response and adverse effects. The objective of this research is to examine the prevalence of ADRs in elderly residents of nursing homes and to identify the most significant risk factors contributing to these events. **Material and methods:** This was a retrospective, cross-sectional study that reviewed the medical records of 125 residents in 2 nursing homes. The study population consisted of all residents aged 65 years or older. Resident characteristics included age, gender, clinical diagnoses, number of comorbidities, residents' functional status, and complete medication history were analyzed using general practitioner documentation in residents' records. Relevant clinical information on ADR characteristics was documented through chart review over 12 months. **Results:** The study included 125 residents with a mean age of 76.52 (SD 7.83), the majority of them were women (66%), with polypharmacy of 5 and above (48%). Overall, 10% of elderlies took ≥ 10 medications (prescribed, or over the counter), and 38% took 5–9. In addition, the mean number of chronic comorbid conditions was approximately four. Mean Charlson comorbidity index was 1.7. Residents with higher Charlson Comorbidity Index showed increased risk of ADRs, r = .552, p < .001. We found that patients with non-ADRs used less medications (M = 3.88, SD = 1.56) compared to those with ADRs, (M = 7.26, SD = 1.27; t (123) = -6.51, p < .001). Cardiovascular, gastrointestinal, and anticoagulant medications were associated to ADRs. Finally, using Pearson's r correlation coefficient we found that there is a significant positive relationship between ADRs and specific drug classes use as well as higher polypharmacy and comorbidity. **Conclusion:** This study highlights the high prevalence of ADRs among elderly patients, with a positive association to polypharmacy, comorbidities, and specific drug classes use.

Keywords: adverse drug reactions, risk factors, elderly, nursing home, polypharmacy, comorbidity

INTRODUCTION

Adverse drug reactions (ADRs) represent a significant public health concern, particularly among the elderly population. Older adults are more vulnerable to ADRs due to age-related physiological changes, the presence of multiple comorbidities, and alterations in pharmacokinetics and pharmacodynamics[1]. This vulnerability is amplified in nursing home settings, where residents often suffer from multiple chronic conditions and are frequently prescribed numerous medications, a phenomenon known as polypharmacy[2]. Polypharmacy, typically defined as the use of five or more medications concurrently, is a well-established risk factor for ADRs[2]. Studies have shown that up to 91% of nursing home residents are affected by polypharmacy[3], significantly increasing the risk of drug-drug interactions, medication errors, and adverse effects[4]. Identifying ADRs in this population is often challenging, as symptoms can be non-specific and are frequently misattributed to normal aging or existing health conditions, leading to underreporting and delayed intervention.

The prevalence of polypharmacy in long-term care facilities has increased substantially over the past two decades[5,6]. This includes both prescribed medications and over-the-counter products. It is estimated that nearly 50% of older adults take at least one medication that is not medically necessary[7]. While medications are essential for managing chronic illnesses, their inappropriate or excessive use may lead to serious consequences, including increased morbidity, prolonged hospitalizations, and higher healthcare costs[8]. Older adults are up to four times more likely to be hospitalized due to ADRs compared to those under the age of 65 (16.6% vs. 4.1%).[9] Contributing factors include multimorbidity, polypharmacy, frailty, and age-related changes in drug absorption, distribution, metabolism, and elimination, all of which increase variability in drug response and susceptibility to adverse effects[9-11].

Certain drug classes are particularly associated with a high incidence of ADRs. A systematic review identified six classes of medications—antibiotics, anticoagulants, cardiac glycosides, diuretics, hypoglycemic agents, and non-steroidal anti-inflammatory drugs (NSAIDs) as responsible for 60–70% of ADRs[12]. Among hospitalized geriatric patients, common ADRs include falls and fractures, cognitive impairment,

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gastrointestinal bleeding, renal dysfunction, hypoglycemia, constipation, urinary retention, QT interval prolongation, and cardiac arrhythmias[13]. Given the high prevalence of polypharmacy and its associated risks in nursing home populations, the proactive identification and management of these risk factors is essential for reducing the incidence of ADRs and improving patient safety among frail older adults in long-term care settings.

The primary objective of this research is to investigate the prevalence of adverse drug reactions in elderly residents of nursing homes and to identify the most significant risk factors contributing to these events. Specifically, the study aims to assess the relationship between polypharmacy and the occurrence of ADRs, evaluate the impact of multimorbidity on ADR prevalence and identify the most commonly implicated drug classes associated with ADRs in this population.

MATERIALS AND METHODS

Study design

This was a retrospective, cross-sectional study that reviewed the medical records of 125 residents in 2 nursing homes.

Participants

The study population consisted of all residents aged 65 years or older.

Data collection

Data collection and clinical assessments for the present study was conducted between June 1 2024 and October 15 2024.

Outcome measures

Resident characteristics included age, gender, clinical diagnoses, number of comorbidities, patients' functional status, and complete medication history were analyzed using general practitioner documentation in patients' records.

Relevant clinical information relating to the characteristics of the ADRs was also documented. ADRs were identified by chart review during a 12-month period.

The medications were, in all cases, chronic treatments administered by oral, inhalation, or ophthalmic routes. All drugs included in this study required a prescription and had been administered to residents for at least 1 month prior to data collection. Over the counter (OTC) medications, nutritional supplements, and herbal medicines were also considered. We excluded as-needed agents, topical agents, single-dose administration, and vaccinations.

The therapeutic categories of medicines were classified according to the Anatomical Therapeutic Chemical (ATC) classification system of the World Health Organization (WHO) Collaborating Center[10].

Polypharmacy is defined as the use of multiple drugs. We categorized participants into three groups based on the number of medications taken: non-polypharmacy (0–4 medicines), polypharmacy (5–9 medicines), and excessive polypharmacy (at least 10 medicines).

Adverse drug events were defined as injuries resulting from use of a drug. A pharmacist and general practitioner from the research team assessed ADR by the severity of the event (preventable, serious, or life-threatening). Examples of preventable events included non-urticarial rashes, falls without associated fracture, hemorrhage not requiring transfusion or hospitalization, and oversedation; examples of serious events included urticaria, falls with fracture, hemorrhage requiring transfusion or hospitalization, and delirium[14].

Co-morbidities were classified using International Classification of Diseases (ICD)-10 criteria (as defined by the World Health Organization). To determine the number of comorbidities that participants had, we noted all of their self-reported chronic diseases, which were of the 18 chronic diseases recorded in ELSA, including diabetes, hypertension, stroke, myocardial infarction, congestive heart failure, angina, lung disease, chronic obstructive pulmonary disease, asthma, arthritis, osteoporosis, cancer, hearing problems, Parkinson's, Alzheimer's disease, dementia, macular degeneration, and glaucoma[15].

For quantification of comorbidities the Charlson Comorbidity Index (categorized using scoring as originally developed—0, 1-2, 3-4, and ≥5) was used[16].

Data analysis

For the descriptive analysis, we calculated frequencies, percentages, as well as mean with standard deviation (SD) for the distribution of variables (see Table 1and Table 2, and Figure 1 and Figure 2).

The relationship between quantitative variables were analyzed using the independent samples T-test analyses. We also employed Pearson's r correlation coefficient to examine the relationships between main variables (see Table 2).

The significance level for the different analyses was established at least at $p < 0.05$. The data analysis was performed using SPSS Statistics for Windows, version 24.

Ethical Considerations

The study was approved by the University of Prishtina, Faculty of Medicine Ethics Committee and carried out in accordance with the Declaration of Helsinki.

RESULTS

The socio-demographic and clinical characteristics of the residents by total population and ADRs experiences are shown in Table 1. The study included 125 residents with a mean age of 76.52 (SD 7.83), the majority of residents were women (66%), with polypharmacy of 5 and above (48%). Overall, 10% of elderlies took ≥ 10 medications (prescribed, or over the counter), and 38% took 5–9. In addition, the mean number of chronic comorbid conditions was approximately four. Mean Charlson comorbidity index was 1.7. The number of medications taken ranged from 0 to 12 with a median number of 5 drugs. Throughout the study period, ADRs were identified

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Table 1. Characteristics of the residents by total population and ADR experiences.

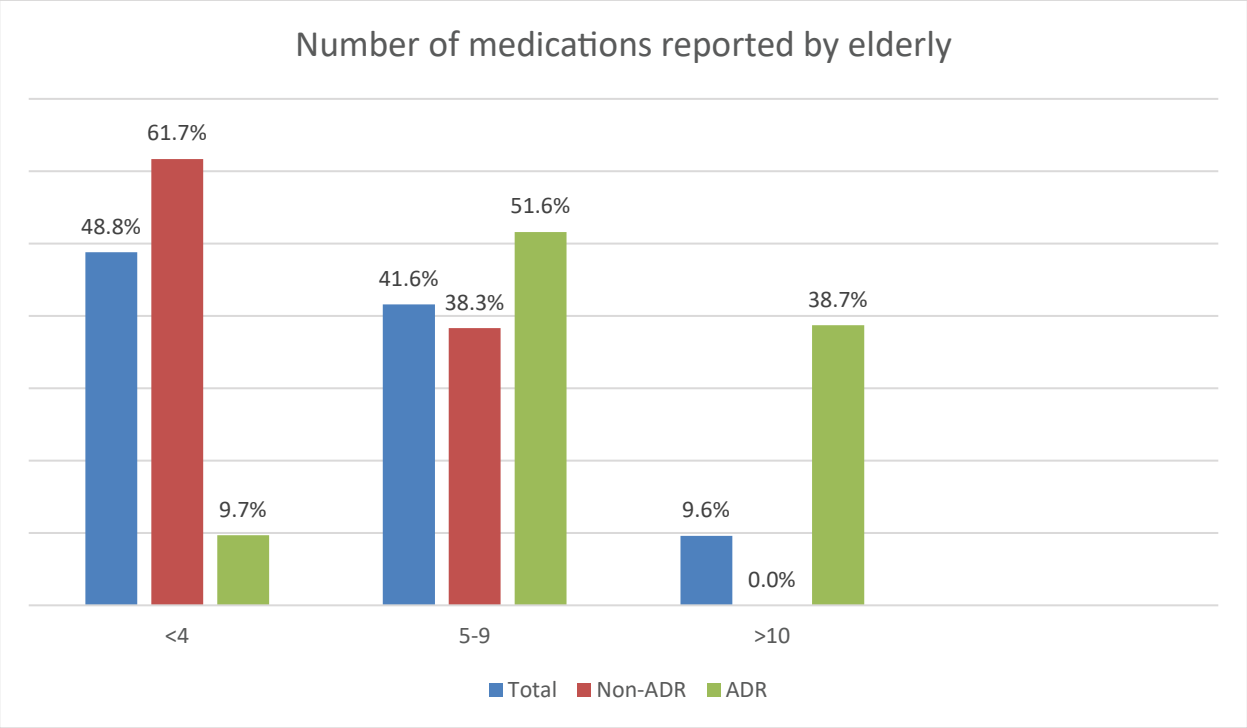
	Total		Residents in non-ADRs group		Residents in ADRs group	
	No	**(%)**	**No**	**(%)**	**No**	**(%)**
Characteristics						
Sex						
Male	42	34%	31	33%	11	36%
Female	83	66%	63	67%	20	64%
Age group (years)						
65-74	56		44	47%	12	39%
75-84	44	35%	32	34%	11	36%
85+	26	21%	18	19%	8	26%
Polypharmacy						
0-4	65	52%	49	39.20%	16	12.80%
05-09	48	38%	35	28%	13	10.40%
>10	12	10%	10	8%	2	1.60%
Comorbidities						
01-04	64	51.20%	16	12.80%	48	38.40%
05-08	59	47.20%	14	11.20%	45	36%
>9	2	1.60%	1	0.80%	1	0.80%
CCI						
01-02	9	15%	6	4.80%	3	2.40%
03-04	106	85%	88	70.40%	18	14.40%
>5	-		-		-	
ADR by the severity of the event						
Preventable	-		-		17	13.60%
Serious	-		-		12	9.60%
Life threatening	-		-		2	1.60%

Abbreviations:ADRs-Adverse drug reactions, Non-ADR- Non-Adverse drug reactions
CCI-Charlson Comorbidity Index

Table 2. Means, standard deviations, and correlations among main variables.

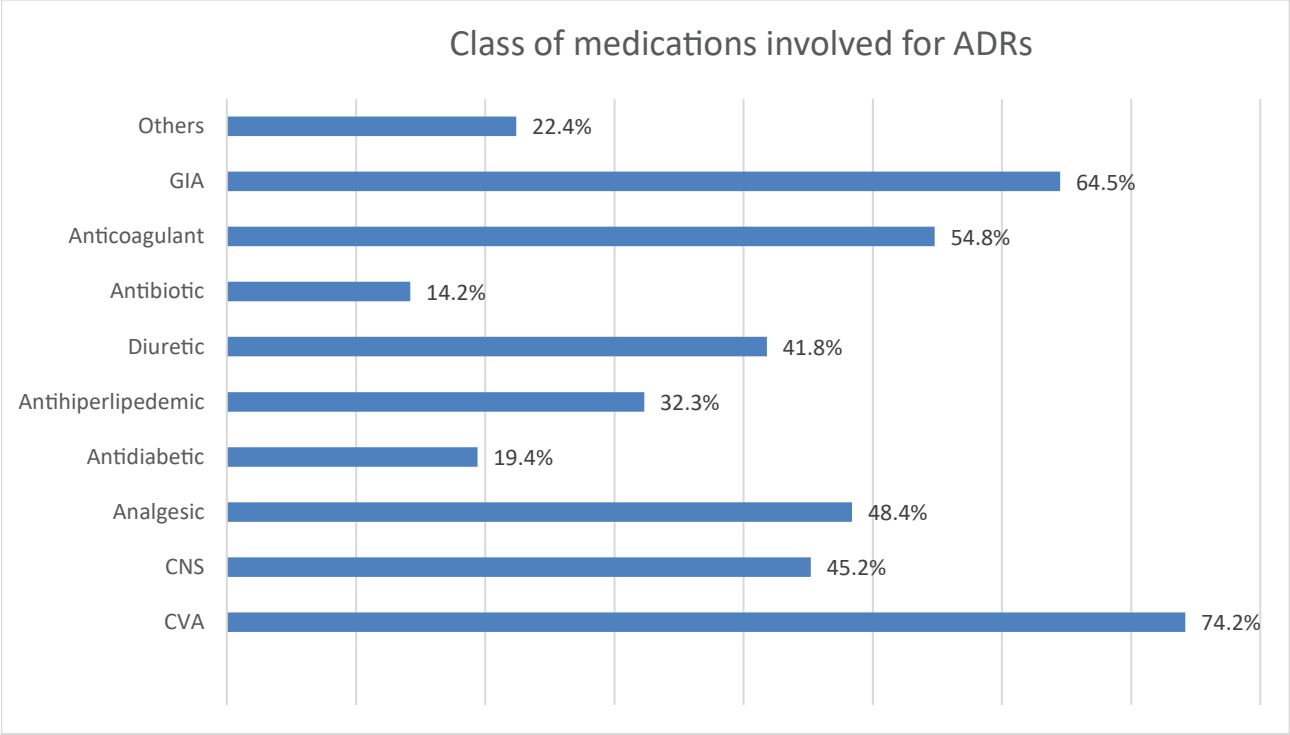
	1	**2**	**3**	**4**	**5**
1. Gender	-				
2. ADRs	-0.047	-			
3. Polypharmacy	0.082	-0.022	-		
4. Comorbidity	0.037	0.004	**.221***	-	
5. Specific drug classes	0.129	**.552****	0.011	0.29	-
M	-	1.51	1.58	1.5	4.72
SD	-	2.73	0.66	0.53	2.41

Abbreviations:ADRs-Adverse drug reactions, M-Mean, SD-Standard deviation
Note. Significant effects are in bold. Gender is coded as 1 (male) and 2 (female).
**p < .01, *p < .05



Abbreviations: ADRs-Adverse drug reactions, Non-ADR- Non-Adverse drug reactions

Figure 1. Number of medications reported by elderly.



Abbreviations: ADRs-Adverse drug reactions, GIA-gastrointestinal agents, CNS-central nervous system, CVA-cardiovascular agents

Figure 2. Class of medications involved for ADRs.

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in 31 of the 125 cases (24.8%). Overall, 13.6% of the ADRs were considered preventable, 9.6% of the 125 classified as serious events, and 1.6% life-threatening.

Next, we examined whether the number of medications used by residents is related to ADRs. In figure 1 we have presented the prevalence of medication use among residents with adverse and non-ADRs. The figure shows that residents who reported ADRs also reported higher number of medication (5-9 medications, 51.6% ADRs) use compared to who reported no ADRs (38.3%). We performed an independent samples t-test to determine whether number of medications use significantly differs between those with adverse and non-ADRs residents. We found that patients with non- ADRs used less medications (M = 3.88, SD = 1.56) compared to those with ADRs, (M = 7.26, SD = 1.27; $t(123) = -6.51$, $p < .001$). This result indicates that increase use of medication increases the ADRs among residents.

We performed another series of independent sample's t-tests to determine the relationship between types of medication and adverse versus non- ADRs. We found that residents who used CVA reported more ADRs, (M = 2.66, SD = 3.26), compared to those with non- ADRs, (M = .82, SD = 2.08); $t(123) = 3.46$, $p = .001$. Similarly, residents who used gastrointestinal agents reported more ADRs (M = 2.24, SD = 3.02) than those with non- ADRs, (M = 1.10, SD = 2.47); $t(123) = 2.29$, $p = .034$; and residents who used anticoagulant reported more ADRs (M = 2.16, SD = 3.09) compared to those with non- ADRs, (M = 1.09, SD = 2.40); $t(123) = 2.18$, $p = .042$. These results indicate that these specific medications, CVA, gastrointestinal agents, and anticoagulant can cause ADRs in residents. In contrast, we found that residents who used diuretics, analgesics, antihyperlipidemics, central nervous system agents, and antidiabetics did not report more ADRs compared to residents with non-ADR (all p values were above .05). The detailed analyses of the medications categories are presented in Figure 2. Cardiovascular agents were most frequently implicated with an ADRs (74.2%), followed by gastrointestinal agents (64.5%) and anticoagulant drugs (54.8%).

Finally, we examined whether higher ADRs relate to gender, polypharmacy, comorbidity, and specific drug classes using Pearson's r correlation coefficient (see Table 2). We found that there is a significant positive relationship between ADRs and specific drug classes use as well as higher polypharmacy and comorbidity. These results indicate that residents with more adverse drug effects also reported more specific medication use, and residents with higher polypharmacy also reported more comorbidity. Residents with higher Charlson Comorbidity Index showed increased risk of ADRs, $r = .552$, $p < .001$. Other relations were not significant.

DISCUSSION

This study revealed a high burden of multimorbidity, polypharmacy, and ADRs among nursing home residents. Nearly half of the cohort (49.0%) had elevated multimorbidity (≥5 chronic conditions), while 48% were prescribed five or more medications, indicating a high prevalence of polypharmacy. A notable 24.8% of residents experienced at least one ADR. The number of regularly scheduled medications was a major risk factor, and certain drug classes—including cardiovascular agents, gastrointestinal drugs, anticoagulants, and psychotropics—were frequently implicated in ADRs. Additionally, a greater number of chronic conditions was associated with increased ADR risk. While sex-based differences were not statistically significant, female residents showed slightly higher rates of ADRs, aligning with previously reported trends. Our findings are consistent with a broad body of literature that underscores the multifactorial nature of ADRs in elderly populations.

The ADR prevalence of 24.8% in this study aligns with prior estimates of 10–30% among elderly nursing home residents[17,18]. This high prevalence reflects the vulnerability of this population, exacerbated by age-related changes in drug metabolism, polypharmacy, and chronic disease burden. Similar figures were observed in an Irish cohort study where 78% of older adults reported at least one adverse drug event over six months[19].

Consistent with prior studies[20-22], polypharmacy was a strong and consistent risk factor for ADRs. The threshold of five or more medications significantly increased ADR risk. One study[22] found that 44.8% of elderly individuals used nine or more medications, while 35.4% used between five and eight—comparable to the distribution in our cohort. Previous research[21] also showed that polypharmacy contributes to preventable events such as falls, confusion, and hospitalizations.

Polypharmacy prevalence has risen over recent decades. Between 1995 and 2005, the proportion of individuals taking ≥5 medications more than doubled[5,21]. This trend is further complicated by the concurrent use of non-prescription medications and supplements—nearly half of older adults take OTC drugs and over half use dietary supplements[2] —heightening the risk of drug-drug and drug-condition interactions.

Our results confirm previous reports[5,24,25] that specific drug classes are disproportionately associated with ADRs. Cardiovascular drugs, gastrointestinal agents, and anticoagulants were particularly implicated. Cardiovascular and GI drugs are linked to ADRs in older adults because of pharmacodynamic changes that heighten sensitivity and impair compensatory mechanisms[26]. These age-related factors, combined with polypharmacy and comorbidities, increase the potential for drug-related harm even at standard doses[27]. Proton pump inhibitors (PPIs), benzodiazepines, antidepressants, and diuretics were also frequently involved—aligning with national pharmacovigilance data, which showed cardiovascular and antithrombotic drugs accounted for 10% of ADR reports, with nearly three-quarters classified as serious or fatal[25].

A significant correlation was observed between the number of chronic conditions and ADR risk, reflecting previous findings[5,21,22,28]. One multivariate analysis[28] found that patients with 4–5 or 6–10 diagnoses had odds ratios for ADRs as high as 28.5 and 12.7, respectively. Our cohort's average of four chronic

illnesses aligns with this data, reinforcing the compounded pharmacological risk posed by comorbidity.

Although our study did not find statistically significant sex differences in ADR rates, the slightly higher prevalence among females aligns with Alhawassi et al.[29], who found female sex, higher comorbidity burden, and polypharmacy to be significant predictors of ADRs. Possible explanations include sex differences in metabolism, hormonal profiles, and body composition.

These findings carry important implications for clinical care and health policy in long-term care facilities. Regular, structured medication reviews and deprescribing should be prioritized for residents on ≥5 medications or high-risk drug classes, as polypharmacy significantly increases ADR risk in older adults[30]. Caution is especially needed when prescribing cardiovascular drugs, psychotropics, anticoagulants, and PPIs in patients with multimorbidity, given their link to ADR-related hospitalizations[31]. Involving pharmacists and geriatricians can enhance ADR detection and promote safer, individualized prescribing, particularly in resource-limited settings[32]. Ongoing educations for healthcare providers is essential to improve ADR recognition and management[33]. These findings support the need for systemic reforms, including prescribing audits, electronic alert systems, and incentives for safe prescribing in aged care[34]. Although sex differences in ADRs were not conclusive, evidence suggests older women may be at higher risk, warranting further investigation[35]. Personalized prescribing that accounts for sex, comorbidities, and medication burden may enhance safety and outcomes in older adults[36].

Strengths and limitations

Despite these insights, this study has some limitations. The main weaknesses are the relatively small sample size and the fact that data were collected from only two nursing homes, which may affect the generalizability of the results. Additionally, as a retrospective study, the information was limited to what was available in medical charts, and in some cases, it was not possible to obtain further details about the patients' conditions or their pharmacological history prior to admission to the nursing home. Furthermore, ADR detection may be influenced by underreporting, particularly for milder symptoms or those mistakenly attributed to disease progression.

CONCLUSION

This study highlights the high prevalence of ADRs among elderly patients, with a positive association to polypharmacy, comorbidities, and specific drug classes use. Understanding these factors is crucial for enhancing patient safety and optimizing pharmacotherapy. To reduce ADRs, strategies such as minimizing inappropriate prescriptions, improving monitoring, and preventing ADRs are essential. Effective strategies should involve individualized prescribing, deprescribing when necessary, enhanced pharmacovigilance, and clinician education. Future research should explore predictive models incorporating electronic health records and comprehensive approach to proactively identify high-risk patients.

CONFLICTS OF INTEREST

All the authors declare no conflicts of interest.

References

1. Kim J, Parish AL. Nursing: polypharmacy and medication management in older adults. Clinics in Integrated Care. 2021 Oct 1;8:100070. Available from: https://doi.org/10.1016/j.intcar.2021.100070
2. Maher RL, Hanlon J, Hajjar ER. Clinical consequences of polypharmacy in elderly. Expert Opin Drug Saf. 2014 Jan 1;13(1):57-65. doi: 10.1517/14740338.2013.827660.
3. Morin L, Johnell K, Laroche ML, Fastbom J, Wastesson JW. The epidemiology of polypharmacy in older adults: register-based prospective cohort study. Clin Epidemiol. 2018 Mar 12;289-98. Available from: https://doi.org/10.2147/CLEP.S153458
4. Davies EA, O'Mahony MS. Adverse drug reactions in special populations–the elderly. Br J Clin Pharmacol. 2015 Oct;80(4):796-807. Available from: https://doi.org/10.1111/bcp.12596
5. Gao LU, Maidment I, Matthews FE, Robinson L, Brayne C; Medical Research Council Cognitive Function and Ageing Study. Medication usage change in older people (65+) in England over 20 years: findings from CFAS I and CFAS II. Age Ageing. 2018 Mar 1;47(2):220-5. doi: 10.1093/ageing/afx158.
6. Jambon J, Choukroun C, Roux-Marson C, Viel É, Leguelinel-Blache G. What Is the Medication Iatrogenic Risk in Elderly Outpatients for Chronic Pain? Clin Neuropharmacol. 2022 May 1;45(3):65-71. doi: 10.1097/WNF.0000000000000505
7. Díez R, Cadenas R, Susperregui J, Sahagún AM, Fernández N, García JJ, et al. Potentially inappropriate medication and polypharmacy in nursing home residents: a cross-sectional study. J Clin Med. 2022 Jun 30;11(13):3808. doi: 10.3390/jcm11133808.
8. Charlesworth CJ, Smit E, Lee DS, Alramadhan F, Odden MC. Polypharmacy among adults aged 65 years and older in the United States: 1988–2010. J Gerontol A Biol Sci Med Sci. 2015 Aug 1;70(8):989-95. doi:10.1093/gerona/glv013.
9. Slabaugh SL, Maio V, Templin M, Abouzaid S. Prevalence and risk of polypharmacy among the elderly in an outpatient setting: a retrospective cohort study in the Emilia-Romagna region, Italy. Drugs Aging. 2010 Dec;27:1019-28. Available from: https://doi.org/10.2165/11584990-000000000-00000
10. Dubrall D, Just KS, Schmid M, Stingl JC, Sachs B. Adverse drug reactions in older adults: a retrospective comparative analysis of

spontaneous reports to the German Federal Institute for Drugs and Medical Devices. BMC Pharmacol Toxicol. 2020 Dec;21:1-20. doi: 10.1186/s40360-020-0392-9.
11. World Health Organization. Medication safety in polypharmacy. Geneva: World Health Organization; 2019. Available from: https://apps.who.int/iris/rest/bitstreams/1235792/retrieve
12. Wiffen P. Adverse drug reactions in hospital patients – A systematic review of the prospective and retrospective studies. Bandolier. 2002 Jun:1–15.
13. Tangiisuran B, Graham Davies J, Wright JE, Rajkumar C. Adverse drug reactions in a population of hospitalized very elderly patients. Drugs Aging. 2012 Aug;29:669-79. doi: 10.1007/BF03262282.
14. Gurwitz JH, Field TS, Avorn J, McCormick D, Jain S, Eckler M, et al. Incidence and preventability of adverse drug events in nursing homes. Am J Med. 2000 Aug 1;109(2):87-94.
15. Ehrlich JR, Hassan SE, Stagg BC. Prevalence of falls and fall-related outcomes in older adults with self-reported vision impairment. J Am Geriatr Soc. 2019 Feb;67(2):239-45. doi: 10.1111/jgs.15628
16. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis. 1987 Jan 1;40(5):373-83.
17. Nickel CH, Ruedinger JM, Messmer AS, Maile S, Peng A, Bodmer M, et al. Drug-related emergency department visits by elderly patients presenting with non-specific complaints. Scand J Trauma Resusc Emerg Med. 2013 Dec;21:15. doi: 10.1186/1757-7241-21-15.
18. Wawruch M, Zikavska M, Wsolova L, Kuzelova M, Kahayova K, Strateny K, et al. Adverse drug reactions related to hospital admission in Slovak elderly patients. Arch Gerontol Geriatr. 2009 Mar 1;48(2):186-90. PMID: 18313773.
19. Cahir C, Bennett K, Teljeur C, Fahey T. Potentially inappropriate prescribing and adverse health outcomes in community dwelling older patients. Br J Clin Pharmacol. 2014 Jan;77(1):201-10. doi: 10.1111/bcp.12161.
20. Shah BM, Hajjar ER. Polypharmacy, adverse drug reactions, and geriatric syndromes. Clin Geriatr Med. 2012 May 1;28(2):173-86. doi: 10.1016/j.cger.2012.01.002.
21. Lavan AH, Gallagher P. Predicting risk of adverse drug reactions in older adults. Ther Adv Drug Saf. 2016 Feb;7(1):11-22. doi:10.1177/2042098615615472
22. Marcum ZA, Amuan ME, Hanlon JT, Aspinall SL, Handler SM, Ruby CM, et al. Prevalence of unplanned hospitalizations caused by adverse drug reactions in older veterans. J Am Geriatr Soc. 2012 Jan;60(1):34-41. doi: 10.1111/j.1532-5415.2011.03772.x.
23. Bourgeois FT, Shannon MW, Valim C, Mandl KD. Adverse drug events in the outpatient setting: an 11-year national analysis. Pharmacoepidemiol Drug Saf. 2010 Sep;19(9):901-10. doi: 10.1002/pds.1984.
24. Huang YT, Steptoe A, Wei L, Zaninotto P. The impact of high-risk medications on mortality risk among older adults with polypharmacy: Evidence from the English Longitudinal Study of Ageing. BMC Med. 2021 Dec;19:1-3. doi: 10.1186/s12916-021-02192-1.
25. Polonia J, Marques J, Lobo M, Vaz I, Oliveira B. Frequency and Impact of Adverse Drug Reactions Induced by Cardiovascular Drugs and Affecting Cardiovascular System: A National 10 years of Surveillance. J Hypertens. 2021 Apr 1;39:e158. doi: 10.1097/01.hjh.0000746120.51486.97.
26. Hilmer SN, McLachlan AJ, Le Couteur DG. Clinical pharmacology in the geriatric patient. Fundam Clin Pharmacol. 2007;21(3):217–30. doi: 10.1111/j.1472-8206.2007.00473.x
27. Alomar MJ. Factors affecting the development of adverse drug reactions (Review article). Saudi Pharm J. 2014;22(2):83–94. doi: 10.1016/j.jsps.2013.02.003
28. Díez R, Cadenas R, Susperregui J, Sahagún AM, Fernández N, García JJ, et al. Drug-related problems and polypharmacy in nursing home residents: a cross-sectional study. Int J Environ Res Public Health. 2022 Apr 4;19(7):4313. doi: 10.3390/ijerph19074313.
29. Alhawassi TM, Krass I, Bajorek BV, Pont LG. A systematic review of the prevalence and risk factors for adverse drug reactions in the elderly in the acute care setting. Clin Interv Aging. 2014 Dec 1;9:2079-86. doi: 10.2147/CIA.S71178.
30. Rankin A, Cadogan CA, Patterson SM, Kerse N, Cardwell CR, Bradley MC, et al. Interventions to improve the appropriate use of polypharmacy for older people. Cochrane Database Syst Rev. 2018;(9):CD008165.
31. Curtin D, Gallagher P, O'Mahony D. High-risk prescribing and adverse drug reactions in older adults. Age Ageing. 2019;48(4):519–25.
32. Kouladjian O'Donnell L, Gnjidic D, Nahas R, Bell JS, Chen TF, Hilmer SN. Impact of pharmacist-led medication review on polypharmacy in aged care facilities. Drugs Aging. 2019;36(2):115–26.
33. Page AT, Clifford RM, Potter K, Schwartz D, Etherton-Beer CD. The role of education in reducing inappropriate prescribing and polypharmacy in older adults: A systematic review. Drugs Aging. 2016;33(11):889–98.
34. Rieckert A, Trampisch US, Klaaßen-Mielke R, Drewelow E, Esmail A, Johansson T, et al. Effectiveness of structured medication reviews in older adults: A cluster-randomised trial. BMJ. 2020;369:m2610.
35. Zazzara MB, Palmer K, Vetrano DL, Carfì A, Graziano O, Onder G. Sex differences in adverse drug reactions in older people: A narrative review. Eur J Clin Pharmacol. 2021;77:759–68.
36. Buss VH, Shields GE, Kosari S, Naunton M. Gender differences in adverse drug reactions in older adults: A systematic review. J Am Geriatr Soc. 2021;69(1):78–88.