RESEARCH PAPER

Assessment of Medication Appropriateness and Medication Error Patterns Among Elderly Patients in a Tertiary Care Hospital: A Prospective Observational Study.

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ABSTRACT

Background:
Age-related physiological changes make older adults more susceptible to potentially inappropriate medications (PIMs) and medication errors, leading to adverse outcomes, prolonged hospitalization, and increased healthcare costs. Assessing medication appropriateness and identifying medication errors are essential for improving patient safety and optimizing pharmacotherapy in elderly patients.

Aim:
To assess medication appropriateness and analyze the pattern of medication errors among geriatric patients admitted to a tertiary care hospital.

Methods:
A prospective observational study was conducted over six months in a tertiary care hospital in Kannur, Kerala. A total of 223 geriatric inpatients aged ≥65 years were enrolled. Demographic, clinical, and medication-related data were collected using a structured case record form. Medication appropriateness was evaluated using the American Geriatrics Society (AGS) Beers Criteria. Medication errors were identified, classified according to the medication-use process, and assessed using NCCMERP severity categories. Data were analyzed using Microsoft Excel and IBM SPSS Version 21.

Results:
Among the 223 participants, 45% were aged 71–80 years and 55.8% were male. Medication appropriateness assessment of 120 prescriptions revealed that 88 (73.3%) contained at least one PIM. Of 1,947 medications reviewed, 237 (12.2%) were identified as PIMs, with non-steroidal anti-inflammatory drugs being the most common. Polypharmacy was observed in 91.7% of patients. A total of 103 medication errors were identified, predominantly during the transcribing phase (45%), followed by prescribing and administration (21% each). Wrong-dose errors were most frequent (26%). Most errors were classified as NCCMERP Categories B and C. Significant associations were observed between error severity and both error type and medication-use phase ($p<0.05$). Clinical pharmacist interventions were widely accepted and effectively resolved most errors.

Conclusion:
Potentially inappropriate prescribing, polypharmacy, and medication errors were highly prevalent among geriatric inpatients. Regular medication review, systematic error monitoring, and active clinical pharmacist involvement can enhance medication safety and improve the quality of geriatric care.

Keywords: Geriatric patients, Beers Criteria, Potentially Inappropriate Medications, Medication Errors, Medication Safety, Clinical Pharmacist Intervention.

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INTRODUCTION

Ageing is a natural biological process associated with progressive decline in physiological functions and increased vulnerability to diseases [1]. India's elderly population is rapidly increasing, with individuals aged

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above 65 years projected to rise from 138 million in 2021 to 194 million by 2031, representing a 41% increase according to the National Statistical Office (NSO) report [2]. Older adults are major consumers of medications and are highly susceptible to drug related problems because of age-related pharmacokinetic and pharmacodynamic changes [3]. Multiple comorbidities are also common in geriatrics which includes diabetes, chronic obstructive pulmonary disease, osteoarthritis, depression, dementia, sensory impairments etc.[4].

The ***American Geriatrics Society Beers Criteria*** is one of the most widely used tools for identifying inappropriate prescribing in older adults, developed by Mark H. Beers in 1991 and periodically updated, the latest 2023 version provides guidance on medications that should generally be avoided, used cautiously, or dose-adjusted in elderly patients [5,6]. The criteria include recommendations regarding drug–disease interactions, drug–drug interactions, renal dose adjustments. [7,8]

Medication errors are among the most common preventable threats to patient safety in healthcare settings. They may occur at any stage of the medication-use process, including prescribing, dispensing, administration, and monitoring. These errors can lead to inappropriate medication use, adverse drug events, prolonged hospital stay, increased healthcare costs, and even mortality.[9]

According to the **National Coordinating Council for Medication Error Reporting and Prevention (NCCMERP)**, a medication error is "*any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the healthcare professional, patient, or consumer.*" Medication errors may arise from failures in prescribing, communication, labeling, dispensing, administration, monitoring, or healthcare systems.[10]

Medication errors negatively affect patients' quality of life and reduce the quality in healthcare services. Studies estimate that approximately 18.7–56% of adverse events among hospitalized patients are related to preventable medication errors. Therefore, identifying the causes, contributing factors, and clinical consequences of medication errors is essential for implementing preventive strategies and improving patient safety.

Polypharmacy, commonly defined *as the concurrent use of five or more medications*, is highly prevalent among older adults due to multiple chronic illnesses. Although necessary for disease management, polypharmacy increases the risk of ADRs, drug interactions, medication errors, inappropriate prescribing, and healthcare costs. Potentially inappropriate medications (PIMs) are a major concern in geriatric care. [11]

Overall, polypharmacy, inappropriate prescribing and medication errors are major contributors to adverse clinical outcomes in geriatric patients. Appropriate application of Beers Criteria and finding out medication errors at the earliest can help to optimize medication therapy, reduce exposure to PIMs, and improve the quality of healthcare in older adults.

NEED OF THE STUDY

As the geriatric population continues to grow, the prevalence of chronic diseases, multiple comorbidities, and the use of multiple medications has increased. Older adults are particularly vulnerable to medication-related problems because of age-related physiological changes, polypharmacy, and inappropriate prescribing practices. These challenges can lead to adverse drug reactions (ADRs), drug interactions, medication errors, longer hospital stays, and increased healthcare costs.

SCOPE OF THE STUDY

This study evaluates potentially inappropriate medications (PIMs), medication errors and polypharmacy. Prescribing patterns will be assessed using the American Geriatrics Society Beers Criteria. The study also identify factors associated with inappropriate prescribing and assess the role of clinical pharmacist interventions in improving medication safety and optimizing geriatric patient care.

AIM AND OBJECTIVES

AIM

The aim of the study was to investigate medication safety in Geriatric patients admitted in a tertiary care hospital with a special focus on medication appropriateness and medication errors for a period of six months.

OBJECTIVES

Primary objectives:

1. To assess the medication appropriateness among geriatric patients in a tertiary care hospital by applying Beers Criteria .
2. To analyse the patterns of medication errors in elderly inpatients.

Secondary objectives

1. To assess geriatric polypharmacy.
2. Identifying predictors and frequency of medication errors.

METHODOLOGY

STUDY SITE

Study was carried out in various departments of a Tertiary Care Hospital, Kannur, Kerala.

STUDY DURATION

Study was conducted over a period of 6 months after getting clearance from IEC.

STUDY POPULATION

Patients aged 65 years and above who were admitted to various departments of a tertiary care hospital in Kannur, Kerala, during the study period.

STUDY CRITERIA

Inclusion Criteria

- Inpatients aged 65 years and above of either sex.
- Patients admitted to the hospital for more than 24 hours.
- Patients who were willing to participate and provided informed consent.

Exclusion Criteria

The following patients were excluded from the study:

- Patients admitted under the Departments of Palliative Medicine, Clinical Oncology, and Haematology.
- Patients admitted to Intensive Care Units (ICUs).
- Solid organ transplant recipients.

STUDY DESIGN

Prospective observational study

SAMPLE SIZE

223 elderly inpatients.

STUDY PROCEDURE

Eligible geriatric patients admitted to various departments of the tertiary care hospital were enrolled after obtaining written informed consent. Data on demographics, clinical characteristics, laboratory findings, and medication history were collected using a predesigned case record form and patient medical records.

Medication appropriateness was assessed using the AGS Beers Criteria to identify potentially inappropriate medications (PIMs). Medication errors were evaluated across different stages of the medication-use process and classified according to their type, contributing factors, and severity using the NCC MERP classification system.

The collected data were entered into Microsoft Excel and analyzed using Microsoft Excel and IBM SPSS Statistics Version 21 to determine the prevalence of PIMs, polypharmacy, and medication errors among geriatric patients. Association between categorical variables was assessed using the Chi-square test/Fisher's Exact Test (small expected frequencies)

CONCERNS

Written informed consent was obtained from all participants before enrollment. Patient confidentiality was maintained throughout the study. The study was approved by the Institutional Human Ethics Committee (Ref. No. 003/2022/CCOPS/IEC), and data collection was initiated only after obtaining ethical clearance.

Potentially Inappropriate Medications (PIMs)

Potentially inappropriate medications (PIMs) were identified using the AGS Beers Criteria, which categorizes medications and medication-related risks in older adults into five groups: (1) medications that are generally considered inappropriate for older adults, (2) medications that may worsen specific diseases or syndromes, (3) medications that should be used with caution, (4) clinically significant drug–drug interactions, and (5) medications requiring dose adjustment based on renal function. In this study, no patients met the Beers Criteria for renal dose adjustment; therefore, no medications were classified as PIMs under this category.

RESULTS

A total of 223 geriatric patients who met the inclusion criteria were enrolled in the study. Among them, 120 patients (53.8%) were prescribed at least one potentially inappropriate medication (PIM) as identified using the AGS Beers Criteria, while 103 (46.2%) samples experienced medication errors during their hospital stay.

Distribution of Sample According to Age and Gender

1. PIM- BEERS Criteria: Out of 120 patients with PIM, 54 (45%) belongs to 71-80 years age group, 45 (38%) belongs to 65-70 years age group, 19 (16%) belongs to 81-90 years age group and 2 (2%) belongs to patients aged above 91. About 67(55.83%) were male and 53(44.16) were female.

ETHICS AND

Table 1: Age distribution in PIP

Age Group (Years)	No of patients (n=230	Percentage (%)
65-70	45	38%
71-80	54	45%
81-90	19	16%
>91	2	2%

Table 2 : Gender wise distribution

Gender	No of patients (n=120)	Percentage
Male	67	55.83%
Female	53	44.16%

2. Medication Errors: A total of 103 medication error cases were analyzed. The mean age of the study population was approximately 70 years for males and 69 years for female. Male patients constituted the majority of cases compared to females. **Figure 1**

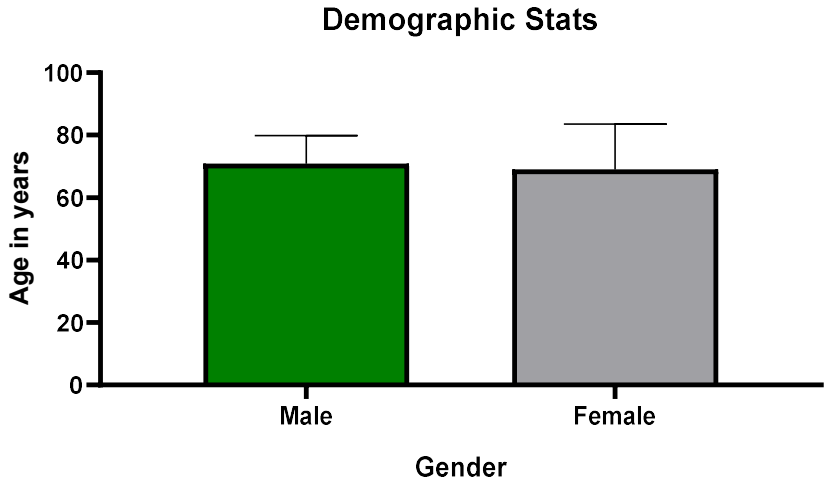

Figure 1: Demographic characteristics

I- POLYPHARMACY

Presciptions from the study participants were thoroughly screened to check polypharmacy. Out of 223 prescriptions 205 prescriptions had more than 5 drugs that is 91.9 % of the participants were observed. Only 8.1% of the participants were receiving less than 5 drugs. (**Table 3)**

Table 3: Polypharmacy

Number of Drugs	No of patients (n=223)	Percentage (%)
<5	18	8.1%
5–7	54	24.2%
8–10	75	33.6%
11–15	56	25.1%
>15	20	9.0%

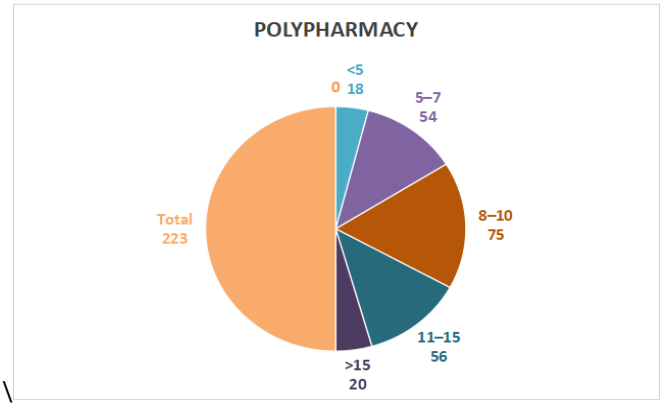

Figure2: Polypharmacy

II- BEERS CRITERIA

1. Distribution of PIM in geriatrics

Prescriptions from the study participants were analyzed using the Beers Criteria. Among the 120 prescriptions evaluated, 88 (73.33%) contained at least one potentially inappropriate medication (PIM). Of the 1,947 drugs analyzed, 237 (12.17%) were identified as inappropriate medications (**Table 4)**.

Table 4 : Distribution of Potentially Inappropriate Medications (PIM) as per Beers Criteria

Parameter	**Total Prescriptions** $n = 120$	**Prescriptions with ≥1 PIM**	**Total Drugs Reviewed**	**Potentially Inappropriate Medications (PIMs)**
Number	120	88	1947	237
Percentage	100%	73.3%	100%	12.17% of total drugs

2. **Frequency of PIM prescribed according to Beers criteria:**

In the study most frequently prescribed classes of PIM were observed as NSAIDs (21%), Corticosteroids (17%), Antihypertensives (12%) Anticonvulsants (11%), Antipsychotics(9%), Opioids (8%), Antihistamines (5%), Prokinetic Agents (4%), Antiarrhythmics (3%), Anti-diabetics (2%), Antibiotics(2%), Anticoagulants(2%), Anticholinergics (2%), Others (1%).(**Table 5)**

Table 5 : Frequency of PIM prescribed according to BEERs criteria

Drugs Category	**Number of drugs**	**Percentage**
NSAIDs	50	21%
Corticosteroids	40	17%
Antihypertensives	28	12%
Anticonvulsants	25	11%
Antipsychotics	21	9%
Opioids	20	8%
Antihistamines	13	5%
Prokinetic Agents	10	4%
Antiarrhythmics	8	3%

Anti Diabetics	7	3%
Antibiotics	5	2%
Anticoagulants	4	2%
Anticholinergics	4	2%
Others	2	1%

3. **BEERs criteria classification**

PIMs identified in the study were grouped in to following classes. (**Table 6)**

Table 6 : Classification according to criteria

BEERS CRITERIA CLASS	PERCENTAGE %
Should be avoided	54%
Should be avoided in certain condition	3%
Use with caution	17%
Combination to be avoided	26%

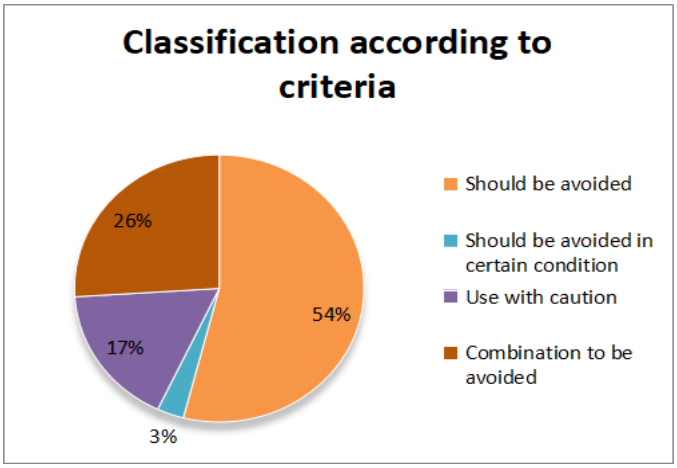

Figure 3 : Classification according to criteria

III- MEDICATION ERRORS

1. **Department-wise Distribution of Medication Errors**

Medication errors were observed across multiple departments. The highest proportion of errors was reported from General Medicine followed by Cardiology and Gastroenterology. Other departments such as Nephrology, Pulmonology, Neurology, and Psychiatry contributed comparatively fewer cases.(**Figure 4)**

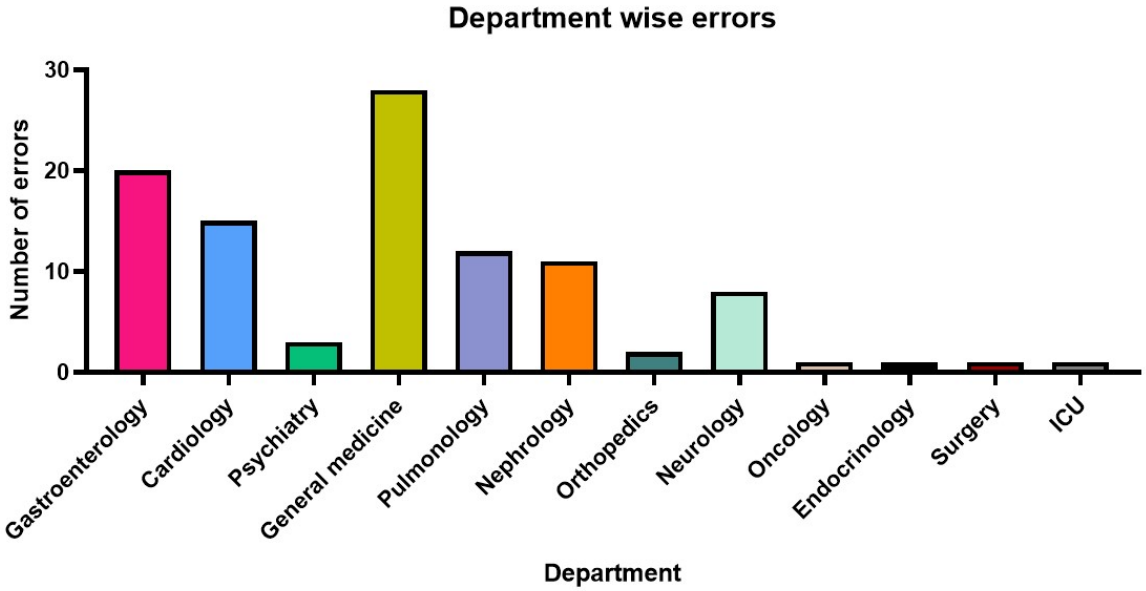

Figure 4: Department wise distribution of medication errors.

2. Distribution Based on Medication Use Phase

Medication errors were categorized according to the medication use process. The majority of errors occurred during Prescribing phase (45%) followed by transcribing (21%) and administration (21%). Fewer errors were noted in dispensing and monitoring phases.(**Table 7)**

Table 7 : Medication Use Phase

Medication Use Phase	No of patients (n=103)	Percentage
Prescribing	46	45
Transcribing	22	21
Monitoring	11	10.5
Administration	22	21
Dispensing	3	3

3. **Types of Medication Errors**

The most frequently observed medication errors was wrong dose errors (26%), followed by wrong drug errors (18%) and wrong frequency errors (13%). Drug duplication, wrong drug and dosing-related errors constituted a significant proportion of total errors.(**Table 8)**

Table 8: Types of medication errors.

Type of errors	No of patients (n=103)	Percentage (%)
Omission error	11	10.3
Wrong time error	11	10.3
Wrong frequency error	13	13
Wrong drug error	19	18
Wrong dose error	27	26
Wrong administration error	4	4
Monitoring error	7	6.4
Drug duplication error	11	10.3
Wrong dosage form error	1	1.3
Wrong duration error	1	1.3

4. **Severity of Medication Errors (NCCMERP Classification)**

Based on NCCMERP categorization, most errors belonged to Category B (29%) and C (20.87%)-(errors that did not cause harm or reached the patient but not result in harm resp.) A considerable number were in Category D (16.02%) and E (9.71%), requiring monitoring or intervention. Few cases progressed to Category F and above, indicating temporary harm requiring prolonged hospitalization.(**Figure 5)**

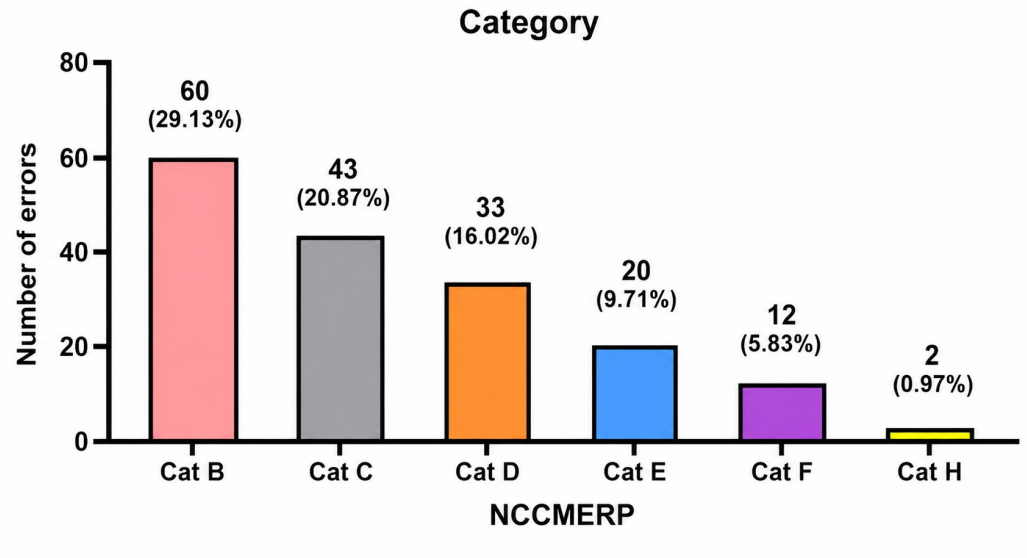

Figure 5: Severity of medication errors.

5. **Contributing Factors of Medication Errors**

The analysis of contributing factors revealed that medication charting errors were the leading cause of medication errors, accounting for 21% of cases, followed by lack of medication review (18%) and protocol nonadherence (14%). Polypharmacy (9%) and dose adjustment issues (7%) were also notable contributors. Factors such as incomplete clinical assessment, communication lapses, and poor medication reconciliation each contributed to errors (6%). (**Figure 6)**

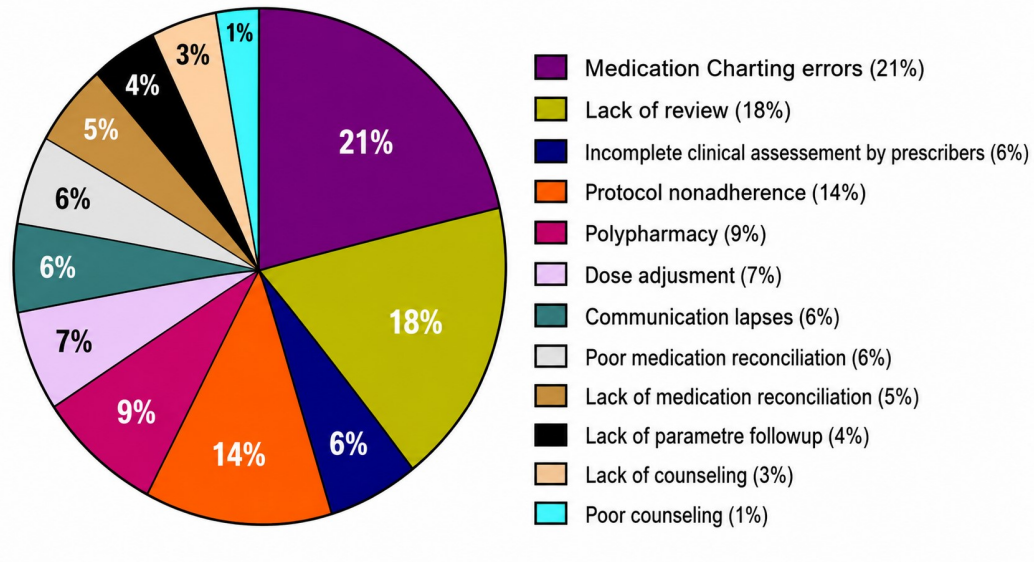

Figure 6: Predictors of medication errors.

6. Association analysis:

Association between categorical variables was assessed among error type vs department, error type vs medication use phase, error severity vs error type and error Severity vs medication use phase using the Chi-square test/Fisher's Exact Test (small expected frequencies)

Findings:

A statistically significant association was observed between error severity and error type, as well as between error severity and medication use phase, as determined by the Fisher's Exact Test ($p < 0.05$). (**Figure 7, Figure 8)**

Interpretation: A statistically significant association was observed between category and medication errors and category and medication error phase ($p < 0.05$)

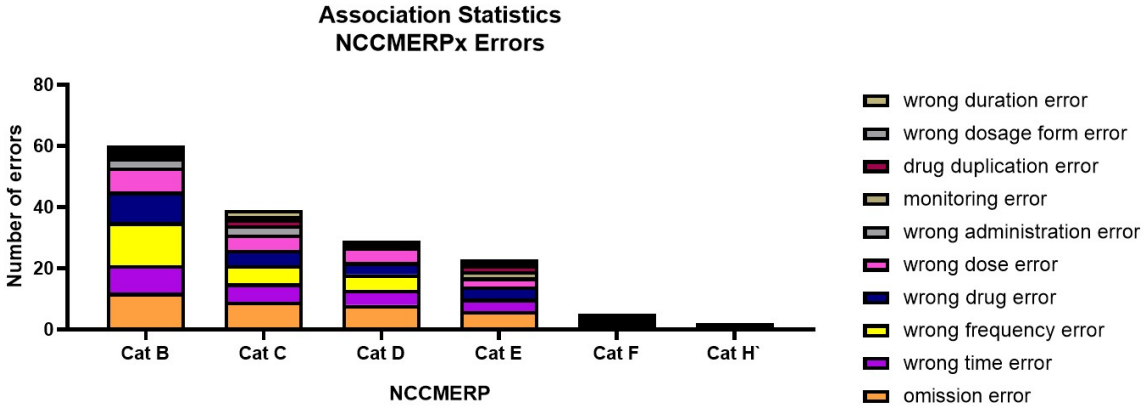

Figure 7: Association analysis (NCCMERP x Errors).Fisher's Exact Test was applied.There observed significance ($p < 0.05$).

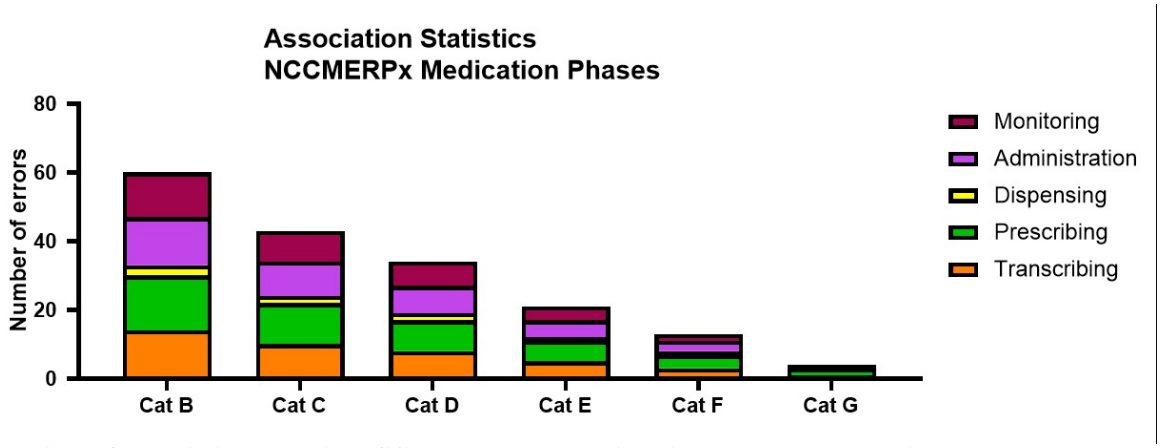

Figure 8 Association analysis (NCCMERP x Errors). Fisher's Exact Test was applied.There observed significance ($p < 0.05$).

7. Pharmacist Interventions

Pharmacist interventions were implemented to address identified medication-related problems, including dose adjustments, drug discontinuation, frequency modifications, monitoring recommendations, and the addition of omitted medications (**Table 9)**. Clinical pharmacist-led strategies such as medication reconciliation, clinical decision support alerts, and deprescribing interventions played a key role in optimizing medication therapy and improving patient safety.

Table 9: Pharmacist Interventions for Medication Errors

Corresponding Pharmacist Intervention	**Intervention Percentage (%)**
Addition of omitted medication	10.3
Timing schedule modification	10.3
Frequency adjustment	13.0
Drug discontinuation/substitution	18.0
Dose adjustment	26.0
Administration correction	4.0
Monitoring recommendation	6.8
Drug discontinuation/deprescribing	10.3
Dosage form modification	1.0

Duration adjustment	1.0

Most of the pharmacist recommendations were accepted by the treating clinicians, while a smaller proportion were partially accepted. The high acceptance rate reflects the value of collaborative practice between pharmacists and physicians in the management of geriatric patients.
As a result of these interventions, the majority of medication errors were successfully resolved, and several potential errors were intercepted before causing patient harm. These findings highlight the important role of clinical pharmacists in identifying medication-related issues, promoting appropriate medication use, and enhancing the overall quality and safety of patient care.

DISCUSSION

The present study highlights the significant burden of potentially inappropriate medications (PIMs), polypharmacy, and medication errors among hospitalized geriatric patients. More than half of the study population (53.8%) had at least one PIM, while 46.2% experienced one or more medication errors. These findings underscore the vulnerability of older adults to medication-related problems due to age-related physiological changes, multiple comorbidities, and the frequent use of multiple medications.

The majority of PIMs were identified in patients aged 71–80 years, suggesting that advancing age is associated with a higher risk of inappropriate prescribing. This may be attributed to increased disease burden, complex therapeutic regimens, and altered pharmacokinetic and pharmacodynamic responses in older adults. The higher prevalence of PIMs among males may reflect the greater number of male admissions during the study period rather than a gender-specific risk. The findings comparable with previous studies[12,15].

Polypharmacy was highly prevalent, with more than 90% of patients receiving five or more medications. Polypharmacy is a well-recognized risk factor for adverse drug reactions, drug–drug interactions, prescribing cascades, and medication non-adherence. The result was higher than that reported in similar studies[16,17,18].The high prevalence observed in this study likely reflects the need to manage multiple chronic conditions simultaneously. However, it also emphasizes the importance of regular medication review and deprescribing strategies to minimize unnecessary medication use.

Most participants (92.5%) had more than one pre-existing comorbidity, which is comparable to findings reported by Alsaad S M et al. in a tertiary care academic medical center in Saudi Arabia.[27] Hypertension was the most common comorbidity (61.66%), which was consistent with previous studies.[25]

Application of the AGS Beers Criteria for Prescription appropriateness revealed that nearly three-fourths (73.33%) of prescriptions contained at least one PIM. This prevalence was higher than that reported by Parveen Bansal et al. (2020) and who observed a PIM prevalence of 61.9% using the 2019 Beers Criteria [20]. NSAIDs and corticosteroids were the most frequently encountered PIMs. The frequent use of NSAIDs in older adults is concerning because of their association with gastrointestinal bleeding, renal impairment, and cardiovascular complications. Similarly, prolonged corticosteroid therapy may increase the risk of osteoporosis, hyperglycemia, immunosuppression, and other adverse outcomes. These findings indicate the need for careful risk–benefit assessment and consideration of safer therapeutic alternatives whenever possible.

The prescribing phase accounted for the highest proportion of medication errors, followed by transcribing and administration. This finding suggests that the initial stages of the medication-use process remain particularly vulnerable to errors. This observation is consistent with studies by Manias et al. (2020) and Assiri et al. (2018), which identified prescribing as the most error-prone stage of the medication-use process. Inadequate patient assessment, incomplete documentation, and failure to consider patient-specific factors such as renal function, comorbidities, and concurrent medications may contribute to prescribing errors[21,22] . Strengthening prescribing practices through evidence-based guidelines, computerized physician order entry systems, and clinical decision support tools may help reduce these errors.

Wrong dose errors emerged as the most common type of medication error, followed by wrong drug and wrong frequency errors. Dose-related errors are especially critical in geriatric patients because age-related changes in drug metabolism and elimination can significantly alter drug response. Similar patterns have been reported by Keers et al. (2013) and Alanazi et al. (2016), who identified dosing errors as a major contributor to medication-related harm in hospitalized patients [23,24].The occurrence of wrong drug and duplication errors further highlights the importance of medication reconciliation and comprehensive review of medication histories during transitions of care.

Most medication errors were categorized as NCC MERP Categories B and C, indicating that they were identified before causing harm or reached the patient without resulting in injury. Although this reflects effective detection mechanisms within the healthcare system, the presence of Category D, E, and F errors

demonstrates that some errors had the potential to adversely affect patient outcomes and required clinical intervention. Early identification and timely corrective measures are therefore essential to prevent progression to more severe harm.Comparable findings were reported by Alsulami et al. (2013) and Velo and Minuz (2009), where the majority of medication errors were associated with minimal or no patient harm [25,26].

Medication charting errors, lack of medication review, and protocol nonadherence were the leading contributors to medication errors. Similar system-related factors have been reported by Manias et al. (2020). These findings suggest that system-related factors play a substantial role in the occurrence of errors. Improving documentation practices, ensuring adherence to institutional protocols, and implementing structured medication review processes may significantly enhance medication safety [21]. Additionally, better communication among healthcare professionals and standardized handover procedures can reduce errors arising from incomplete information transfer.

Clinical pharmacist interventions played a crucial role in identifying and resolving medication-related problems. The high acceptance rate of pharmacist recommendations by clinicians demonstrates the value of collaborative multidisciplinary care. Interventions such as medication reconciliation, dose optimization, deprescribing, and monitoring recommendations not only resolved existing medication-related problems but also prevented potential harm. These findings support the integration of clinical pharmacists into routine geriatric care as an effective strategy for improving medication appropriateness and patient safety.

Recommendations

1. **Implement routine medication review** for all hospitalized geriatric patients, particularly those receiving five or more medications.
2. **Incorporate AGS Beers Criteria® screening** into clinical practice to facilitate early identification of potentially inappropriate medications.
3. **Strengthen medication reconciliation processes** during admission, transfer, and discharge to minimize prescribing and transcribing errors.
4. **Expand clinical pharmacist involvement** in multidisciplinary healthcare teams to optimize medication therapy and reduce medication-related problems.
5. **Utilize electronic prescribing systems and clinical decision support tools** to reduce dose-related and prescribing errors.
6. **Promote deprescribing initiatives** to reduce unnecessary medication use and the risks associated with polypharmacy.
7. **Establish continuous monitoring and reporting systems** for medication errors to identify trends and implement targeted quality improvement measures.
8. **Conduct regular training programs** for healthcare professionals on geriatric pharmacotherapy, medication safety, and error prevention.

CONCLUSION

The study highlights the high prevalence of polypharmacy, comorbidities, and potentially inappropriate medication use among geriatric patients in a tertiary care hospital setting. Application of the Beers Criteria identified a considerable proportion of prescriptions containing PIMs, with NSAIDs and corticosteroids being the most commonly implicated drug classes.

The study also highlights the significant burden of medication errors among geriatric patients. Prescribing and transcribing stages were identified as the most vulnerable points in the medication use process, with wrong dose, drug duplication, and frequency errors being the most common. Although most errors resulted in minimal harm, the presence of clinically significant errors emphasizes the need for improved medication safety practices.

The findings demonstrate the importance of regular medication review, adherence to validated prescribing criteria, accurate medication reconciliation, and close patient monitoring. In addition, the high acceptance of pharmacist-led interventions highlights the valuable role of clinical pharmacists in identifying and preventing medication errors.

Overall, a multidisciplinary and system-based approach involving physicians, pharmacists, nurses, and healthcare institutions is essential to enhance medication safety, reduce preventable harm, and improve the quality of care in geriatric patients.

Abbreviations:

ADR – Adverse Drug Reaction; **DRP** – Drug-Related Problem; **PIM** – Potentially Inappropriate Medication; **NCC MERP** – National Coordinating Council for Medication Error Reporting and Prevention; **WHO** – World Health Organization; **NSAIDs** – Non-Steroidal Anti-Inflammatory Drugs; **PPIs** – Proton Pump Inhibitors; **ICU** – Intensive Care Unit; **eGFR** – Estimated Glomerular Filtration Rate; **SD** – Standard Deviation; **SPSS** – Statistical Package for the Social Sciences.

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Conflicts of Interests
The authors have no conflicts of interest to declare

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Author Contribution
Soumya M K: Conceptualization, methodology, data collection, data analysis, and manuscript drafting. Dr. R. Margret Chandira : Supervision, validation, and critical review of the manuscript. Dr. Sujith S Nair: Data validation, manuscript editing and reviewing. All authors approved the final version for publication.

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