Pharmaceutical Approaches for Geriatric Patient Care

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Abstract
Geriatric pharmacotherapy presents unique challenges arising from the complex interplay of age-related physiological changes, multimorbidity, and polypharmacy. Elderly patients—typically defined as those aged 65 years and above—represent a rapidly growing segment of the global population, and their pharmaceutical care demands a specialized, individualized approach. Age-associated alterations in pharmacokinetics (PK) and pharmacodynamics (PD), including reduced hepatic metabolism, declining renal function, altered body composition, and heightened receptor sensitivity, fundamentally change how drugs are absorbed, distributed, metabolized, and eliminated. These changes increase vulnerability to adverse drug reactions (ADRs), drug-drug interactions (DDIs), and potentially inappropriate medication (PIM) use. This article aims to provide a clinically focused review of pharmaceutical strategies for optimizing drug therapy in geriatric patients. Key strategies discussed include individualized dose adjustment based on renal and hepatic function, structured medication review using validated tools such as the STOPP/START criteria and Beers Criteria, evidence-based deprescribing, and multidisciplinary pharmaceutical care interventions. Patient-friendly drug delivery systems—including modified-release formulations, orally disintegrating tablets, and transdermal patches—are highlighted as important approaches for improving adherence and therapeutic outcomes. Clinical applications across common geriatric conditions, including cardiovascular disease, neurodegenerative disorders, and chronic metabolic diseases, are also addressed. Collectively, optimized pharmaceutical care in geriatrics requires integration of clinical pharmacology, patient-centered counseling, and advanced drug delivery strategies to ensure safe, effective, and individualized therapy in older adults.

Keywords: Geriatric pharmacotherapy, polypharmacy, medication safety, elderly patients, pharmaceutical care, deprescribing

1. Introduction

1.1. Aging Population and Healthcare Challenges

The global population of individuals aged 65 years and older is projected to reach 1.5 billion by 2050, representing nearly 16% of total world population [1, 2]. This demographic transformation imposes substantial pressure on healthcare systems, particularly in the domain of pharmaceutical management. Older adults are disproportionately affected by chronic diseases—including cardiovascular disorders, type 2 diabetes mellitus, osteoarthritis, and neurodegenerative conditions—necessitating concurrent use of multiple medications [3]. This reality places elderly patients at significantly elevated risk for drug-related morbidity, adverse outcomes, and preventable hospitalizations [4].

1.2. Importance of Pharmaceutical Care in Geriatrics

Pharmaceutical care in the geriatric population demands a paradigm beyond routine prescription practices. The convergence of polypharmacy, physiological decline, cognitive impairment, and social vulnerability requires a comprehensive, patient-centered approach to medication management [5]. Clinical pharmacists, geriatricians, and multidisciplinary care teams play critical roles in ensuring that drug therapy is appropriate, safe, and effective for each individual patient [6]. Structured medication reviews, pharmacist-led interventions, and the use of clinical decision-support tools have demonstrated significant improvements in therapeutic outcomes and reduction in ADRs in older adults [7].

1.3. Scope of the Article

This review examines the principal pharmaceutical approaches for geriatric patient care, encompassing age-related pharmacokinetic and pharmacodynamic changes, polypharmacy management, dose optimization strategies, pharmaceutical care interventions, drug delivery considerations, and clinical applications across major geriatric disease states. The article synthesizes evidence from clinical guidelines, systematic reviews, and pharmacotherapy research to provide a practically applicable resource for healthcare professionals managing older adult patients.

2. Age-Related Changes Influencing Drug Therapy

2.1. Pharmacokinetic Changes in Elderly Patients

Aging is associated with a cascade of physiological changes that significantly alter drug pharmacokinetics [8]. Hepatic drug metabolism is reduced due to decreasing hepatic mass and blood flow—up to 40% in advanced age—resulting in impaired first-pass metabolism and elevated plasma concentrations of drugs such as propranolol, lidocaine, and morphine [9]. Renal function declines progressively, with glomerular filtration rate (GFR) decreasing approximately 1 mL/min/year after age 40 [10]. This necessitates dose reduction for renally eliminated drugs including digoxin, metformin, and aminoglycosides to prevent accumulation and toxicity. Body composition changes—increased adiposity and reduced lean body mass and total body water—alter the volume of distribution (Vd) of drugs: lipophilic agents such as diazepam demonstrate prolonged half-lives, while hydrophilic drugs such as lithium achieve higher peak concentrations [11]. Additionally, reduced serum albumin in frail elderly patients increases the free fraction of highly protein-bound drugs, elevating pharmacological activity and toxicity risk. These changes are summarized in Table 1.

Table 1: Age-Related Physiological Changes Affecting Drug Therapy in Elderly Patients

Physiological Parameter	Age-Related Change	Clinical Consequence
Hepatic mass & blood flow	↓ 20–40%	Reduced first-pass metabolism; increased bioavailability of lipophilic drugs
Glomerular filtration rate	↓ ~1 mL/min per year after 40	Accumulation of renally cleared drugs (e.g., digoxin, aminoglycosides)
Body fat composition	↑ by 20–40%	Increased Vd for lipophilic drugs; prolonged half-life
Lean body mass / TBW	↓ significantly	Reduced Vd for hydrophilic drugs; higher plasma concentrations
Serum albumin	↓ (especially in frailty)	Increased free drug fraction; risk of toxicity for highly protein-bound drugs
Gastric motility & pH	↓ motility; ↑ pH	Altered drug absorption; delayed Tmax
Receptor sensitivity (CNS)	↑ sensitivity to CNS drugs	Enhanced effects of benzodiazepines, opioids, anticholinergics
Cardiac output & perfusion	↓ by ~1% per year	Reduced tissue perfusion; impaired drug distribution

2.2. Pharmacodynamic Alterations

Beyond pharmacokinetics, aging produces notable pharmacodynamic changes that alter drug response independently of plasma drug concentration [12]. Elderly patients exhibit increased sensitivity of central nervous system (CNS) receptors to benzodiazepines, opioids, and anticholinergic agents, predisposing them to cognitive impairment, excessive sedation, and falls [13]. Conversely, decreased baroreceptor sensitivity and reduced autonomic responsiveness increase susceptibility to orthostatic hypotension with antihypertensives and diuretics [14]. Altered cardiac responsiveness to beta-adrenergic agonists and antagonists necessitates careful dose titration in older adults with heart disease. These pharmacodynamic shifts, compounded by age-related PK changes, significantly narrow the therapeutic window for many commonly used drug classes in geriatric practice [15].

2.3. Impact on Drug Safety and Efficacy

The dual impact of altered PK and PD parameters substantially increases the risk of ADRs, treatment failure, and drug toxicity in the geriatric population [16]. ADRs account for approximately 10–15% of hospital admissions in older adults, many of which are preventable [17]. Drugs with narrow therapeutic indices—including warfarin, phenytoin, digoxin, and lithium—require particularly vigilant monitoring and dose adjustment. Recognition of these age-related changes is fundamental to the development of safe and effective pharmacotherapeutic strategies in elderly patients.

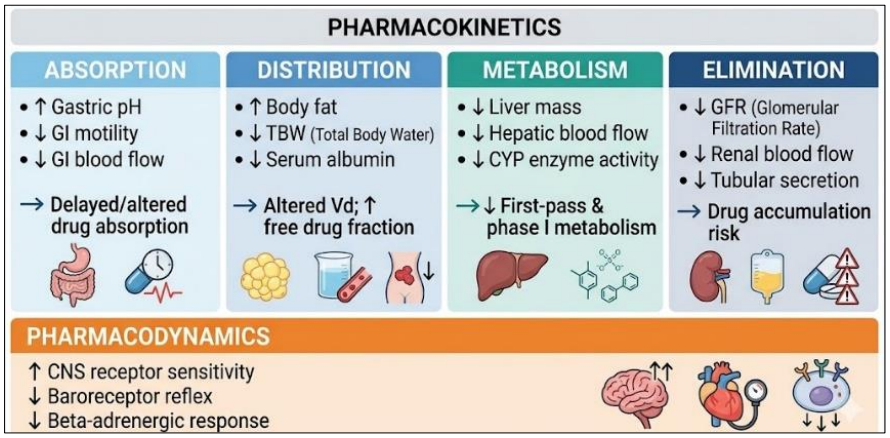

Fig 2: Age-Related Physiological Changes Affecting Pharmacokinetics and Pharmacodynamics

3. Polypharmacy and Medication Management

3.1. Causes of Polypharmacy in Elderly Populations

Polypharmacy, conventionally defined as the concurrent use of five or more medications, affects an estimated 40–50% of individuals aged 65 years and above [18]. Its principal drivers include multimorbidity, fragmented care among multiple specialists, inadequate medication reconciliation at care transitions, and the application of disease-specific clinical guidelines that fail to account for cumulative drug burden [19]. The prescribing cascade—wherein new medications are initiated to treat the side effects of existing ones—further compounds polypharmacy and amplifies therapeutic complexity. Common drug-related problems arising in this context are detailed in Table 2.

Table 2: Common Drug-Related Problems in Geriatric Pharmacotherapy

Drug-Related Problem	Common Examples	Potential Consequences
Polypharmacy (≥5 drugs)	Multiple chronic disease medications	Drug interactions, ADRs, poor adherence
Potentially inappropriate medications (PIMs)	Benzodiazepines, NSAIDs, first-gen antihistamines	Falls, cognitive impairment, GI bleeding
Drug-drug interactions (DDIs)	Warfarin + NSAIDs; digoxin + diuretics	Bleeding, toxicity, arrhythmias
Drug-disease interactions	NSAIDs in renal impairment; beta-blockers in COPD	Disease exacerbation, hospitalization
Therapeutic duplication	Two ACE inhibitors or two statins	Toxicity without added benefit
Under-prescribing	No statin after MI; no anticoagulant in AF	Preventable morbidity and mortality
Non-adherence	Complex regimens, cognitive decline, cost	Treatment failure, disease progression

3.2. Drug-Drug Interactions and Adverse Drug Reactions

Drug-drug interactions (DDIs) represent a major clinical concern in polypharmacy-laden geriatric patients [20]. Clinically significant DDIs—such as the combination of warfarin with NSAIDs increasing hemorrhagic risk, or ACE inhibitors with potassium-sparing diuretics causing hyperkalemia—are prevalent and may produce severe outcomes. ADRs in elderly patients often present atypically: cognitive dysfunction, falls, urinary incontinence, and anorexia may be the sole manifestations of drug toxicity rather than classical organ-specific signs [21]. The use of validated screening tools such as the Beers Criteria (American Geriatrics Society) and the STOPP/START criteria provides a systematic framework for identifying PIMs and initiating safer therapeutic alternatives.

3.3. Medication Review and Deprescribing Strategies

Structured medication review remains the cornerstone of polypharmacy management [22]. Comprehensive medication review involves systematic assessment of each drug's indication, dose appropriateness, potential for harm, and patient preferences. Deprescribing—the deliberate, supervised tapering or discontinuation of medications—has emerged as an evidence-based approach for reducing drug burden without compromising therapeutic outcomes [23]. Strategies such as Medication Appropriateness Index (MAI), STOPPFrail criteria for frail patients, and multidisciplinary team-based reviews are increasingly integrated into geriatric care pathways. Table 3 outlines principal strategies for polypharmacy management.

Table 3: Strategies to Manage Polypharmacy in Geriatric Patients

Strategy	Description	Tools / Instruments
Medication review (structured)	Systematic evaluation of all medications for appropriateness, effectiveness, and safety	STOPP/START criteria, Beers Criteria
Deprescribing	Planned dose reduction or discontinuation of inappropriate or burdensome drugs	Deprescribing guidelines, STOPPFrail
Multidisciplinary team (MDT) approach	Collaboration of geriatricians, pharmacists, nurses, and GPs	Care plans, pharmacist-led reviews
Electronic prescribing & alerts	Clinical decision support to detect PIMs and DDIs at point-of-care	CPOE systems, drug interaction software
Patient & caregiver education	Improving knowledge about medications, purpose, and side effects	Medication counseling, leaflets, apps
Regular monitoring & follow-up	Periodic reassessment of medication burden and therapeutic goals	Lab monitoring, functional assessment

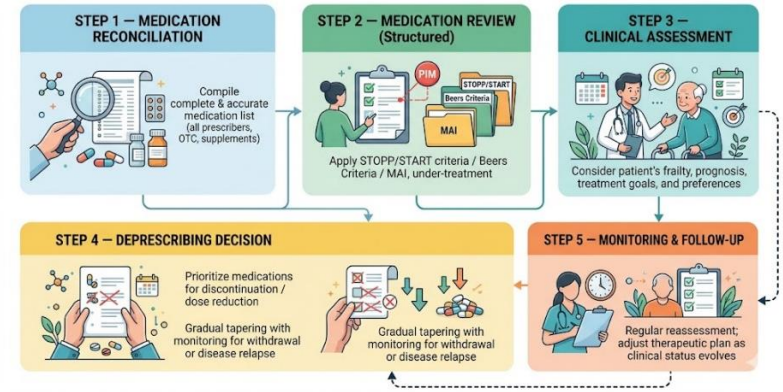

Fig 2: Polypharmacy Management and Medication Review Process in Elderly Patients

4. Pharmaceutical Care Strategies in Geriatric Patients

4.1. Dose Adjustment and Individualized Therapy

Individualized dose adjustment is paramount in geriatric pharmacotherapy [24]. For renally eliminated drugs, GFR estimation using the Cockcroft-Gault equation or CKD-EPI formula is recommended for dose calculation rather than serum creatinine alone, as the latter may underestimate renal impairment in sarcopenic elderly patients. Hepatic function assessment guides the dose modification of drugs with significant first-pass metabolism. Therapeutic drug monitoring (TDM) is valuable for drugs with narrow therapeutic indices, such as vancomycin, aminoglycosides, and lithium, enabling target-concentration-guided dosing. In frail or very old patients (>80 years), the principle of 'start low, go slow' should universally guide drug initiation and titration.

4.2. Clinical Pharmacy Interventions

Clinical pharmacists are pivotal members of geriatric care teams, contributing to improved medication safety through comprehensive medication reconciliation, structured reviews, and patient education [25]. Pharmacist-led interventions have demonstrated reductions in PIMs, ADRs, and preventable hospitalizations across multiple randomized controlled trials. Integration of pharmacists into hospital-based geriatric assessment units, outpatient clinics, and transitional care programs has produced measurable improvements in quality prescribing metrics. Electronic prescribing systems with embedded clinical decision support algorithms further enhance the pharmacist's capacity to detect drug-related problems in real time.

4.3. Medication Adherence and Patient Counseling

Non-adherence to prescribed medications is a pervasive challenge in elderly patients, attributed to complex regimens, cognitive impairment, visual or dexterity limitations, cost barriers, and health literacy deficits [26]. Simplified dosing schedules—achieved through once-daily formulations and fixed-dose combinations—significantly enhance adherence. Patient counseling using the teach-back method, individualized written medication instructions, and compliance aids such as pill organizers and dosette boxes improve self-medication accuracy. Engagement of caregivers and family members in medication management further supports adherence in patients with cognitive decline. Table 4 summarizes pharmaceutical interventions for improving medication safety and adherence.

Table 4: Pharmaceutical Interventions to Improve Medication Safety and Adherence in Elderly Populations

Intervention	Mechanism / Approach	Expected Outcome
Pharmacist-led medication reconciliation	Comparison of medication lists across transitions of care	Reduced medication errors and ADRs
Simplification of drug regimens	Once-daily formulations, fixed-dose combinations	Improved adherence, reduced pill burden
Dose individualization (renal/hepatic adjustment)	Cockcroft-Gault or CKD-EPI for dose calculation	Prevention of drug toxicity
Patient counseling and education	Verbal and written instructions, teach-back method	Improved self-management and adherence
Compliance aids (pill organizers, blister packs)	Organized packaging for daily/weekly doses	Reduced missed doses and errors
Telepharmacy and remote monitoring	Digital follow-up for homebound elderly patients	Timely detection of ADRs
Medication adherence devices (smart pillboxes)	Electronic reminders and tracking	Improved adherence rates

5. Drug Delivery Considerations for Geriatric Patients

5.1. Modified and Controlled Drug Delivery Systems

Conventional drug formulations may be suboptimal for elderly patients due to swallowing difficulties (dysphagia), cognitive impairment, and altered gastrointestinal physiology [27]. Modified-release (MR) formulations—including extended-release (ER), sustained-release (SR), and controlled-release (CR) systems—reduce dosing frequency and minimize peak-trough plasma fluctuations, thereby improving tolerability. Transdermal drug delivery systems (patches) for drugs such as fentanyl, rivastigmine, and rotigotine offer non-invasive administration with consistent plasma drug levels, bypass hepatic first-pass metabolism, and eliminate the need for oral intake—significant advantages in patients with dysphagia or gastrointestinal disorders.

5.2. Patient-Friendly Dosage Forms

Orally disintegrating tablets (ODTs) and orodispersible films dissolve rapidly in the oral cavity without water, making them ideal for elderly patients with swallowing difficulties or those at risk of aspiration [28]. Liquid formulations and suspensions facilitate dose flexibility and swallowing ease

but require careful dose measurement, particularly in cognitively impaired patients. Smaller-sized tablets, easy-open packaging, and color-coded blister packs represent practical pharmaceutical design considerations that substantially reduce medication errors and improve adherence in the geriatric population.

5.3. Role of Advanced Pharmaceutical Technologies

Emerging drug delivery technologies hold promise for optimizing geriatric pharmacotherapy. Nanoparticle-based drug delivery systems enable targeted, controlled drug release and improved bioavailability for drugs with poor absorption profiles in elderly patients [29]. Implantable drug delivery devices for hormones and analgesics provide consistent drug release over months, eliminating adherence barriers entirely. Smart inhalers equipped with electronic dose counters and connectivity features support adherence monitoring in elderly patients with chronic obstructive pulmonary disease (COPD) or asthma. Personalized 3D-printed medications—enabling customized doses and polypill formulations—represent a transformative future direction for individualized geriatric care.

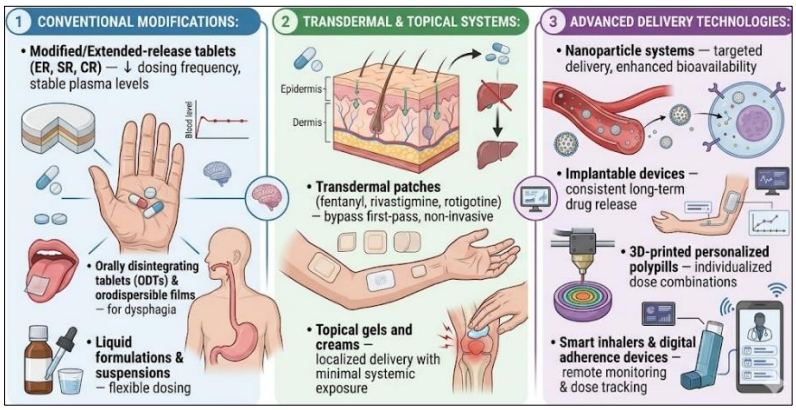

Fig 3: Advanced Pharmaceutical and Drug Delivery Strategies for Geriatric Therapeutics

6. Clinical Applications

6.1. Cardiovascular Diseases in Elderly Patients

Cardiovascular disease remains the leading cause of morbidity and mortality in older adults [30]. Pharmacotherapy for hypertension in the elderly requires individualized blood pressure targets, with evidence supporting thiazide diuretics, calcium channel blockers, and ACE inhibitors/ARBs as first-line agents. Particular caution is warranted regarding orthostatic hypotension risk, which is heightened in frail elderly patients. Anticoagulation therapy with direct oral anticoagulants (DOACs) for atrial fibrillation demands dose adjustment based on renal function and careful bleeding risk assessment. Heart failure management requires judicious titration of beta-blockers, sacubitril/valsartan, and diuretics, with vigilant monitoring for electrolyte disturbances and renal deterioration [4, 14].

6.2. Neurodegenerative Disorders

The management of Alzheimer's disease and other dementias involves cholinesterase inhibitors (donepezil, rivastigmine, galantamine) and the NMDA antagonist memantine, all of which require dose adjustment in renal impairment [13]. Behavioral and psychological symptoms of dementia (BPSD) are frequently managed with off-label antipsychotics, which carry significant risks of stroke, sedation, and mortality in elderly patients—necessitating restricted use and regular review. Parkinson's disease therapy with levodopa-carbidopa and dopamine agonists is complicated by age-related cognitive sensitivity, orthostatic hypotension, and complex drug-drug interaction profiles [21].

6.3. Chronic Metabolic and Inflammatory Diseases

Type 2 diabetes management in elderly patients requires individualized glycemic targets to avoid hypoglycemia, which is particularly dangerous in this population due to reduced awareness and risk of falls [19]. Metformin remains a first-line agent but requires dose reduction and eventual discontinuation as GFR declines. Sodium-glucose cotransporter-2 (SGLT-2) inhibitors offer cardiorenal protective benefits, though must be used cautiously in elderly patients at risk for urinary tract infections, dehydration, and volume depletion. Osteoarthritis and rheumatologic conditions necessitate a preference for acetaminophen, topical NSAIDs, and non-pharmacological approaches over systemic NSAIDs, which carry heightened risks of gastrointestinal bleeding, renal impairment, and cardiovascular events in the elderly [17].

7. Challenges and Future Perspectives

7.1. Medication Safety Challenges

Despite growing recognition of geriatric-specific pharmaceutical risks, significant challenges persist in achieving optimal medication safety in elderly patients [22]. Underrepresentation of older adults—particularly those with multimorbidity and cognitive impairment—in clinical trials results in a paucity of high-quality evidence for drug use in this population [16]. Clinicians frequently extrapolate prescribing decisions from younger trial populations, potentially amplifying risks. Cognitive decline and communication barriers complicate medication history-taking, consent, and adverse event reporting. Healthcare transition points—hospital admission, discharge, and care home transfer—represent high-risk intervals for medication errors and reconciliation failures.

7.2. Healthcare System Considerations

Systemic barriers compound individual patient-level challenges [23]. Fragmented care between primary, secondary, and social care sectors leads to inadequate coordination of medication management. Limited integration of clinical pharmacists in community and primary care settings restricts access to structured medication review for the majority of

older adults. Electronic prescribing systems with inadequate age-specific or geriatric dosing alerts perpetuate PIM prescribing. Resource constraints and time pressures in primary care consultations further limit the implementation of comprehensive pharmaceutical care protocols.

7.3. Emerging Pharmaceutical Innovations in Geriatric Care

Technological and pharmacological innovations offer compelling opportunities to advance geriatric pharmacotherapy [29]. Artificial intelligence (AI)-powered clinical decision support systems capable of integrating patient-specific data—including genomics, comorbidity profiles, and renal function—are being developed to provide real-time, personalized prescribing recommendations. Pharmacogenomics-guided prescribing holds promise for optimizing drug selection and dosing based on individual metabolic genotypes, reducing ADR risk in high-risk elderly patients. Digital health platforms, wearable monitoring devices, and telepharmacy services are expanding access to medication management support for homebound and rural elderly populations, addressing equity gaps in pharmaceutical care delivery.

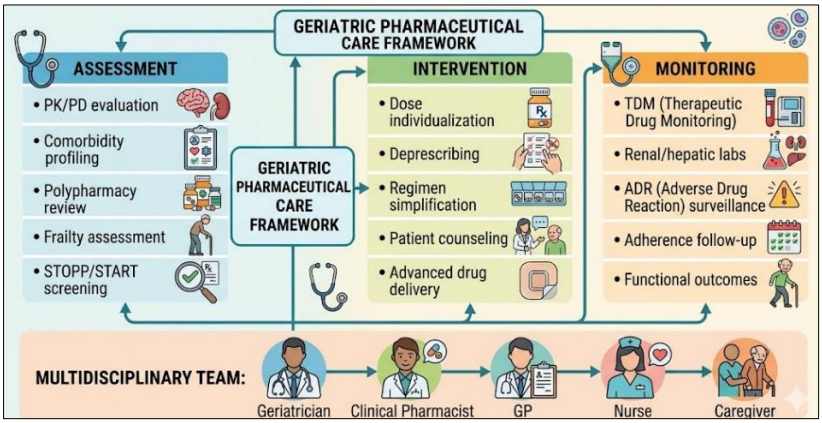

Fig 4: Overview of Pharmaceutical Care Strategies for Geriatric Patients

8. Conclusion

Pharmaceutical care for geriatric patients represents one of the most clinically complex and consequential domains of modern pharmacotherapy. Age-related pharmacokinetic and pharmacodynamic alterations, the prevalence of polypharmacy, multimorbidity, and the heightened vulnerability to adverse drug events necessitate a fundamentally different and more individualized approach to prescribing and medication management in older adults. The implementation of structured medication reviews, evidence-based deprescribing, multidisciplinary pharmaceutical care, and patient-friendly drug delivery technologies are essential strategies for optimizing therapeutic outcomes and minimizing drug-related harm in this population. Dose individualization guided by renal and hepatic function assessments, application of validated screening tools such as the Beers Criteria and STOPP/START criteria, and active engagement of clinical pharmacists across all care settings form the pillars of safe geriatric pharmacotherapy. Future advances in pharmacogenomics, artificial intelligence-driven clinical decision support, and personalized drug delivery systems hold transformative potential for addressing the remaining gaps in geriatric pharmaceutical care. A commitment to patient-centered, evidence-based, and interdisciplinary approaches will be essential in meeting the pharmaceutical care needs of an aging global population.

References

1. World Health Organization. Ageing and health. Geneva: WHO; 2022.
2. United Nations. World population ageing 2020 highlights. New York: UN; 2020.
3. Barnett K, Mercer SW, Norbury M, Watt G, Wyke S, Guthrie B. Epidemiology of multimorbidity and implications for health care, research, and medical education: a cross-sectional study. Lancet. 2012;380(9836):37–43.
4. Mangoni AA, Jackson SH. Age-related changes in pharmacokinetics and pharmacodynamics: basic principles and practical applications. Br J Clin Pharmacol. 2004;57(1):6–14.
5. Fried TR, O'Leary J, Towle V, Goldstein MK, Trentalange M, Martin DK. Health outcomes associated with polypharmacy in community-dwelling older adults: a systematic review. J Am Geriatr Soc. 2014;62(12):2261–72.
6. Gnjidic D, Hilmer SN, Blyth FM, Naganathan V, Waite L, Seibel MJ, *et al*. Polypharmacy cutoff and outcomes: five or more medicines were used to identify community-dwelling older men at risk of different adverse outcomes. J Clin Epidemiol. 2012;65(9):989–95.
7. Steinman MA, Hanlon JT. Managing medications in clinically complex elders: there's got to be a better way. JAMA. 2010;304(14):1592–601.
8. Turnheim K. When drug therapy gets old: pharmacokinetics and pharmacodynamics in the elderly. Exp Gerontol. 2003;38(8):843–53.
9. McLean AJ, Le Couteur DG. Aging biology and geriatric clinical pharmacology. Pharmacol Rev. 2004;56(2):163–84.
10. Lindeman RD, Tobin J, Shock NW. Longitudinal studies on the rate of decline in renal function with age. J Am Geriatr Soc. 1985;33(4):278–85.
11. Klotz U. Pharmacokinetics and drug metabolism in the elderly. Drug Metab Rev. 2009;41(2):67–76.
12. Rowe JW, Kahn RL. Human aging: usual and successful. Science. 1987;237(4811):143–9.

13. Birks JS, Harvey RJ. Donepezil for dementia due to Alzheimer's disease. Cochrane Database Syst Rev. 2018;6:CD001190.
14. Beckett NS, Peters R, Fletcher AE, Staessen JA, Liu L, Dumitrascu D, *et al*. Treatment of hypertension in patients 80 years of age or older. N Engl J Med. 2008;358(18):1887–98.
15. Gallagher P, O'Mahony D. STOPP (screening tool of older persons' potentially inappropriate prescriptions): application to acutely ill elderly patients and comparison with Beers' criteria. Age Ageing. 2008;37(6):673–9.
16. Routledge PA, O'Mahony MS, Woodhouse KW. Adverse drug reactions in elderly patients. Br J Clin Pharmacol. 2004;57(2):121–6.
17. Budnitz DS, Lovegrove MC, Shehab N, Richards CL. Emergency hospitalizations for adverse drug events in older Americans. N Engl J Med. 2011;365(21):2002–12.
18. Maher RL, Hanlon J, Hajjar ER. Clinical consequences of polypharmacy in elderly. Expert Opin Drug Saf. 2014;13(1):57–65.
19. Scott IA, Hilmer SN, Reeve E, Potter K, Le Couteur D, Rigby D, *et al*. Reducing inappropriate polypharmacy: the process of deprescribing. JAMA Intern Med. 2015;175(5):827–34.
20. Qato DM, Wilder J, Schumm LP, Gillet V, Alexander GC. Changes in prescription and over-the-counter medication and dietary supplement use among older adults in the United States, 2005 vs 2011. JAMA Intern Med. 2016;176(4):473–82.
21. Pirmohamed M, James S, Meakin S, Green C, Scott AK, Walley TJ, *et al*. Adverse drug reactions as cause of admission to hospital: prospective analysis of 18 820 patients. BMJ. 2004;329(7456):15–9.
22. O'Mahony D, O'Sullivan D, Byrne S, O'Connor MN, Ryan C, Gallagher P. STOPP/START criteria for potentially inappropriate prescribing in older people: version 2. Age Ageing. 2015;44(2):213–8.
23. Reeve E, Gnjidic D, Long J, Hilmer S. A systematic review of the emerging definition of deprescribing with network analysis. Br J Clin Pharmacol. 2015;80(6):1254–68.
24. American Geriatrics Society. 2023 updated AGS Beers Criteria for potentially inappropriate medication use in older adults. J Am Geriatr Soc. 2023;71(7):2052–81.
25. Hanlon JT, Schmader KE, Ruby CM, Weinberger M. Suboptimal prescribing in older inpatients and outpatients. J Am Geriatr Soc. 2001;49(2):200–9.
26. Saini SD, Schoenfeld P, Kaulback K, Dubinsky MC. Effect of medication dosing frequency on adherence in chronic diseases. Am J Manag Care. 2009;15(6):e22–33.
27. Liu F, Ranmal S, Batchelor HK, Orlu-Gul M, Ernest TB, Thomas IW, *et al*. Patient-centred pharmaceutical design to improve acceptability of medicines: similarities and differences in paediatric and geriatric populations. Drugs. 2014;74(16):1871–89.
28. Stegemann S, Gosch M, Breitkreutz J. Swallowing dysfunction and dysphagia is an unrecognized challenge for oral drug therapy. Int J Pharm. 2012;430(1–2):197–206.
29. Alexopoulos GS. Pharmacotherapy for late-life depression. J Clin Psychiatry. 2011;72(1):e04.
30. Gaziano TA, Bitton A, Anand S, Abrahams-Gessel S, Murphy A. Growing epidemic of coronary heart disease in low- and middle-income countries. Curr Probl Cardiol. 2010;35(2):72–115.