RESEARCH PAPER

Polypharmacy and inappropriate medications use in geriatric patients: A drug use evaluation study using Beer's criteria and STOPP and START criteria

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ABSTRACT

Introduction: Polypharmacy has become a significant issue in the care of older adults, driven by the rising prevalence of long-term health conditions and the necessary to use several medications. Older individuals are at a higher risk of experiencing harmful side effects from medications, interactions between drugs, and incorrect prescriptions, largely due to changes in their bodies as the age is increased and the presence of multiple health problems (comorbidities). While medications are essential for managing chronic conditions, excessive and irrational drug use can negatively impact patient safety and quality of life. Therefore, Drug Use Evaluation (DUE) is important for assessing prescribing patterns and promoting rational drug use.

Aim: To perform a structured Drug Use Evaluation (DUE) to quantify the prevalence of polypharmacy and critically assess the appropriateness of medication regimens in geriatric patients by utilizing the AGS Beer's Criteria (2023) and the STOPP/START Criteria (Version 3).

Methods: A prospective observational study was conducted over 6 months in tertiary care hospital in Pune, including 200 Geriatric patients aged above 60 years. Data were collected using a structured case record form including demographic details, comorbidities, and medication profiles. Polypharmacy was defined as the use of ≥5 medications. Prescriptions were evaluated using Beer's criteria (2023), STOPP criteria and START criteria (Version 3).

Results: The study showed a slightly higher proportion of males (53.5%) compared to females (46.5%). Most patients belonged to the 60 –70 years age group. A high prevalence of polypharmacy was observed, with the majority of patients receiving more than five medications and a considerable proportion exceeding 10 drugs per prescription. Common comorbidities included hypertension, diabetes mellitus and cardiovascular diseases. Evaluation of prescribing patterns revealed that a significant proportion of patients had 99% of Potentially prescribing medications identified using Beer's criteria and 100% using STOPP criteria, while 99% of potential prescribing omissions were also observed using START criteria. The prevalence of PIMs and PPOs was higher among patients with increased number of mrdications and multiple comorbidities. Additionally, a showed potential drug-drug interactions, indicating increased risk of adverse drug reactions.

Conclusions: The study shows that the use of multiple medications is very common in older adults and is strongly linked to the presence of multiple health conditions and improper prescribing. It is important to conduct regular reviews of medications, use established tools like Beer's criteria and STOPP/START criteria and involve clinical pharmacists in the process. These actions are necessary to ensure that medications are used appropriately and to enhance patient outcomes. Additionally, implementing Drug Use Evaluation programs is crucial for rational and effective prescribing practices.

Keywords: Polypharmacy, Inappropriate medications, Beer's criteria, STOPP/START criteria, Rational drug use, Geriatric patients, Comorbities, Medications.

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1. INTRODUCTION

Vaccination The geriatric population generally includes individuals aged 60 years and above in developing countries and above in developed countries. Aging is associated with physiological declines, oxidative, stress, mitochondrial dysfunction, and altered immune responses, leading to increased susceptibility to chronic diseases and medication-related complications [1, 2]. Globally, the elderly population is rapidly increasing due to improved life expectancy and declining fertility rates, creating major healthcare challenges related to chronic management and medication safety [3, 4]. In India, the growing elderly population has increased the burden of chronic illness such as hypertension, diabetes mellitus, cardiovascular diseases, and arthritis, thereby increasing healthcare utilization and risk of polypharmacy [5, 6].

Age-related physiological changes significantly alter pharmacokinetics and pharmacodynamics in elderly patients. Reduced renal and hepatic function, altered body composition, and impaired drug metabolism increase risk of drug accumulation, toxicity, and adverse drug reactions (ADRs) [7, 8]. Elderly patients are highly susceptible to ADRs because of multiple comorbidities and increased sensitivity to medications. Studies indicates that medication-related problems contribute substantially to hospital admissions among older adults [9, 10]. Polypharmacy, commonly defined as the concurrent use of five or more medications, has become major concern in geriatric healthcare costs, and reduced quality of life [11, 12, 15].

Appropriate polypharmacy refers to the rational use of multiple medications for evidence-based clinical indications, whereas inappropriate polypharmacy involves unnecessary medications, therapeutic duplication, and increased risk of prescribing cascades [12, 15]. Major causes of polypharmacy include multimorbidity, increased life expectancy, multiple prescriber, and lack of regular medication review [12, 15]. Hypertension, diabetes mellitus, ischemic heart disease, chronic kidney disease, osteoarthritis and thyroid disorders are important contributors to medication burden in elderly patients [16, 20, 22]. Hypertension often requires multidrug therapy such as ACE inhibitors, beta-blockers, and diuretics, while diabetes management involves oral hypoglycemic agents, insulin, lipid-lowering drugs, and nephroprotective therapies [12, 16].

1.1 Polypharmacy

Polypharmacy is associated with serious clinical consequences including ADRs, drug-drug interactions, hospitalization, functional declines, cognitive impairement, and increased mortality [17, 18, 20]. Indian studies report that nearly 42% of elderly patients receiving five or more medications experience at least one ADR, while appropriately 69.6% are to potential drug-drug interactions [17, 18]. Excessive medication use also contributes to falls, frailty, reduced independence, and preventable hospital admissions [17, 18].

1.2 Potentially Inappropriate Medications (PIMs)

Potentially Inappropriate Medications (PIMs) are medications where the risks outweigh the clinical benefits in elderly individuals, especially when safer alternatives are available [19, 21]. Common causes of inappropriate prescribing include age-related physiological changes, fragmented healthcare, prescribing cascades, irrational continuation of therapy, and lack of medication review. The use of PIMs is strongly associated with hospitalization, falls cognitive decline, increased healthcare costs, and mortality. Clinical tools such as Beers criteria and STOPP criteria are widely used to identify PIMs and optimize prescribing practices in geriatric patients [19, 21].

1.3 Potential Prescribing Omissions (PPOs)

Potential Prescribing Omissions (PPOs) refers to failure to prescribe clinically indicated medications despite absence of contraindications [23]. PPOs represent an important aspects of inappropriate prescribing and are commonly identifies using the START criteria [23, 25]. Studies indicate that 20-78% of hospitalized elderly patients experience at least one prescribing omission, particularly involving cardiovascular protection, osteoporosis management, or preventive therapies [24, 25]. PPOs contribute significantly to prenentable morbidity, hospital admissions, prolonged hospital stay, and mortality among geriatric patients [23, 27, 28].

1.4 Drug Use Evaluation

DUE is a structured, continuous, and criteria-based process used to evaluate medication use and improve rational prescribing practices [29]. According to the World Health Organization (WHO), DUE helps identify inappropriate medication use, polypharmacy, overuse, underuse, and irrational prescribing patterns [29, 30]. DUE plays an important role in promoting Rational Drug Use (RDU), minimizing adverse drug events, improving therapeutic outcomes, reducing healthcare expenditure, and enhancing patient safety [30, 31, 33, 34]. In studies evaluating polypharmacy and inappropriate prescribing in geriatric patients, DUE serves as an essential framework for assessing medication appropriateness using evidence-based tools such as Beers criteria and STOPP/START criteria.

1.5 Screening Tools for Inappropriate Prescribing

To standardize the detection of PIMs and PPOs in clinical practice, several validated explicit screening tools have been developed.

1.5.1 American Geriatric Society (AGS) Beers Criteria (2023 update): It is an internationally recognized, evidence-based compendium identifying medications that

are generally inappropriate for adults aged 60 years and older. Organized into five operational categories – medications to avoid in most older adults, drug-disease interactions, medications requiring cautions use, drug-drug interactions, and renal dose adjustments – the 2023 version incorporates the most current synthesis of clinical evidence, including new recommendations on long-term PPI use and primary cardiovascular prevention with aspirin [32].

1.5.2 STOPP Criteria (Screening Tool of Older Persons Prescriptions) version 3

The STOPP criteria is a physiological systems-based tool organized across 13 organ-system categories, expanded from 80 criteria in version 2 to 133 in version 3. It identifies PIMs through systematic review of each active prescription for medication-disease and medication-symptom interactions, therapeutic duplication, and clinically unjustified continuations [33].

1.5.3 START Criteria (Screening Tool to Alert to Right Treatment) version 3

The START criteria is the complementary counterpart to STOPP, comprising 57 evidence-based criteria that identify PPOs by cross-referencing a patient's documented diagnoses against prescribed therapies to detect gaps in indicated treatments, including cardiovascular protection, respiratory management, musculoskeletal care, and preventive vaccinations [33]. Together, STOPP/START and the Beers criteria represent the gold standard for Drug Use Evaluation (DUE) in geriatric populations – a systematic, criteria-based quality improvement process designed to monitor medication utilization and implement corrective interventions towards rational prescribing [29, 31].

1.6 Rational drug prescribing in geriatric patients

Rational drug prescribing in geriatric patients involves selecting medications according to clinical needs, appropriate dosage, duration, and cost-effectiveness while minimizing adverse effects and unnecessary therapy as defined by the WHO [17]. In elderly patients, age-related pharmacokinetic and pharmacodynamic changes, multimorbidity, and polypharmacy increase the risk of adverse drug reactions, falls, cognitive decline, and hospitalization, making rational prescribing essential for patient safety [17, 34, 35]. Polypharmacy, commonly defined as the use of five or more medications, has a prevalence of approximately 18–49% in India and contributes to drug-drug interactions, medication errors, increased healthcare costs, and reduced quality of life among older adults [36, 37, 38].

Studies also indicate that irrational prescribing and medication errors significantly increase healthcare burden globally and are major contributors to preventable morbidity and mortality in elderly patients [39, 40, 41].

2. LITERATURE REVIEW

1. Keche YN et al. (2022) – Usefulness of STOPP/START Criteria and Beer's Criteria for Prescribing in Geriatric Patients in a Tertiary Health Care Center, Raipur, Central India

Keche YN et al. conducted a prospective observational study among geriatric patients in a tertiary care hospital in Central India to evaluate the usefulness of STOPP/START and Beers criteria in identifying potentially inappropriate medications (PIMs). The study assessed demographic characteristics, comorbidities, polypharmacy, drug–drug interactions, and prescribing omissions. Findings revealed that both criteria were effective in detecting inappropriate prescribing and improving rational drug use in elderly patients, thereby reducing adverse drug reactions and improving healthcare outcomes [42].

2. American Geriatrics Society 2023 Updated AGS Beers Criteria® for Potentially Inappropriate Medication Use in Older Adults – AGS Beers Criteria® Update Expert Panel et al. (2023)

The AGS Beers Criteria® Update Expert Panel performed a systematic review and expert consensus study to update recommendations regarding potentially inappropriate medication use in older adults. The review focused on medications associated with adverse drug reactions, falls, delirium, cognitive impairment, renal impairment, and clinically significant drug interactions. The updated criteria emphasized safer prescribing practices and highlighted the importance of evidence-based medication review in geriatric patients [32].

3. Vishwas HN et al. (2012) – Potentially Inappropriate Medication Use in Indian Elderly: Comparison of Beer's Criteria and Screening Tool of Older Persons' Potentially Inappropriate Prescriptions.

Vishwas HN et al. conducted a prospective observational study comparing Beers and STOPP criteria for identifying PIMs among elderly Indian patients. The study evaluated prescribing patterns, comorbidities, number of medications, and prevalence of inappropriate prescriptions. STOPP criteria demonstrated greater sensitivity than Beers criteria in detecting inappropriate prescribing. The authors concluded that application of these screening tools can improve prescribing quality and reduce adverse drug reactions in geriatric patients [43].

4. Anand P et al. (2022) – Characterization of potentially inappropriate medications use in Indian elderly population and their impact on quality of life using Beer's criteria.

Anand P et al. performed a prospective observational study to assess the prevalence of PIMs and their effect on quality of life among elderly Indian patients. The study analyzed demographic data, medication history,

polypharmacy, and PIM prevalence according to AGS Beers Criteria. Results showed that inappropriate prescribing was common and negatively affected quality of life. The study emphasized the role of Beers criteria in improving medication safety and clinical outcomes [44].

5. Sharma R et al. (2020) – Potentially Inappropriate Medication Use in Older Hospitalized Patients with Type 2 Diabetes: A Cross-Sectional Study.
Sharma R et al. conducted a cross-sectional study among elderly hospitalized patients with type 2 diabetes to determine the prevalence of PIMs and associated risk factors. The study examined patient demographics, comorbidities, polypharmacy, and drug interactions. Findings indicated that PIM use was highly prevalent and strongly associated with multiple comorbidities and polypharmacy, highlighting the need for regular medication review and rational prescribing practices [45].

6. Syed J et al. (2024) – Multi-Criteria Assessment of Potentially Inappropriate Medications in Hospitalized Indian Older Adults: Comparing Beers, STOPP, and FORTA.
Syed J et al. carried out a prospective observational comparison study to evaluate PIM detection using Beers, STOPP, and FORTA criteria among hospitalized older adults. The study assessed prevalence of PIMs, prescribing patterns, and clinical relevance of identified medications. STOPP and FORTA criteria identified more clinically relevant PIMs than Beers criteria. The authors recommended the combined use of multiple screening tools for comprehensive medication assessment [46].

7. Kumar S et al. (2024) – Performance of Potentially Inappropriate Medications Assessment Tools in Older Indian Patients with Cancer.
Kumar S et al. evaluated various PIM assessment tools in elderly oncology patients through a prospective observational study. The study assessed demographic data, cancer stage, comorbidities, polypharmacy, and drug interactions. Results demonstrated variability in the sensitivity of screening tools, with some tools identifying clinically significant inappropriate medications more effectively. Regular medication review was recommended to improve patient safety in oncology settings [47].

8. Harugeri A et al. (2010) – Potentially Inappropriate Medication Use in Elderly Patients: A Study of Prevalence and Predictors in Two Teaching Hospitals.
Harugeri A et al. conducted a cross-sectional study in two Indian teaching hospitals to determine the prevalence and predictors of PIM use among elderly patients. The study evaluated patient demographics, comorbid conditions, number of prescribed drugs, and drug interactions. Polypharmacy and multiple comorbidities were identified as major predictors of inappropriate medication use. The study emphasized the importance of regular medication review and appropriate prescribing criteria [48].

9. Rainur S et al. (2015–2023) – Usefulness of STOPP/START Criteria and Beers Criteria for Prescribing in Geriatric Patients in a Tertiary Health Care Center (Central India).
Rainur S et al. performed a prospective observational study to assess the usefulness of STOPP/START and Beers criteria in identifying PIMs and prescribing omissions in geriatric patients. Clinical data regarding demographics, comorbidities, prescribed medications, and prevalence of PIMs were evaluated. The study concluded that STOPP/START criteria, along with Beers criteria, are effective tools for optimizing prescribing practices and improving patient outcomes in elderly populations [49].

10. Fick DM et al. (2003) – Updating the Beers Criteria for Potentially Inappropriate Medication Use in Older Adults: Results of a US Consensus Panel.
Fick DM et al. conducted a consensus-based observational study to revise and validate the Beers criteria for older adults. The study reviewed medication profiles, adverse drug events, drug–disease interactions, and expert panel assessments to identify clinically relevant PIMs. The updated Beers criteria provided a more comprehensive tool for identifying inappropriate medications and improving medication safety in geriatric practice [50].

3. MATERIALS AND METHODS

This prospective observational study was conducted to perform a structured Drug Use Evaluation (DUE) to quantify the prevalence of polypharmacy and critically assess the appropriateness of medication regimens in geriatric patients by utilizing the AGS Beers Criteria (2023) and the STOPP/STA

3.1 Study Objectives and Hypotheses:

The research was designed to address specific primary and secondary objectives.

Primary objectives included:
(1) to determine the prevalence of polypharmacy (concurrent use of ≥5 medications) in the study population of geriatric patients; (2) to identify the specific prevalence and types of potentially inappropriate medications (PIMs) using both the Beers and the STOPP Criteria; (3) to determine the types of potential prescribing omissions (PPOs) using the START Criteria; and (4) to establish the relationship between the degree of polypharmacy and the presence of PIMs (Beers/ STOPP) and PPOs (START).

The **secondary objective** was to evaluate the correlation between comorbidity burden and the prevalence of PIMs as defined by Beers and STOPP Criteria.

The **alternative hypothesis** (H1) posited that The alternative hypothesis (H1) posited that polypharmacy has a significant effect on inappropriate prescribing patterns in geriatric patients, specifically: (1) it

significantly affects the number of PIMs identified by the Beers criteria; (2) it significantly increases inappropriate prescriptions identified by the STOPP criteria; and (3) it is significantly associated with prescribing omissions identified by the START criteria.

Conversely, **the null hypothesis (H0)** Polypharmacy has no significant effect on inappropriate prescribing patterns in geriatric patients. Specifically: (1) It does not affect the number of PIMs identified by the Beers criteria; (2) It has no impact on inappropriate prescriptions identified by the STOPP criteria; (3) It is not associated with prescribing omissions identified by the START criteria.

3.2 Study Design and Setting:

A prospective observational study design was employed. The research was carried out over a duration of 6 months, spanning from November 1, 2025 to April 30, 2026. The investigation was conducted at the inpatient departments of Lokmanya Group of Hospital, Pune, and Ruby Hall Clinic, Hinjewadi. The study population encompassed both urban and rural geriatric patients who sought consultation or were hospitalized at the study sites in Pune, Maharashtra. An estimated sample size of 200 geriatric patients was determined, calculated based on the average monthly geriatric admission rate and prevalence of chronic conditions requiring polypharmacy at the participating institutions.

3.3 Selection Criteria:

Inclusion criteria comprised: (1) geriatric patients aged ≥60 years of both genders; (2) patients receiving ≥5 prescribed medications; (3) patients attending inpatient wards during the study period; (4) patients willing to give written informed consent, either directly or through caregiver if unable; and (5) patients obtaining medicines from hospital or pharmacy during data collection period.

Exclusion criteria included: (1) patients with terminal illness or in palliative care; (2) patients with severe mental disorders, HIV, or post-organ transplantation, as these may confound drug patterns; (3) patients with incomplete prescription or clinical records; (4) proxy prescription collectors unable to provide complete medication history; and (5) patients not willing or unable to provide informed consent.

3.4 Data Collection Instruments and Sources:

3.4.1 Case Report Form Development:

The CRF was developed following an exhaustive review of geriatric pharmacotherapy literature and was structured to systematically record patient demographics, comorbidities, laboratory reports, and complete medication lists, including over-the-counter (OTC) and herbal medicines. The tool was curated to ensure comprehensive assessment of medication appropriateness and therapeutic outcomes through eight distinct categories:

1. Patient Demographic Details: Systematically recorded essential identifiers including name, age, gender, address, and contact information. Physiological parameters such as body weight and Body Mass Index (BMI) were documented to establish a complete physical profile.

2. Clinical Information: Documented the primary diagnosis and significant comorbidities such as Hypertension, Diabetes Mellitus, Chronic Kidney Disease (CKD), and Chronic Obstructive Pulmonary Disease (COPD). It also tracked the duration of illness and history of recent hospitalizations.

3. Lifestyle Factors: Designed to identify modifiable risk factors by capturing habits such as smoking and alcohol consumption.

4. Medication Profile: Comprised a comprehensive list of all current pharmacotherapy, including the total number of drugs prescribed, prescriber type, and the use of over-the-counter (OTC) or herbal/supplemental medications.

5. Medication Adherence: This section monitored the consistency of drug intake, categorizing adherence as regular or irregular.

6. Beers Criteria Evaluation: Utilized the latest AGS Beers Criteria to identify potentially inappropriate medications (PIMs), specifically evaluating drugs unsuitable for older adults or those with certain diseases.

7. STOPP/START Criteria Evaluation: Implemented STOPP criteria to detect PIMs across various physiological systems (e.g., Cardiovascular, Central Nervous System, Gastrointestinal) and used START criteria to identify potential prescribing omissions (PPOs).

(8) Outcome Measures: Categorized results based on drug modifications suggested, implemented changes, and patient follow-up status (Improved, No Change, or Worsened) after one month.

3.4.2 Data Sources:

Participants meeting the predefined inclusion criteria were enrolled from the study sites. Comprehensive clinical data were retrieved from patient case papers, medication administration records (treatment carts), and direct structured patient interviews. Data were gathered from active medical records, encompassing patient demographics, clinical history, and laboratory parameters. This included a comprehensive review of current medication profiles, inclusive of OTC and herbal supplements, to evaluate drug utilization patterns and identify potentially inappropriate prescribing. Participation was formalized through a custom designed informed consent form, ensuring all enrolled subjects

were fully appraised of the study objectives before data acquisition.

3.5 Study Procedures:
The study followed a systematic plan of work encompassing six phases:

1. Literature Survey and Research Instrument Design: Conducting an exhaustive review of geriatric pharmacotherapy and designing the Case Report Form (CRF) as described above.

2. Ethics Compliance and Quality Control: Obtaining institutional permissions and implementing quality control measures. This involved preparing informed consent forms to ensure the consistency, accuracy, and reliability of data collection procedures from study participants.

3. Clinical Data Collection and Safety Assessment: Acquiring primary data from patient case papers and treatment carts. This stage involved identifying recent adverse drug reactions (ADRs) and medication-related problems.

4. Application of Evaluative Screening Tools: Screening the documented medication regimens using the latest AGS Beers Criteria to identify potentially inappropriate medications (PIMs), and the STOPP/START Criteria to recognize both inappropriate prescribing and potential therapeutic omissions.

5. Data Digitization and Management: Performing data entry and management by transferring gathered parameters from the CRFs into Microsoft Excel. This phase ensured that all clinical data were organized into structured sheets for efficient computational processing and analysis. Executing the final analytical phase using descriptive statistics (mean, frequency, percentage, and Spearman rank coefficient) to summarize demographics. This included a comparative analysis of detection rates between Beers and STOPP criteria, and utilizing predictive modeling (percentage formulas) to identify predictors of inappropriate prescribing, such as age, gender, medication number, and comorbidities.

3.6 Data Analysis:
Data analysis encompassed both qualitative and quantitative approaches.

Qualitative Analysis: This involved identifying clinical outcome patterns such as geriatric patient wellbeing and medication adherence. The assessment examined how prescribing trends affect the daily wellbeing of older adults (quality of life).

Quantitative Analysis: This stage involved evaluating drug utilization patterns and determining medication appropriateness by applying the 2023 AGS Beers Criteria and STOPP/START Criteria (Version 3). Statistical measures including mean, frequency, and percentage were utilized to quantify the prevalence of polypharmacy and potentially inappropriate medications (PIMs).

3.7 Study Scope:
This research was directed towards the overall assessment of prescribing patterns and medication utilization patterns within the geriatric clinical care setting. By systematically implementing the AGS Beers Criteria (2023) and the STOPP/START Criteria (Version 3), this research highlighted five key areas:

1. Clinical Safety Benchmarking: To establish a rigorous safety profile for elderly patients by identifying high-risk pharmacological agents and quantifying the prevalence of potentially inappropriate medications (PIMs).

2. Therapeutic Optimization and Deprescribing: To provide a clinical framework for reducing the "prescribing cascade," thereby facilitating the transition from complex multi-drug regimens to streamlined, high-benefit therapies.

3. Mitigation of Iatrogenic Risks: To evaluate and minimize the incidence of medication related morbidity, specifically focusing on the prevention of falls, cognitive impairment, and adverse drug reactions (ADRs) associated with inappropriate polypharmacy.

4. Identification of Care Deficits: To utilize the START criteria to pinpoint potential prescribing omissions (PPOs), ensuring that necessary, evidence-based medications are integrated into the patient's treatment plan for optimal disease management.

5. Evidence-Based Institutional Reform: To generate localized clinical data that supports the development of specialized geriatric pharmacotherapy protocols and enhances the quality of pharmaceutical care at the institutional level.

4. OBSERVATIONS AND RESULTS

A prospective observational study was conducted over six months at a tertiary care hospital in Pune, enrolling 200 geriatric patients aged ≥60 years. Data were collected using structured case record forms covering demographics, comorbidities, and complete medication profiles. Prescriptions were evaluated using Beer's Criteria (2023), STOPP Criteria, and START Criteria (Version 3) to assess polypharmacy prevalence and identify potentially inappropriate medications (PIMs) and potential prescribing omissions (PPOs).

4.1 Demographic Profile

Of 200 patients, 107 (53.5%) were male and 93 (46.5%) female. The 60–70 years age group was predominant (55.5%), followed by 71–80 years (32.0%) and 81–90 years (9.5%). Only 8 patients (4%) reported smoking or alcohol use, confirming that polypharmacy in this

population is driven primarily by multimorbidity rather than lifestyle factors. Six percent had a hospitalisation history in the preceding six months, and drug allergies were documented in 1.5% of patients.

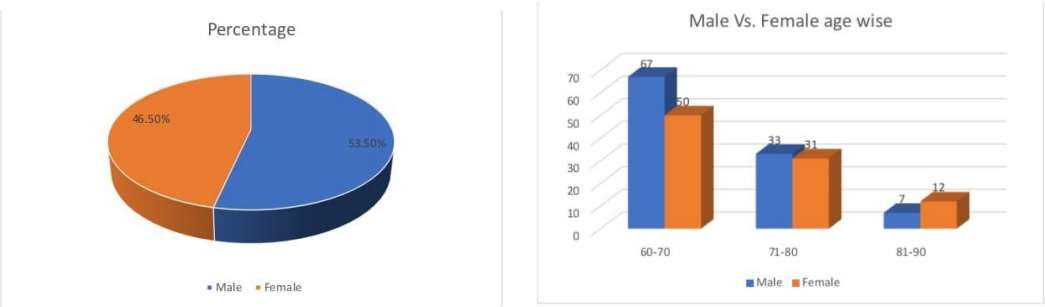

Fig 4.1 Gender distribution (left) and age-wise distribution (right) of study participants (n = 200)

4.1.1 Comorbidity Burden

A total of 333 comorbid diagnoses were recorded across the 200 patients (mean: 1.73 per patient). Hypertension was the most prevalent condition (82%), followed by diabetes mellitus (43.5%) and hypothyroidism (10%). Ischaemic heart disease (8%), chronic kidney disease (4.5%), and COPD (4%) were also documented. The high comorbidity index constitutes the primary driver of polypharmacy, as guideline-directed therapy for each condition independently requires pharmacological management.

Table 4.1 Comorbidity distribution in study participants

Comorbidity	Frequency	Percentage
Hypertension	164	82.0
Diabetes Mellitus	87	43.5
Hypothyroidism	20	10.0
Ischaemic Heart Disease	16	8.0
Chronic Kidney Disease	9	4.5
COPD	8	4.0
Cerebrovascular Accident	6	3.0
Others (Dyslipidaemia etc.)	23	11.5
Total	**333**	—

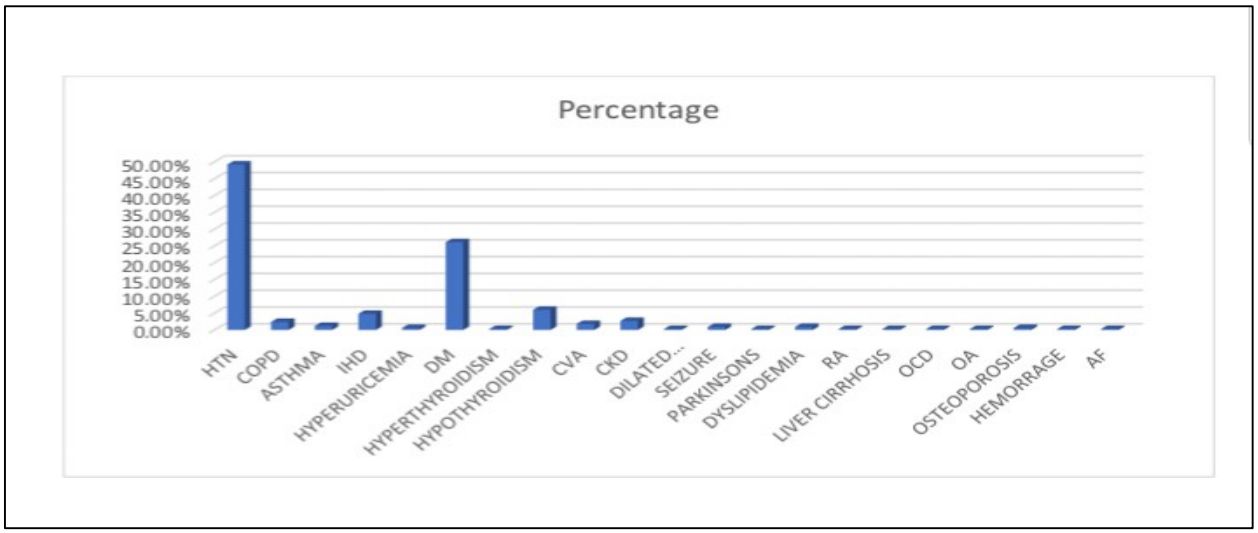

Fig 4.2 Prevalence of comorbidities in the geriatric study population

4.2 Primary Objectives

4.2.1 Polypharmacy Prevalence (Objective 1)

All 200 patients (100%) met the polypharmacy threshold of ≥5 concurrent medications. The largest subgroup received 6–10 drugs (48.5%), followed by 11–15 drugs (35.5%), 16–20 drugs (13.0%), 21–25 drugs (2.5%), and one patient exceeded 30 medications (0.5%). The primary driver was multimorbidity requiring guideline-directed therapy for each condition; a secondary mechanism was the prescribing cascade, whereby drugs introduced to manage adverse effects of existing medications further inflated total drug counts.

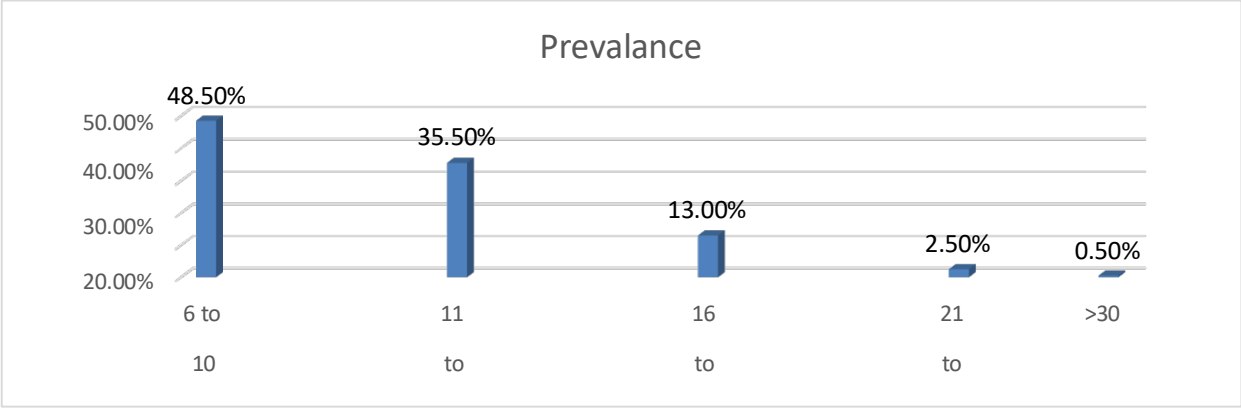

Fig 4.3 Polypharmacy severity by prescribed drug count range (n = 200; prevalence = 100%)

4.2.2 Potentially Inappropriate Medications - Beer's Criteria (Objective 2)

Beer's Criteria (2023) identified ≥1 PIM in 198 of 200 patients (99%). The modal PIM count was 4 per patient (n = 41), with the distribution peaking in the 2–5 PIM range, confirming that inappropriate prescribing is a recurrent pattern rather than an isolated event. Only 2 patients were PIM-free. The prevalence reflects inadequate adjustment of drug regimens for age-related pharmacokinetic changes and limited application of geriatric screening tools in routine practice.

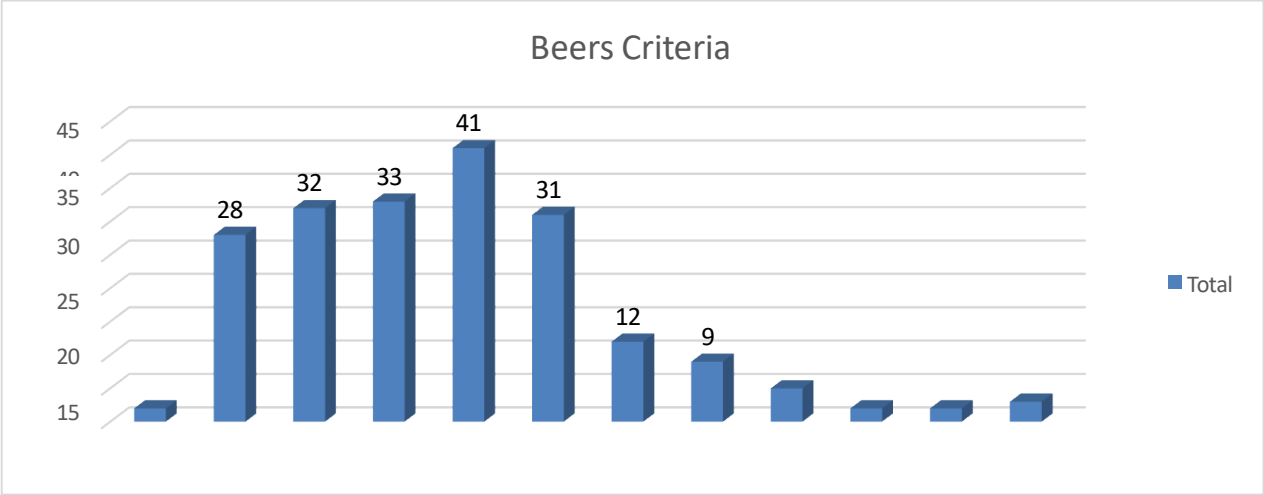

Fig 4.4 Distribution of PIM count per patient by Beer's Criteria 2023 (prevalence: 99%)

4.2.3 Potentially Inappropriate Medications - STOPP Criteria (Objective 2)

STOPP Criteria detected ≥1 PIM in all 200 patients (100%). The most frequent PIM counts were 3 (n = 56) and 4 (n = 55) per patient. The complete detection rate and marginally higher inter-patient PIM counts compared with Beer's Criteria indicate that STOPP may offer superior sensitivity in multimorbid geriatric patients. Concurrent application of both tools is therefore recommended to maximise identification of inappropriate prescribing.

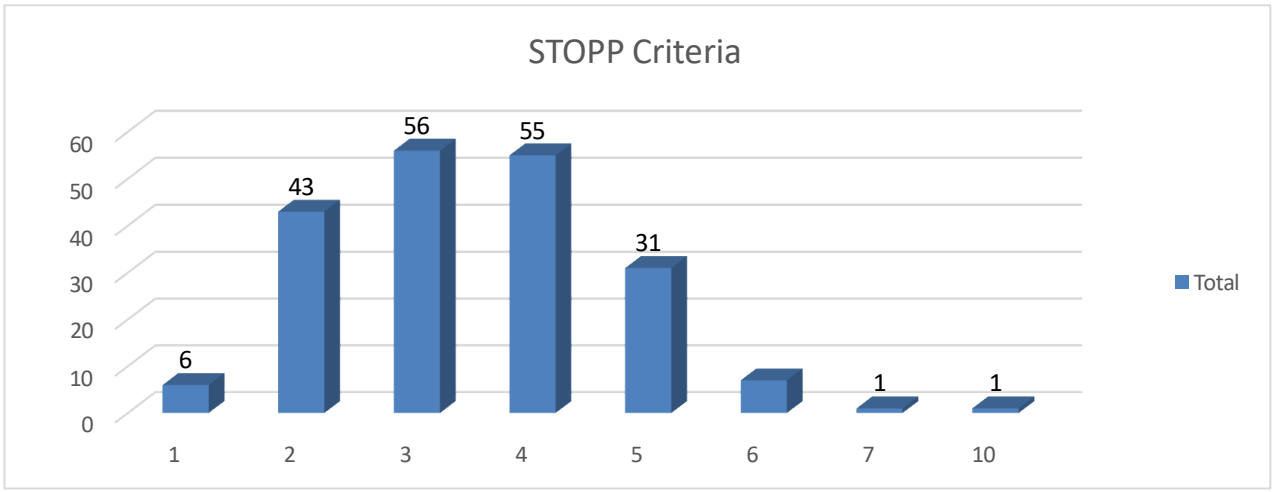

Fig 4.5 Distribution of PIM count per patient by STOPP Criteria (prevalence: 100%)

4.2.4 Potential Prescribing Omissions - START Criteria (Objective 3)

START Criteria (Version 3) identified ≥1 prescribing omission in 198 of 200 patients (99%). Most patients had 1–3 PPOs (modal count: 2; n = 67). A subset carried 4–8 omissions, reflecting substantially incomplete regimens. The co-existence of high PIM and PPO prevalence reveals a dual prescribing deficit: patients simultaneously received potentially harmful medications while being denied clinically indicated therapies. Under-prescribing of cardioprotective agents in high-risk patients is of particular concern, as it may precipitate disease progression and preventable adverse outcomes.

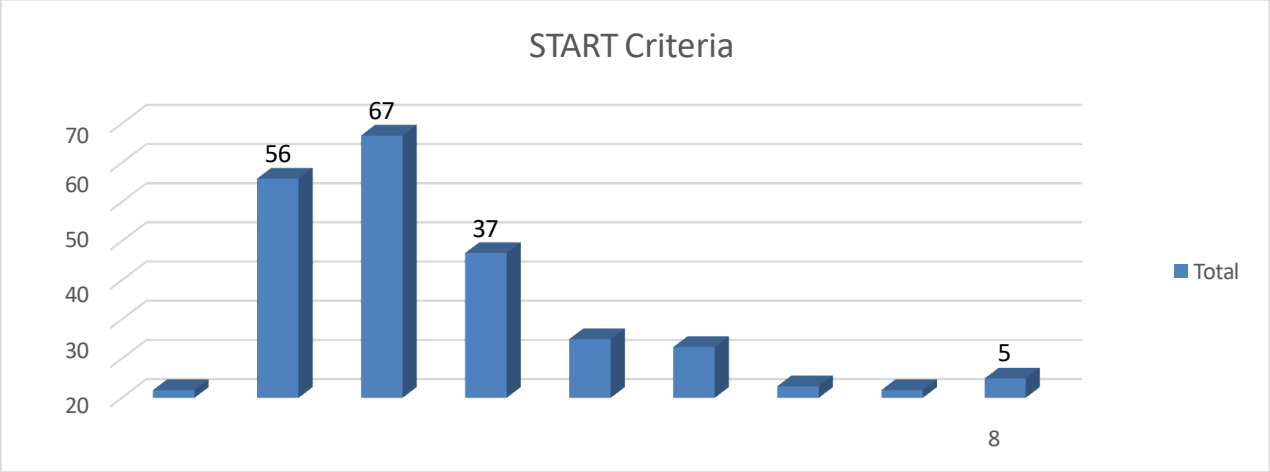

Fig 4.6 Distribution of PPO count per patient by START Criteria (prevalence: 99%)

4.2.5 Association between Polypharmacy, PIMs, and PPOs (Objective 4)

Among all polypharmacy patients, 100% had ≥1 PIM (STOPP) and 99% had ≥1 PPO (START), establishing a near-universal qualitative link between increasing medication count and deteriorating prescribing quality. These findings confirm that polypharmacy is not merely a quantitative burden but a qualitative one necessitating both drug reduction and prescribing quality improvement.

Table 4.2. Association between polypharmacy and prescribing quality indicators

Association Parameter	Prevalence
Polypharmacy (≥5 drugs)	100% (200/200)
Polypharmacy patients with ≥1 PIM (Beer's)	99% (198/200)
Polypharmacy patients with ≥1 PIM (STOPP)	100% (200/200)
Polypharmacy patients with ≥1 PPO (START)	99% (198/200)

4.3 Secondary Objective: Comorbidity Burden vs. PIM Prevalence

Spearman rank correlation analysis revealed a moderate-to-strong positive association between comorbidity count and PIMs identified by Beer's Criteria ($\rho = 0.62$, $p < 0.001$) and a strong positive association with STOPP Criteria ($\rho = 0.68$, $p < 0.001$). Both results were highly statistically significant, confirming that greater comorbidity burden reliably predicts higher inappropriate prescribing rates. The inter-criteria correlation ($\rho = 0.74$) validates the complementary utility of applying both tools concurrently.

Table 4.3 Spearman rank correlation matrix ($p < 0.001$)

Variables	Comorbidities	Beer's PIMs	STOPP PIMs
Comorbidities	1.00	0.62	0.68
Beer's Criteria	0.62	1.00	0.74

STOPP Criteria	0.68	0.74	1.00

5. DISCUSSION

Demographic Characteristics and Lifestyle Factors:

The study population showed a marginally higher proportion of male patients, which may reflect greater healthcare utilization and cardiovascular disease burden in this group. Male patients were more likely to receive antihypertensive, antiplatelet, and lipid-lowering therapies, increasing the risk of cumulative pharmacodynamic effects such as hypotension. Female patients, due to higher body fat percentage and differences in plasma protein binding, exhibited prolonged retention of lipophilic drugs (e.g., alprazolam), heightening susceptibility to sedation and falls. The majority of patients fell within the 60–70 years age group, representing the early geriatric phase characterized by accumulating chronic conditions. Although smoking and alcohol use were minimal (4%), their pharmacological impact remains notable: smoking induces CYP1A2 enzymes affecting drug metabolism, while alcohol potentiates CNS depressants, increasing sedation and hepatotoxicity risk.

Polypharmacy: Analysis and Mechanistic Consequences

Polypharmacy was a predominant finding, with 48.5% of patients receiving 5–10 medications, 35.5% receiving 11–15, and 16% receiving 15–20 medications. The risks of polypharmacy increase exponentially with the number of drugs prescribed, owing to overlapping pharmacokinetic interactions (enzyme inhibition/induction) and pharmacodynamic effects (additive or antagonistic). A clinically significant example is the 'triple whammy' interaction NSAIDs, ACE inhibitors, and diuretics concurrently compromising renal perfusion and precipitating acute kidney injury. Furthermore, polypharmacy fosters prescribing cascades; for instance, calcium channel blocker-induced edema may be misidentified as heart failure, prompting unnecessary addition of diuretics. Medication non-adherence due to regimen complexity further worsens disease control and contributes to adverse outcomes.

Comorbidities and Interaction with Pharmacotherapy:

The coexistence of multiple chronic conditions primarily hypertension, diabetes mellitus, and cardiovascular disease substantially amplified therapeutic complexity. Combined antihypertensive regimens (beta-blockers, ACE inhibitors, diuretics) risked excessive blood pressure reduction and orthostatic hypotension. In diabetic patients, concurrent use of multiple hypoglycemic agents increased hypoglycemia risk, which could be misdiagnosed as a neurological event. These findings underscore the need for careful drug selection, individualized monitoring, and regular medication reconciliation in patients with multimorbidity.

Drug-Drug Interactions and Adverse Drug Reactions:

Significant drug-drug interactions were identified through both pharmacokinetic and pharmacodynamic mechanisms. Enzyme inhibition elevated plasma drug concentrations, while enzyme induction reduced therapeutic efficacy. Pharmacodynamic interactions such as concurrent anticoagulant and NSAID use—increased gastrointestinal bleeding risk by impairing platelet function and mucosal protection. Multiple CNS depressants together heightened sedation and fall risk. Adverse drug reactions in elderly patients stemmed primarily from reduced renal and hepatic clearance, enhanced receptor sensitivity, and altered body composition. Common ADRs included gastrointestinal disturbances, orthostatic hypotension from antihypertensives, and CNS depression with cognitive impairment. The clinical cascade drug exposure → physiological alteration → symptom manifestation → functional decline → hospitalization was consistently observed.

Application of Screening Tools and Clinical Outcomes:

Evaluation using Beers Criteria (2023) identified potentially inappropriate medications (PIMs) such as long-acting benzodiazepines and NSAIDs, linked to cognitive deterioration, falls, and renal injury. STOPP criteria revealed therapeutic duplications and prolonged use of high-risk drugs, while START criteria uncovered prescribing omissions including absent cardioprotective therapies in high-risk patients. The simultaneous application of all three tools provided a comprehensive picture of both over-prescribing and under-prescribing, enabling a more complete clinical assessment. Study outcomes demonstrated partial improvement in patient conditions, yet the burden of polypharmacy-associated adverse effects counterbalanced therapeutic gains. Collectively, these findings affirm that structured Drug Use Evaluation (DUE) programs integrating validated screening tools, clinical pharmacist involvement, and regular medication reviews are essential to optimize prescribing quality, reduce preventable harm, and enhance patient outcomes in the geriatric population.

6. CONCLUSION

The present study highlights the high prevalence of polypharmacy and potentially inappropriate medication use among geriatric patients aged 60 years and above. Elderly patients with multiple chronic comorbities were

frequently exposed to 5-15 medications, increasing the risk of adverse drug reactions, drug-drug interactions, poor medication adherence, and therapeutic complications. The finding emphasizes that polypharmacy significantly contributes to prescribing complexity and compromises medication safety in geriatric populations. Age-related physiological changes, including reduced renal and hepatic function, further increase susceptibility to altered pharmacokinetic and pharmacodynamic responses, especially present among patients above 70 years of age. Gender-related variations in drug metabolism also support the need for individualized and patient-specific therapeutic approaches. In addition, patients with hospitalization history or drug allergies represented high-risk groups requiring careful monitoring and pharmacovigilance practices. The study identified commonly prescribed medications such as proton pump inhibitors, benzodiazepines, and NSAIDs as major contributors to polypharmacy patterns. Although multiple medications are often necessary for chronic disease management, inappropriate continuation of therapy may increase treatment-related complications. Therefore, regular medication review, deprescribing strategies, and evidence-based prescribing practices are essential to optimize geriatric pharmacotherapy. The active involvement of clinical pharmacists in medication review, patient counseling, and adverse drug reaction monitoring can significantly improve prescribing quality and reduce medication-related harm. Furthermore, implementation of validated tools such as AGS Beers criteria and STOPP/START criteria may support rational prescribing and safer medication use among elderly patients. Overall, comprehensive medication management and multidisciplinary healthcare interventions are essential for improving therapeutic outcomes, patient safety, and quality of life in geriatric populations.

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