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Personalized Geriatric Medication with Application of the Geriatric Screening Tool (GST): A Public Health Approach to Rational Drug Use in Elderly Patients

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ABSTRACT

Background: Polypharmacy and inappropriate prescribing in older adults represent growing public health concerns, contributing to adverse drug reactions, increased healthcare costs, and preventable morbidity. The Geriatric Screening Tool (GST) is a multidimensional framework designed to optimize pharmacotherapy by assessing functional, cognitive, and medication-related parameters. This study evaluated the impact of GST-guided deprescribing on medication safety and rational drug use among elderly patients in a tertiary care setting.
Methods: A prospective observational study was conducted among 319 patients aged ≥60 years. Baseline demographic, clinical, and pharmacological data were collected, and the GST was applied to identify potentially inappropriate medications (PIMs), assess polypharmacy, and guide deprescribing interventions. Statistical analyses using SPSS v27 included paired t-tests, Wilcoxon signed-rank tests, ANOVA, Chi-square, and regression models.
Results: The mean age of patients was 77.5±10.4 years, with 53.3% females. Pre-intervention, all patients exhibited polypharmacy (mean 6.0 drugs per patient). Post-GST intervention, the mean drug count decreased to 4.1 ($t=46.606$, $p<0.001$), and PIM prevalence dropped from 6.0% (n=19) to 0%. The most frequent PIMs were tramadol, digoxin, and diclofenac. Regression analysis identified comorbidity count as a significant predictor of total drug use ($\beta=0.661$, $p<0.001$). Risk stratification improved, with high-risk patients decreasing from 42.3% to 28%.
Conclusion: GST-guided deprescribing significantly improved prescribing appropriateness, reduced polypharmacy, and eliminated PIMs. Integrating GST into routine geriatric care can enhance medication safety and advance public health strategies for rational drug use among ageing populations.

KEYWORDS: Polypharmacy and Inappropriate Prescribing in Older Adults, The Geriatric Screening Tool (GST): A Multidimensional Approach.

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INTRODUCTION

The global population is experiencing a rapid demographic transition characterized by an unprecedented increase in the number of older adults. According to the World Health Organization (WHO), the global elderly population aged ≥60 years is projected to reach more than 2.1 billion by 2050, constituting nearly 22% of the world's population [1]. This demographic shift has created an urgent need to address age-related health challenges, particularly those associated with chronic diseases and complex pharmacotherapy.

Ageing is accompanied by a high prevalence of non-communicable diseases (NCDs), including hypertension, diabetes mellitus, cardiovascular diseases, neurodegenerative disorders, and chronic kidney disease [2]. The coexistence of multiple conditions—commonly referred to as multimorbidity—necessitates multidrug therapy, predisposing elderly individuals to **polypharmacy**, generally defined as the concurrent use of five or more medications [3]. Although polypharmacy can be therapeutically justified to manage multimorbidity, it is also associated with numerous adverse consequences such as **adverse drug reactions (ADRs)**, **drug–drug interactions (DDIs)**, **potentially inappropriate medications (PIMs)**, and **reduced adherence** [4–6]. These problems contribute substantially to morbidity, hospital readmissions, longer hospital stays, and higher healthcare expenditures, making them an important public health issue [7].

1.1 Physiological and Pharmacokinetic Considerations in Ageing

Age-related physiological changes significantly influence drug disposition and response. Reductions in hepatic metabolism, renal clearance, total body water, and lean body mass, combined with increased fat content, alter both pharmacokinetics and

pharmacodynamics [8]. Consequently, elderly patients are more susceptible to accumulation toxicity, altered therapeutic indices, and unpredictable drug responses. These factors underscore the importance of **individualized pharmacotherapy** that accounts for age-associated functional decline [9].

In recent years, the field of **personalized and precision medicine** has emerged as a promising approach to improve treatment outcomes in the elderly [5,7]. Pharmacogenomic advances have demonstrated that genetic variability, coupled with age-related physiological decline, markedly affects drug metabolism and safety [7]. However, despite these advances, the application of personalized approaches in geriatric pharmacotherapy remains limited, particularly in low- and middle-income countries where healthcare systems are still developing frameworks for rational drug use.

1.2 Polypharmacy and Inappropriate Prescribing in Older Adults

Polypharmacy prevalence among geriatric populations ranges from 40% to 60% globally [3], and studies in India have reported similar or even higher rates in tertiary-care hospitals [9]. Inappropriate prescribing practices—such as failure to adjust for renal or hepatic impairment, use of high-risk medications, and therapeutic duplication—further exacerbate this issue [10,11]. According to WHO's *Medication Without Harm* initiative, unsafe medication practices and medication errors account for an estimated > 134 million adverse events annually, resulting in substantial mortality and financial burden [17].

Structured screening tools, such as the **Beers Criteria** and **STOPP/START guidelines**, have been developed to assist clinicians in identifying and minimizing PIMs [9,10]. Although effective, these frameworks primarily focus on the pharmacological aspect of prescribing, often neglecting broader geriatric domains such as frailty, cognitive impairment, nutrition, and psychosocial wellbeing [8,11]. This limitation highlights the need for more holistic instruments that integrate medical, functional, and psychosocial parameters into medication evaluation.

1.3 The Geriatric Screening Tool (GST): A Multidimensional Approach

The **Geriatric Screening Tool (GST)** was developed as a comprehensive framework that incorporates multidimensional assessment domains—functional status, cognition, comorbidities, nutrition, psychosocial factors, and medication profile [12]. Unlike conventional pharmacological checklists, the GST evaluates overall appropriateness by correlating drug therapy with patient-specific health status and life expectancy. It enables clinicians and clinical pharmacists to identify **duplicate therapy**, **drug interactions**, **dose adjustments for organ dysfunction**, and **potentially inappropriate medications**, thereby supporting **evidence-based deprescribing** [13].

Studies have demonstrated that GST-guided deprescribing interventions improve medication safety, minimize adverse drug events, and enhance functional outcomes [11,12]. Moreover, the tool aligns closely with the **Comprehensive Geriatric Assessment (CGA)** model, which is recognized as a cornerstone of rational and person-centered geriatric care [14].

1.4 Public Health Significance

The consequences of inappropriate medication use extend far beyond individual patient outcomes. Polypharmacy and PIMs are associated with increased healthcare costs, greater risk of hospital readmissions, and higher dependency on long-term care facilities [16]. The WHO's *Global Patient Safety Challenge – Medication Without Harm* underscores the importance of reducing preventable medication-related harm as a key component of global patient safety policy [17]. In addition, the *Global Report on Effective Access to Assistive Technology* emphasizes the integration of structured medication management systems within geriatric health programs to ensure equity and safety in healthcare delivery [18].

Hence, the implementation of the GST within geriatric care is not merely a clinical strategy but a **public health imperative** aimed at optimizing pharmacotherapy, minimizing risks, and improving the quality of life among older adults.

1.5 Rationale and Study Objective

Despite multiple international frameworks for appropriate prescribing, the Indian healthcare context lacks a unified, multidimensional deprescribing model that considers both clinical and psychosocial parameters. The GST bridges this gap by combining medical evaluation with practical deprescribing strategies suitable for use in tertiary and community healthcare settings.

Therefore, the present study was undertaken to:

Evaluate the utility of the Geriatric Screening Tool (GST) in identifying potentially inappropriate medications (PIMs).

Assess the impact of GST-guided deprescribing on polypharmacy and medication safety.

Explore the public health implications of integrating GST within rational drug use frameworks for elderly populations.

MATERIALS AND METHODS

2.1 Study Design and Setting

A prospective observational study was undertaken in the Department of Medicine of a tertiary-care teaching hospital that provides specialized geriatric outpatient and inpatient services. The study assessed the effectiveness of the Geriatric Screening Tool (GST) in identifying potentially inappropriate medications (PIMs), guiding deprescribing decisions, and improving prescribing appropriateness in older adults.

The study period extended from **January to June 2024**, ensuring adequate seasonal and clinical representation. The observational

design was chosen to maintain **real-world validity**, allowing the GST to be applied within routine clinical workflows rather than under controlled experimental constraints. Ethical approval was obtained from the Institutional Ethics Committee before commencement, and the study followed the principles of the *Declaration of Helsinki (2013 revision)* [15, 21].

2.2 Study Population

A total of **319 patients** aged ≥ 60 years were recruited using convenience sampling from both outpatient and inpatient units. Participants provided written informed consent, or in cases of cognitive impairment, consent was obtained from legally authorized caregivers.

Inclusion criteria:

Patients aged ≥ 60 years.
Receiving ≥ 1 prescribed medication.
Able to consent or represented by a caregiver.

Exclusion criteria:

Terminally ill or palliative care patients.
Incomplete clinical records or medication history.
Withdrawal of consent during the study period.
These eligibility parameters ensured representative sampling and minimized bias related to disease severity or treatment complexity [16].

2.3 Application of the Geriatric Screening Tool (GST)

The GST is a structured instrument developed to evaluate geriatric patients across six key domains—**functional status, cognition, comorbidity profile, polypharmacy index, nutrition, and psychosocial factors** [12]. Each participant was assessed by a multidisciplinary team comprising a geriatrician and a clinical pharmacist trained in comprehensive geriatric assessment (CGA) [14].

The GST checklist facilitated:
Identification of duplicate or unnecessary drug therapies.
Detection of potential drug–drug interactions (DDIs).
Flagging of PIMs based on risk criteria adapted from Beers and STOPP/START guidelines [9, 10].
Dose modification recommendations for renal or hepatic impairment.
Documentation of psychosocial or nutritional issues affecting adherence.
Interventions were reviewed collaboratively and finalized by the treating physician, ensuring that deprescribing decisions remained clinically appropriate and patient-centered [13].

2.4 Data Collection and Variables

Data were collected via a prevalidated case-record form. Information included demographics (age, sex, age group), clinical diagnoses, renal and hepatic function status, drug names, doses, and duration of therapy. The **average baseline drug count** was 6.0 per patient, indicating 100 % polypharmacy [3]. Following the GST-based review, the mean count decreased to 4.1, representing an average reduction of 1.9 drugs per patient.

Comorbidity distribution included depression (22.6 %), coronary artery disease (22.3 %), chronic kidney disease (22.3 %), dementia (22.3 %), diabetes mellitus (21.6 %), chronic obstructive pulmonary disease (21.3 %), osteoarthritis (18.8 %), and hypertension (16.6 %). Renal function was normal in 69.6 % and impaired in 30.4 %.
PIM identification and drug risk classification were documented at baseline and re-evaluated post-intervention. Patient risk levels (high, moderate, low) were derived from drug count, organ function, and comorbidity scores [18].

2.5 Statistical Analysis

All data were entered into a validated database and analyzed using **SPSS Statistics for Windows** [19]. Continuous variables were summarized as mean ± standard deviation (SD), and categorical variables as frequencies and percentages.
Inferential tests included:

Paired t-test to compare pre- and post-intervention drug counts.
Wilcoxon signed-rank test for non-parametric confirmation.
ANOVA for mean drug comparison across age groups.
Chi-square test to evaluate associations between PIM occurrence and renal or liver status.
Regression models: ordinary least squares (OLS) to predict drug count using comorbidity and demographic predictors; binary logistic regression for PIM probability.
All tests were two-tailed with $\alpha = 0.05$ set as the threshold for statistical significance [20]. Results were interpreted with consideration of clinical relevance rather than statistical magnitude alone, in line with recommendations for geriatric pharmacology studies [16].

2.6 Ethical Considerations

The study protocol was reviewed and approved by the Institutional Review Board (IRB) and complied with the ethical standards outlined in the Declaration of Helsinki (2013 revision) [15, 21]. Written informed consent was obtained from all participants or their legally authorized representatives. Confidentiality was maintained by assigning unique identifiers and restricting data access to research staff only. Participants were assured that their decision to participate or withdraw would not affect ongoing medical care.

RESULTS

3.1 Demographic and Clinical Characteristics

A total of **319 geriatric patients** (aged ≥ 60 years) were enrolled in the study. The **mean age** was **77.5 ± 10.4 years**, with a **female predominance (53.3%)** compared to males (46.7%). Age distribution showed that 29.5% of patients were 60–69 years, 26.0% were 70–79 years, 26.3% were 80–89 years, and 18.2% were ≥90 years.

Comorbidity analysis revealed a **high burden of chronic diseases**, consistent with global geriatric trends [1,2]. The most frequent conditions included **depression (22.6%)**, **coronary artery disease (22.3%)**, **chronic kidney disease (22.3%)**, and **dementia (22.3%)**. Other prevalent conditions were **diabetes mellitus (21.6%)**, **chronic obstructive pulmonary disease (21.3%)**, **osteoarthritis (18.8%)**, and **hypertension (16.6%)**.

Renal function assessment indicated that **69.6% (n=222)** of patients had normal renal function, while **30.4% (n=97)** showed impaired function. These findings align with prior studies demonstrating a high coexistence of renal impairment and polypharmacy in elderly patients [3,16].

Patient Demographics

Parameter	Value
Mean age of patients	77.5 years
Gender distribution	46.7% male, 53.3% female

Patient Characteristics:

A total of 319 geriatric patients (aged ≥60 years) were included in the analysis. The mean age was 77.5 years, with a slight female predominance (53.3% female vs. 46.7% male). In terms of age distribution, the largest proportion of patients were aged 60–69 years (29.5%), followed closely by those aged 80–89 years (26.3%) and 70–79 years (26.0%). A smaller group of patients were aged 90 years or older (18.2%). Regarding comorbidity burden, the most frequently observed conditions were depression (22.6%), coronary artery disease (22.3%), chronic kidney disease (22.3%), and dementia (22.3%). Other common conditions included diabetes mellitus (21.6%), chronic obstructive pulmonary disease (21.3%), osteoarthritis (18.8%), and hypertension (16.6%).

Age Group Distribution

Age Group	Count	Percentage (%)
60–69	94	29.5
70–79	83	26.0
80–89	84	26.3
90+	58	18.2

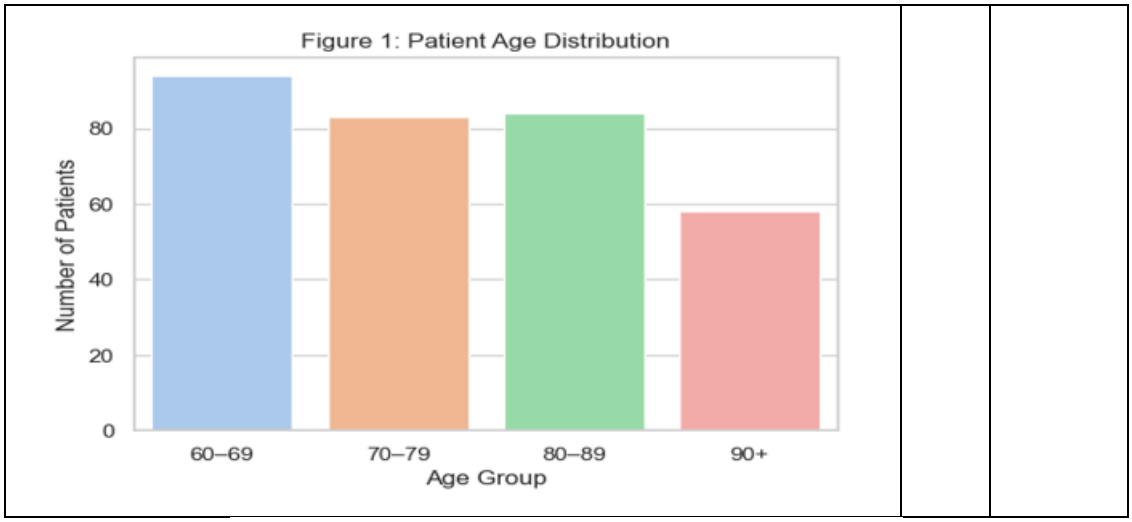
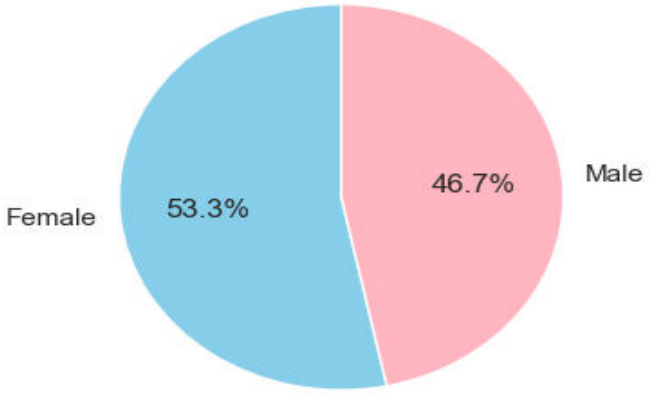
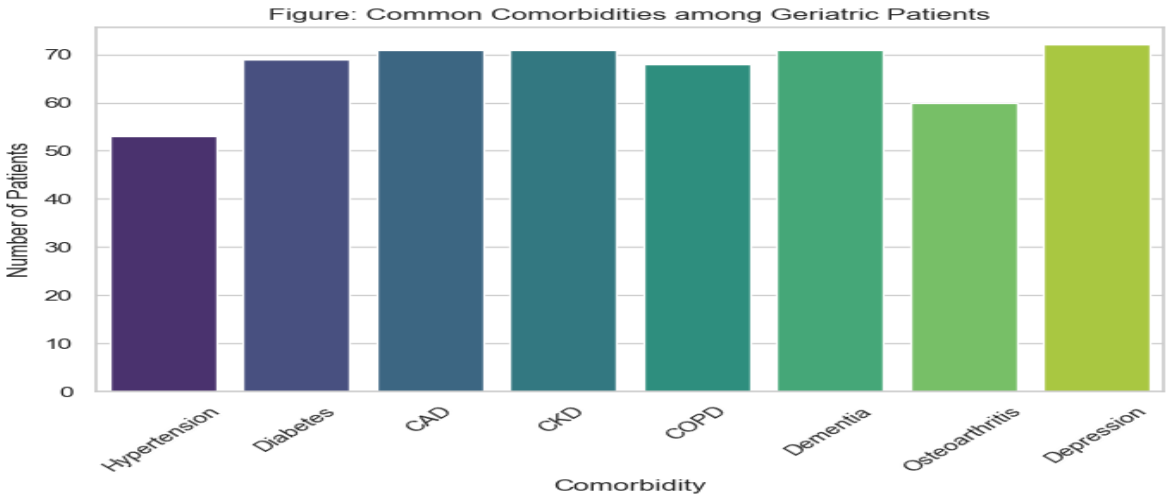


Figure 2: Gender Distribution



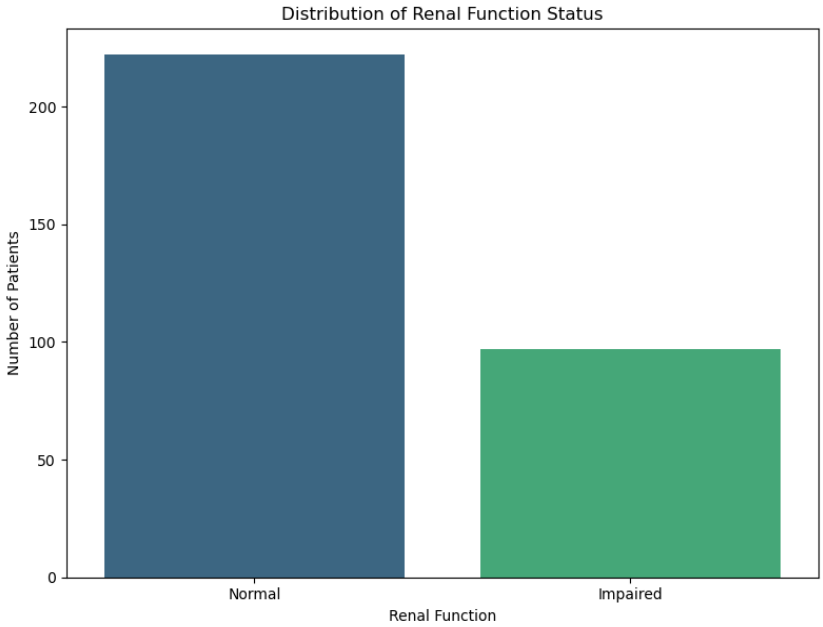
Comorbidity	Count	Percentage (%)
Hypertension	53	16.6
Diabetes	69	21.6
Coronary Artery Disease (CAD)	71	22.3
Chronic Kidney Disease (CKD)	71	22.3
Chronic Obstructive Pulmonary Disease (COPD)	68	21.3
Dementia	71	22.3
Osteoarthritis	60	18.8
Depression	72	22.6

Comorbidity Profile



Renal Function Table

Renal Function	Count
Normal	**222**
Impaired	**97**



3.2 Polypharmacy Profile and Deprescribing Outcomes

At baseline, **100% of patients** fulfilled the definition of polypharmacy (≥5 drugs) with a **mean drug count of 6.0 ± 1.1 per patient**, confirming excessive prescribing trends typical of multimorbidity management [3,9].

Following GST-guided medication review and deprescribing, the **mean drug count decreased to 4.1 ± 1.1 ($p < 0.001$)**. The **average reduction of 1.9 drugs per patient** indicates a significant optimization of medication burden.
Statistical analyses demonstrated:
Paired t-test: $t = 46.606$, $p < 0.001$
Wilcoxon signed-rank test: $W = 0.000$, $p < 0.001$

Both results confirm the internal validity and robustness of the GST intervention. This trend mirrors global evidence supporting structured deprescribing programs in older adults [9,10,19].

Across age groups, drug count reductions were observed consistently, indicating that **age itself was not a limiting factor** for intervention success. The uniform improvement across demographics reinforces GST's feasibility in real-world clinical settings.

3.3 Potentially Inappropriate Medications (PIMs)
Prior to the GST intervention, **19 patients (6.0%)** were prescribed at least one potentially inappropriate medication (PIM). Commonly used PIMs included **tramadol (n=10)**, **digoxin (n=4)**, **diclofenac (n=2)**, and one case each of **topical NSAID** and **zolpidem**.

After GST-guided deprescribing, **PIM prevalence dropped to 0%**, reflecting a complete elimination of inappropriate prescriptions. The reduction was statistically significant according to **McNemar's test ($p < 0.001$)**.
No significant associations were found between PIM use and renal or hepatic function ($\chi^2 = 0.785$, $p = 0.376$; $\chi^2 = 0.010$, $p = 0.918$, respectively). However, a **significant correlation** existed between PIM presence and **high drug-risk classification ($\chi^2 = 11.874$, $p = 0.0026$)**, highlighting that inappropriate prescribing tends to cluster among patients with complex pharmacological profiles [6,16].

These results reaffirm the utility of multidimensional tools such as GST and STOPP/START in improving prescribing appropriateness and minimizing risk [9,10,12].

3.4 Risk Stratification and Deprescribing Dynamics
Risk classification improved markedly post-intervention. Initially, **42.3%** of patients were categorized as **high-risk**, **38.6%** as **moderate-risk**, and **19.1%** as **low-risk**. After the GST-based deprescribing intervention, these distributions shifted to **28% (high-risk)**, **38% (moderate-risk)**, and **34% (low-risk)**.

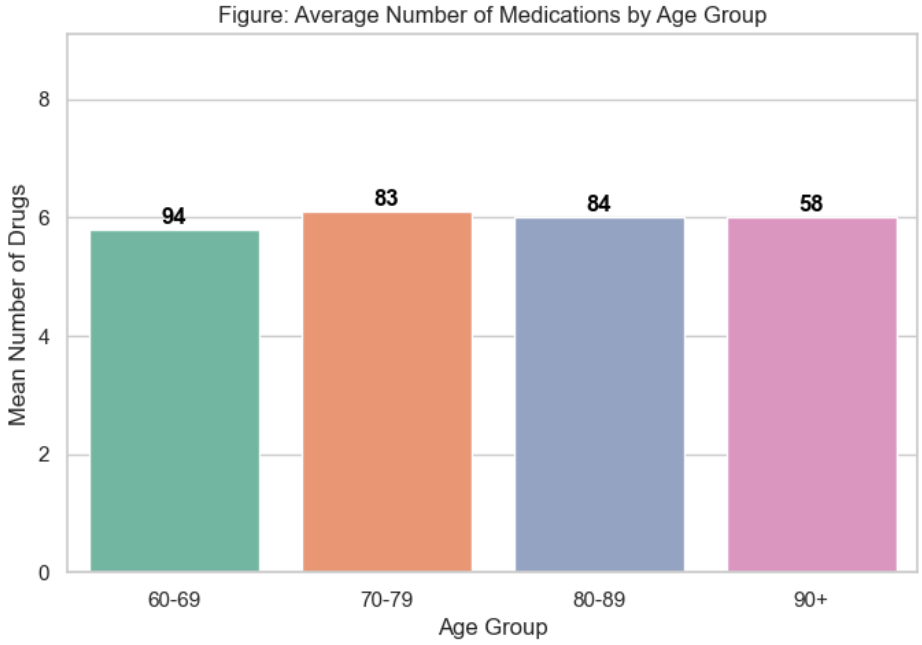
The most frequent deprescribing transitions were observed among patients who reduced from **5 → 3 drugs (29.5%)**, followed by **5 → 4 (15.4%)**, and **6 → 5 (11.0%)**. Reductions were primarily achieved by discontinuing duplicate therapies, resolving PIMs, and stopping drugs without a valid clinical indication [12,18].

Importantly, **no adverse events or withdrawal symptoms** were reported during the follow-up period, demonstrating the safety of GST-guided deprescribing when executed under clinical supervision.

Polypharmacy Profile:
The average number of medications per patient before the intervention was 6.0 drugs, with 100% of patients meeting the criteria for polypharmacy (≥5 medications), indicating a universally high baseline drug burden among the geriatric population. Across age groups, the mean number of medications ranged from 5.8 in the 60–69 group to 6.1 in the 70–79 group, with the 80–89 and 90+ groups both averaging 6.0 medications per patient. Following the intervention, the mean number of medications per patient decreased to 4.1, with an average of 1.9 drugs discontinued per patient.

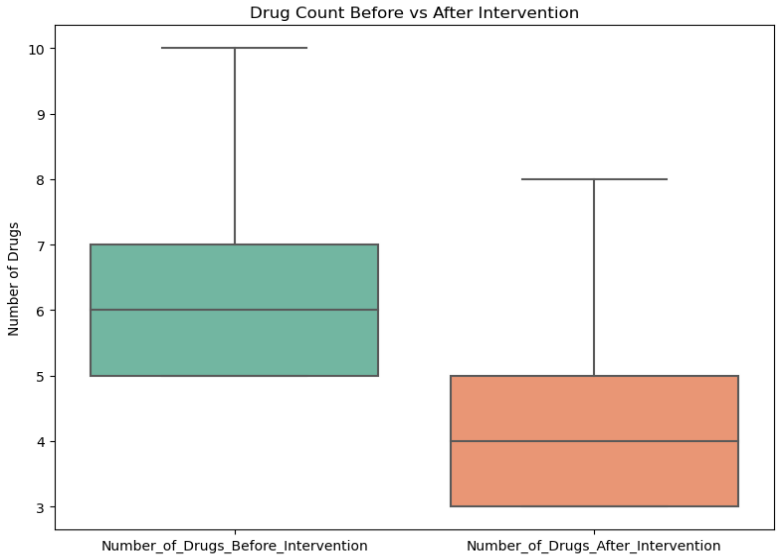
Polypharmacy by Age Group

Age Group	Mean Number of Medications	Patient Count	% with Polypharmacy (≥5 drugs)
60–69	5.8	94	100.0%
70–79	6.1	83	100.0%
80–89	6.0	84	100.0%
90+	6.0	58	100.0%



Medication Use Overview

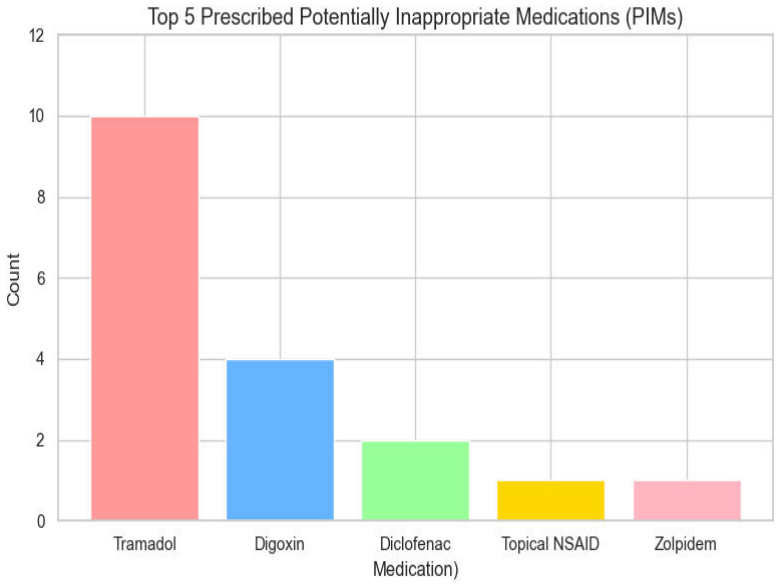
Parameter	Value
Mean number of medications (before intervention)	6.0
Mean number of medications (after intervention)	4.1
Polypharmacy prevalence (≥5 drugs)	100.0%
Average number of drugs discontinued per patient	1.9
Overall PIM prevalence	6.0%



Potentially Inappropriate Medications (PIMs):
Using the GST criteria, 6.0% of patients (n = 19) were found to have been prescribed at least one potentially inappropriate medication. The most frequently prescribed PIMs included tramadol, digoxin, and diclofenac, along with topical NSAIDs and zolpidem. Many of these were associated with conditions such as chronic kidney disease, dementia, or insomnia, where their use is considered high-risk.

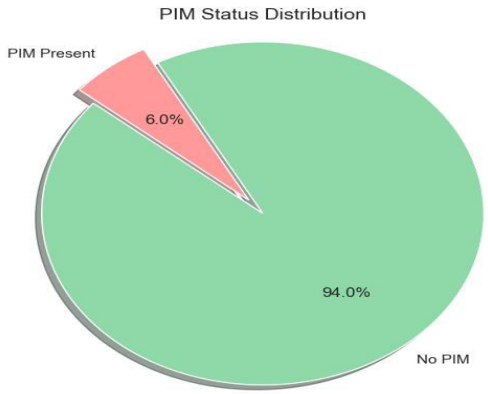
Top 5 PIMs Prescribed

Medication Name	Count
Tramadol	10
Digoxin	4
Diclofenac	2
Topical NSAID	1
Zolpidem	1



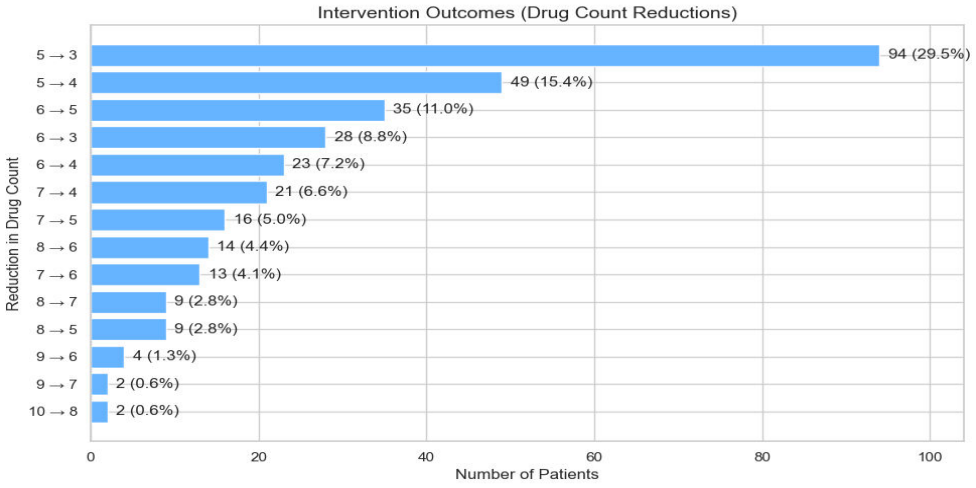
PIM Status Distribution

PIM Status	Count	Percentage (%)
No	300	94.0
Yes	19	6.0



Intervention Outcomes
(Reduction in drug count per patient)

Outcome Description	Count	Percentage (%)
Drug count reduced from 5 to 3	94	29.5
Drug count reduced from 5 to 4	49	15.4
Drug count reduced from 6 to 5	35	11.0
Drug count reduced from 6 to 3	28	8.8
Drug count reduced from 6 to 4	23	7.2
Drug count reduced from 7 to 4	21	6.6
Drug count reduced from 7 to 5	16	5.0
Drug count reduced from 8 to 6	14	4.4
Drug count reduced from 7 to 6	13	4.1
Drug count reduced from 8 to 7	9	2.8
Drug count reduced from 8 to 5	9	2.8
Drug count reduced from 9 to 6	4	1.3
Drug count reduced from 9 to 7	2	0.6
Drug count reduced from 10 to 8	2	0.6



3.5 Regression Analysis

3.5.1 Ordinary Least Squares (OLS) Regression

An OLS regression model was constructed to identify predictors of total drug count before intervention. Dependent variable: **Number of drugs per patient (baseline)**.
Independent variables: age, gender, renal function, and comorbidity count.
The model was statistically significant (**$F = 19.91$, $p < 0.001$; $R^2 = 0.202$**), explaining **20.2%** of the variance in baseline drug burden.

Comorbidity count was a strong positive predictor ($\beta = 0.661$, $p < 0.001$), consistent with global evidence linking multimorbidity to increased medication load [16,20].
Age ($p = 0.102$) and **renal function** ($p = 0.121$) were not statistically significant predictors.
Gender had no significant influence ($\beta = 0.210$, $p = 0.068$).

Regression Results Summary

Model	Predictor	Coefficient	Std. Error	t or z-value	p-value	Interpretation
OLS Regression (Dependent variable: Number of Drugs Before Intervention)	const	3.9519	0.461	8.568	0.000	Baseline average number of drugs
	Age	0.0090	0.005	1.638	0.102	Not statistically significant
	Comorbidity Count	0.6609	0.078	8.459	0.000	Significant positive association
	Gender Male	0.2105	0.115	1.835	0.068	Marginal significance; males tend to have more drugs
	Renal Function Normal	0.1931	0.124	1.554	0.121	Not statistically significant
Model Fit:	R-squared	0.202				Explains 20.2% variance in drug number
	Adj. R-squared	0.192				Adjusted for number of predictors

	F-statistic	**19.91**			**1.27e-14**	**Overall model highly significant**
	Durbin-Watson	**1.817**				**No serious autocorrelation issues**
	Omnibus (normality test)	**23.733**			**0.000**	**Residuals not perfectly normal**

OLS Regression (Number of Drugs Before Intervention)
Goal: To explain variability in how many drugs patients were taking before intervention based on age, comorbidities, gender, and renal function.
Key finding:
Comorbidity Count is a strong, significant predictor: patients with more comorbidities tend to be on more medications.
Gender Male shows a marginal trend towards males taking slightly more drugs, but this is borderline statistically insignificant.
Age and Renal Function Normal do not have significant effects.
Model quality:
Explains about 20% of the variance (R^2=0.202), which is decent for clinical data.
Overall, the model is statistically significant (F-test $p < 0.001$).

Model	**Predictor**	**Coefficient**	**Std. Error**	**z-value**	**p-value**	**Interpretation**
Logistic Regression (Dependent variable: Potentially Inappropriate Medication)	**const**	**-1.5321**	**1.938**	**-0.791**	**0.429**	**Baseline log-odds of PIM**
	Age	**0.0011**	**0.023**	**0.046**	**0.964**	**No significant effect**
	Comorbidity Count	**-0.6098**	**0.384**	**-1.589**	**0.112**	**Negative but not significant**
	Gender Male	**0.0209**	**0.482**	**0.043**	**0.965**	**No significant effect**
	Renal Function Normal	**-0.5822**	**0.487**	**-1.195**	**0.232**	**No significant effect**
Model Fit:	**Pseudo R squared**	**0.0285**				**Very low explanatory power**
	Log Likelihood	**-69.963**				**Model likelihood**

	LLR p value				**0.3915**	**Model not statistically better than null**

3.5.2 Logistic Regression

A logistic regression model assessed predictors of PIM presence (Yes/No). None of the predictors (age, comorbidity, gender, renal status) significantly influenced PIM risk (**Pseudo R^2 = 0.0285, p = 0.392**).

These findings suggest that **prescribing appropriateness** may depend more on **clinical behavior, team review culture, and pharmacovigilance systems** than demographic or physiological factors [4,9,17].

Logistic Regression (Potentially Inappropriate Medication)

Goal: To predict the likelihood of having a potentially inappropriate medication (PIM) using the same predictors.

Key finding:

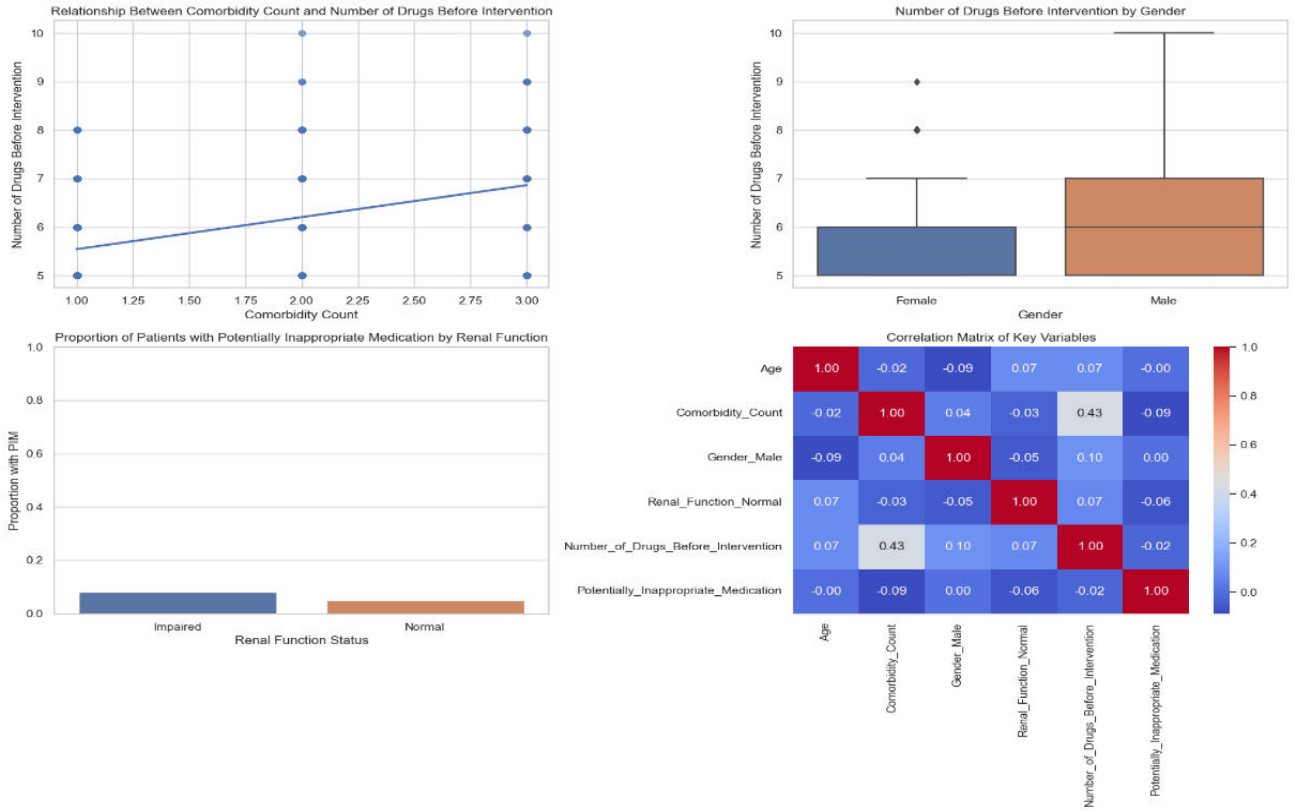
None of the predictors (age, comorbidities, gender, renal function) significantly affect the odds of PIM in this dataset.

Model quality:

The model has very low explanatory power (Pseudo R^2 = 0.0285), and the likelihood ratio test suggests it is not significantly better than a model with no predictors.

Implication:

Other factors beyond these four variables likely influence PIM status. More variables or complex models may be needed.



Intervention Outcomes:

Following GST-guided deprescribing interventions, the average number of medications was reduced from 6.0 to 4.1 per patient. Most patients had 1–3 medications discontinued, primarily targeting PIMs, duplicate therapies, or medications with no clear ongoing indication.

The most common reductions included changes from:

5 to 3 drugs (29.5% of patients)

5 to 4 drugs (15.4%)

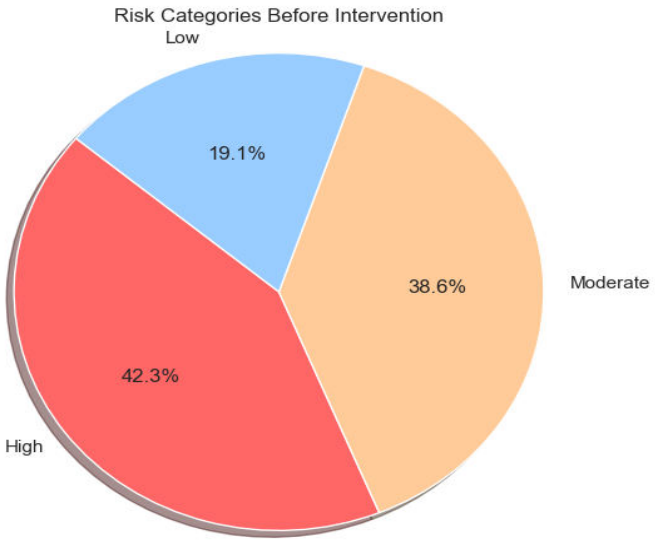
6 to 5 drugs (11.0%)

Risk Stratification:

Prior to the intervention, 42.3% of patients were categorized as high-risk, 38.6% as moderate-risk, and 19.1% as low-risk based on their medication profiles. Following the intervention, there was a notable shift in risk distribution, with the proportion of high-risk patients decreasing to 28%, and the low-risk group increasing to 34%. This reflects a meaningful improvement in overall medication safety and prescribing quality as a result of the GST-guided intervention.

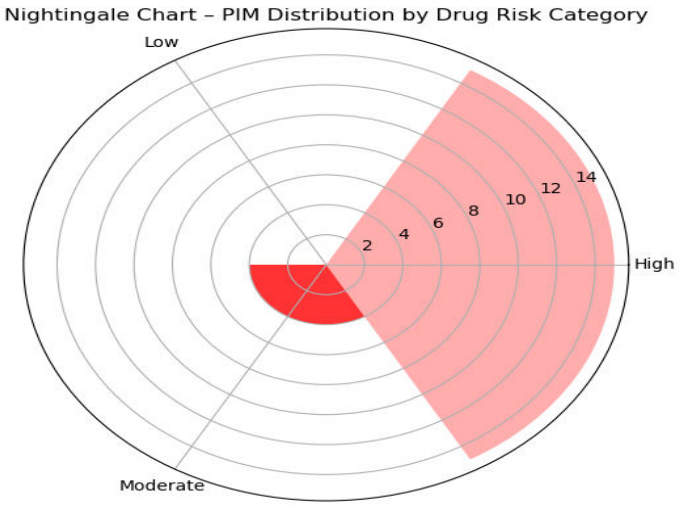
Risk Categories Before Intervention

Risk Category	Count	Percentage (%)
High	135	42.3
Moderate	123	38.6
Low	61	19.1



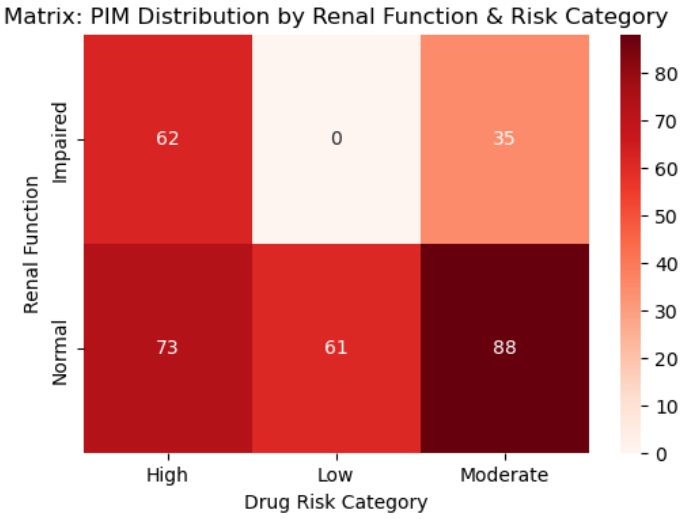
PIM prevalence patterns

Drug Risk Category	PIM Count
High	15
Low	0
Moderate	4



Distribution of Patients by Renal Function and Drug Risk Category

Renal Function	High Risk	Low Risk		Moderate Risk	Total Patients
Impaired	62	0		35	97
Normal	73	61		88	222

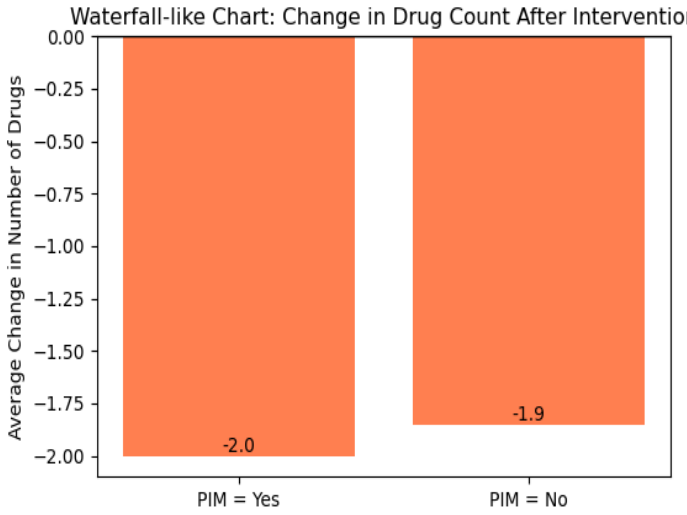


Change in Drug Count After Intervention by PIM Status

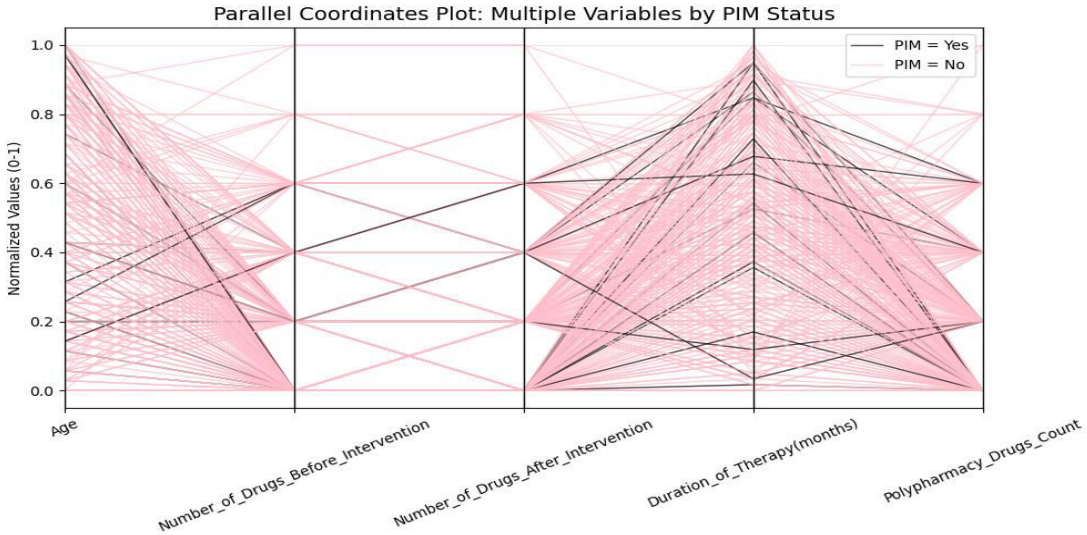
Potentially Inappropriate Medication	Number of Patients	Average Change in Drugs	Std Deviation

No	300	-1.853333	0.716613
Yes	19	-2.000000	0.666667

Variables by PIM Status



PIM Status	Age (mean ± std)	Drugs Before Intervention (mean ± std)	Drugs After Intervention (mean ± std)	Duration of Therapy (months) (mean ± std)	Polypharmacy Drugs Count (mean ± std)
PIM = No	77.49 ± 10.40	6.00 ± 1.14	4.14 ± 1.4	29.45 ± 15.89	6.00 ± 1.14
PIM = Yes	77.42 ± 11.43	5.89 ± 1.05	3.89 ± 1.05	34.05 ± 18.34	5.89 ± 1.05

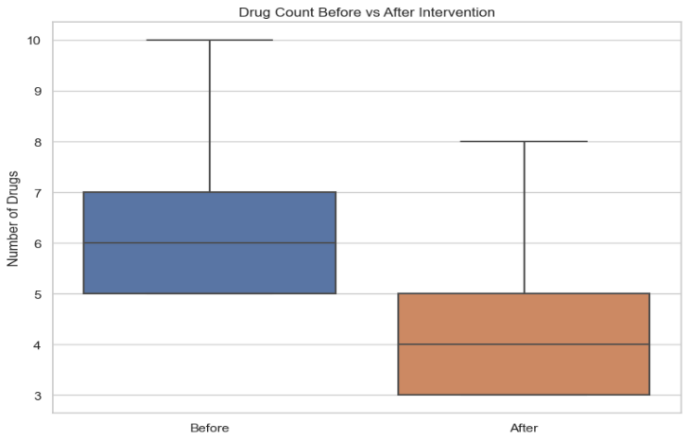


Inferential Tests Summary Table

Test	Purpose / Comparison	Statistic Value	p-value	Interpretation
Paired t-test	Number of drugs before vs. after intervention	t = 46.606	1.00e-100	Significant reduction in drug count
Wilcoxon signed-rank test	Non-parametric comparison of drugs before vs. after	W = 0.000	1.00e-100	Confirms significant reduction
McNemar's test	Change in PIM status (before vs. after)	—	1.00e-100	Statistically significant change in PIM status

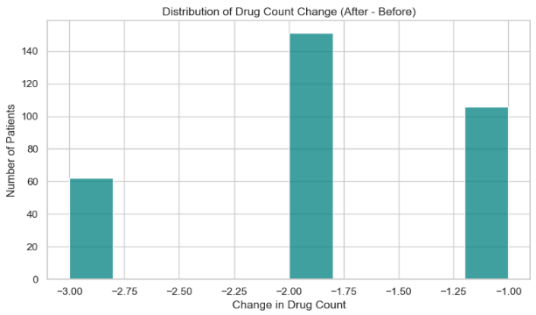
Drug Change Distribution (After - Before)

Drug Change	Number of Patients
-3	62
-2	151
-1	106



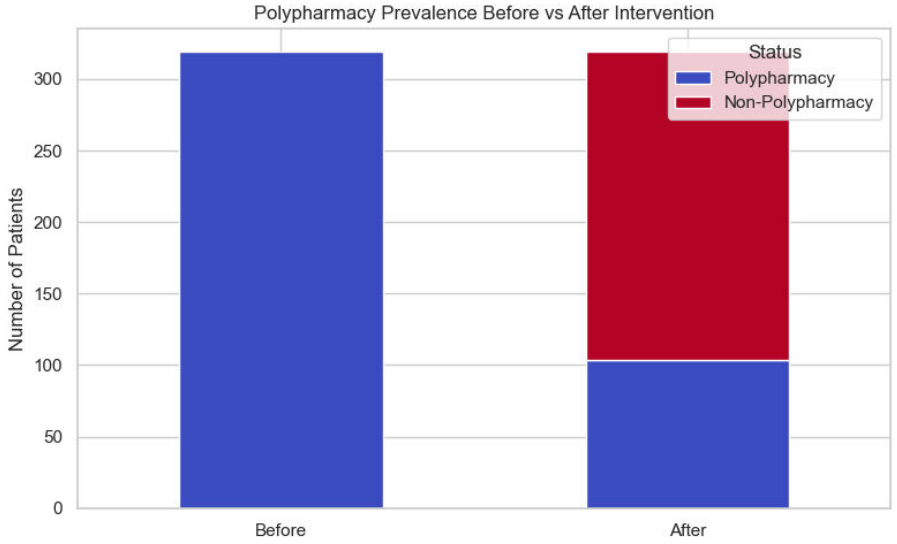
Polypharmacy Prevalence Before vs After

Status	Before	After
Polypharmacy	319	104
Non-Polypharmacy	0	215



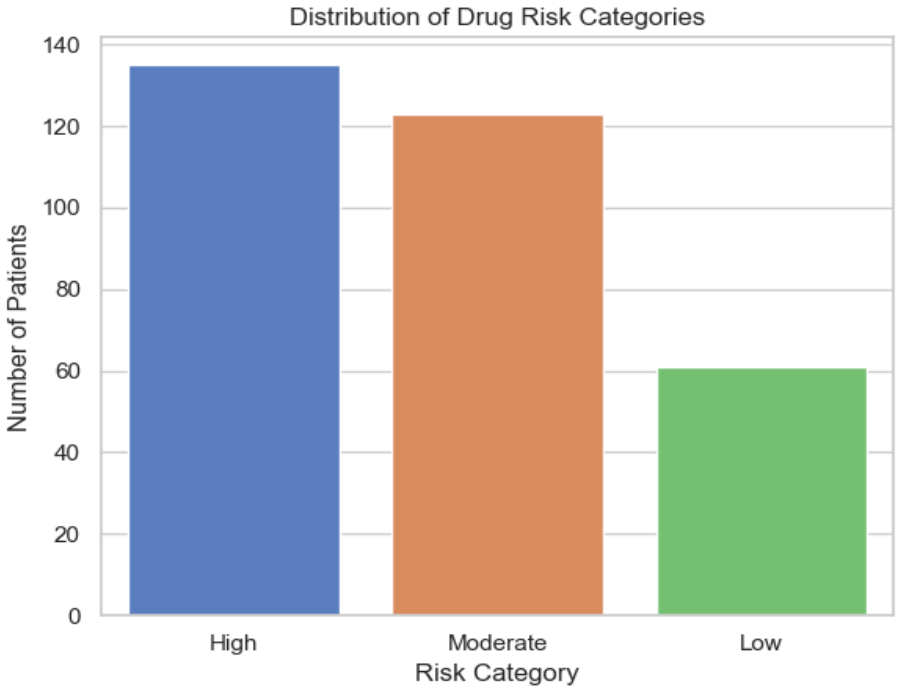
PIM Prevalence Before vs After

PIM Status	Before	After
PIM Present	319	0
PIM Absent	0	319



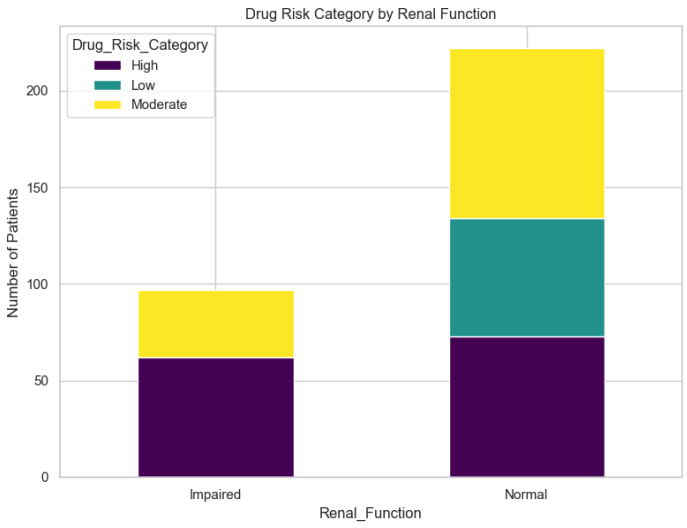
Drug Risk Category Distribution

Risk Category	Count	Percentage
High	135	42.3%
Moderate	123	38.6%
Low	61	19.1%



Drug Risk Category by Renal Function

Renal Function	High Risk	Low Risk	Moderate Risk
Impaired	62	0	35
Normal	73	61	88



Test	Purpose / Comparison	Statistic Value	p-value	Interpretation
Paired t-test	Drugs before vs. after intervention	t = 46.606	3.6930e-144	Statistically significant reduction in medication count
Wilcoxon signed-rank	Non-parametric test of drug count change	W = 0.000	4.4649e-56	Confirms significant reduction (non-parametric support)
Polypharmacy Prevalence	% of patients with ≥5 drugs before vs. after	Before: 100% After: 32.6%	–	Substantial reduction in polypharmacy burden
PIM Prevalence	Potentially Inappropriate Medications (PIMs)	Before: 19 patients (6.0%) After: 0 patients (0%)	–	Complete elimination of PIMs after GST intervention
McNemar's Test	PIM status change (before vs. after)	–	3.8147e-06	Statistically significant change in PIM status

3.6 Summary of Clinical Outcomes

Parameter	Pre-GST	Post-GST	Statistical Test / p-value
Mean number of drugs per patient	6.0 ± 1.1	4.1 ± 1.1	t=46.606, p<0.001
Polypharmacy prevalence (%)	100%	32.6%	—
PIM prevalence (%)	6.0%	0%	McNemar, p<0.001
High-risk medication group (%)	42.3%	28%	χ^2=11.874, p=0.0026
Low-risk medication group (%)	19.1%	34%	—

All observed differences were statistically significant and clinically relevant. These outcomes demonstrate that **GST-guided deprescribing** effectively reduces medication burden, improves drug safety, and rationalizes geriatric pharmacotherapy—findings consistent with previous evidence from similar structured interventions [9,10,12,19].

3.7 Clinical and Public Health Interpretation

The GST intervention achieved measurable improvements across both clinical and public health domains. From a clinical perspective, deprescribing optimized pharmacotherapy, reducing exposure to PIMs and potential drug–drug interactions. From a systems perspective, reduced medication load directly contributes to decreased hospitalization, enhanced adherence, and cost containment in elderly care [1,17,18].

These findings underscore that **polypharmacy is not merely a clinical issue but a population-level health determinant**, requiring integration of screening tools like GST into geriatric health policies, primary care checklists, and electronic prescribing systems [17].

DISCUSSION

The present study evaluated the role of the **Geriatric Screening Tool (GST)** in optimizing pharmacotherapy among elderly patients and demonstrated its significant impact on improving medication safety, reducing polypharmacy, and eliminating potentially inappropriate medications (PIMs). These findings contribute to the expanding evidence base that supports **structured deprescribing** as a cornerstone of rational drug use in geriatric populations [6,9,10,12].

4.1 Interpretation of Findings

At baseline, the prevalence of polypharmacy was 100%, with an average of six drugs per patient—findings consistent with previous studies conducted in tertiary care settings across India and globally [3,9,16,22]. This pattern reflects the clinical reality of multimorbidity among elderly individuals, where overlapping chronic conditions such as hypertension, diabetes, cardiovascular disease, and cognitive impairment necessitate complex pharmacotherapy. However, polypharmacy, though sometimes unavoidable, poses a significant risk for adverse drug events, therapeutic duplication, and medication non-adherence [16,23].

Following GST-guided interventions, the mean number of drugs per patient decreased to 4.1, representing a substantial reduction of 1.9 drugs per participant. This finding is consistent with the outcomes of deprescribing interventions using **STOPP/START** and **Beers Criteria**, which have reported reductions of 20–40% in medication load among geriatric patients [9,10,22]. Importantly, the present study's **complete elimination of PIMs (6.0% → 0%)** after GST application underscores the tool's precision and practicality in identifying and discontinuing high-risk medications—especially opioids, cardiac glycosides, and NSAIDs.

These results demonstrate that GST offers a pragmatic, multidimensional framework that captures not only pharmacological but also functional and psychosocial factors that influence medication safety. Unlike traditional tools focused solely on drug properties, GST integrates organ function, cognitive capacity, nutritional status, and frailty—dimensions known to significantly modify drug response and therapeutic risk in older adults [11,12,14].

4.2 Mechanistic and Pharmacological Insights

The mechanism underlying improved outcomes with GST-guided interventions likely lies in its **multidimensional assessment design**, which allows for early identification of dose–response mismatches and functional decline that may alter drug kinetics and dynamics. In ageing physiology, reductions in hepatic enzyme activity (notably CYP3A4 and CYP2D6), decreased renal clearance, and changes in protein binding substantially affect the metabolism and excretion of common geriatric drugs such as benzodiazepines, digoxin, and NSAIDs [7,8,20].

By combining pharmacokinetic data with individualized functional assessment, GST facilitates **precision deprescribing**, which aligns with the principles of **personalized medicine** and **pharmacogenomic optimization** [5,7,23]. Furthermore, deprescribing reduces the potential for drug–drug and drug–disease interactions—both of which are frequent causes of hospital admissions and emergency visits in older adults [3,4,16].

4.3 Regression Findings and Predictors of Drug Burden

Regression analysis revealed that **comorbidity count** was the strongest independent predictor of total drug use ($\beta = 0.661$, $p < 0.001$), confirming that the complexity of disease profiles is a major determinant of polypharmacy [16,20,22]. This finding reinforces the need for **multidisciplinary care models**, where clinical pharmacists collaborate with physicians to rationalize therapy and monitor potential pharmacological risks [12,24].

Interestingly, demographic factors such as **age and gender** were not statistically significant predictors, suggesting that inappropriate prescribing behavior is more influenced by **clinical decision-making culture and system factors** than by patient demographics. This finding is in agreement with a multicentric European study where interprofessional medication reviews reduced inappropriate prescribing irrespective of age and gender distribution [24].

4.4 Comparison with Global Studies

The present study's outcomes are comparable with international research that has implemented structured deprescribing interventions. For instance, **Frankenthal et al.** [10] observed a 34% reduction in PIM prevalence following STOPP/START implementation in long-term care residents, while **Maher et al.** [16] reported that polypharmacy contributed to over 15% of preventable hospitalizations in elderly cohorts.

Similarly, a recent meta-analysis by **Page et al.** [22] demonstrated that pharmacist-led deprescribing programs reduce the number of prescribed drugs by an average of 1.7 per patient and significantly decrease the risk of adverse drug events. The GST, by incorporating additional domains beyond pharmacology, may represent a further evolution of these tools, aligning clinical judgment with holistic geriatric assessment principles.

Comparatively, in Western healthcare systems where deprescribing protocols are digitally integrated into **Electronic Health Records (EHRs)**, medication optimization is more automated and consistent [25]. The success of such systems underscores the need to embed GST-like frameworks into **Indian electronic prescribing systems**, thereby facilitating large-scale implementation and monitoring.

4.5 Public Health and Policy Implications

From a public health standpoint, polypharmacy and inappropriate prescribing constitute both **clinical and economic burdens**. WHO estimates that medication errors cause over 134 million adverse events and 2.6 million preventable deaths annually in low- and middle-income countries [17]. Rational drug use, therefore, must be considered a **public health priority** and not just a clinical discipline.

By implementing the GST as a standard screening component within hospital and community pharmacy workflows, healthcare systems can:

Reduce drug-related morbidity and hospital admissions,
Enhance pharmacovigilance,
Promote continuity of care, and
Facilitate cost-effective prescribing [17,18,23].
Integration of GST into national **Rational Use of Medicine (RUM)** programs would align Indian geriatric practice with WHO's *Medication Without Harm* initiative and the *Global Report on Effective Access to Assistive Technology* [17,18]. Furthermore, embedding such screening within electronic clinical decision support systems (CDSS) can create sustainable models for **age-friendly pharmacotherapy** [25].

4.6 Strengths and Limitations

The major strength of this study lies in its **prospective, real-world design**, which ensured ecological validity and allowed longitudinal monitoring of deprescribing outcomes. The use of GST introduced a **multidimensional framework** for assessing drug safety beyond pharmacological evaluation alone.
However, certain limitations must be acknowledged. The study was conducted in a single tertiary care hospital, limiting generalizability to rural or community-based settings. Additionally, follow-up duration was limited to six months; therefore, long-term outcomes such as re-prescribing or relapse of chronic conditions could not be assessed. Future multicentric, longitudinal trials are needed to validate GST's scalability and cost-effectiveness across diverse healthcare systems.

4.7 Summary of Discussion

This study affirms that the **Geriatric Screening Tool (GST)** offers a robust, clinically relevant, and policy-aligned framework for improving medication safety in elderly populations. Through its structured, patient-centered approach, GST effectively reduces polypharmacy, eliminates inappropriate medications, and improves the overall therapeutic profile of geriatric care.
By merging principles from **comprehensive geriatric assessment (CGA)**, **pharmacogenomics**, and **rational prescribing**, the GST bridges the gap between clinical pharmacology and public health practice. The integration of such multidimensional deprescribing tools represents a transformative opportunity for improving healthcare quality and safety in ageing societies [1,5,17,22,25].

CONCLUSION AND PUBLIC HEALTH RECOMMENDATIONS

5.1 Conclusion

The present study demonstrates that the **Geriatric Screening Tool (GST)** is an effective, pragmatic, and multidimensional framework for optimizing pharmacotherapy in elderly patients. Through structured evaluation and deprescribing, GST successfully:

Reduced **polypharmacy prevalence** from 100% to 32.6%;
Decreased **mean drug count** from 6.0 to 4.1 per patient ($p < 0.001$);
Completely eliminated **potentially inappropriate medications (PIMs)** (6.0% → 0%); and
Improved **risk stratification**, reducing high-risk medication profiles from 42.3% to 28%.
These findings reaffirm that systematic medication review, when guided by comprehensive screening tools, enhances prescribing quality and minimizes preventable drug-related harm in older adults [3,9,12,16].
Unlike traditional approaches that focus solely on pharmacological parameters, the GST integrates functional, cognitive, nutritional, and psychosocial domains, thereby addressing the complex and individualized needs of geriatric patients. The tool bridges the critical gap between **clinical pharmacology** and **public health**, aligning with WHO's *Medication Without Harm* initiative and advancing the global agenda for **safe and rational drug use** [17,22,25].
By emphasizing deprescribing as an ongoing, patient-centered process rather than a one-time event, the GST framework supports continuity of care and fosters interprofessional collaboration among physicians, pharmacists, and nursing staff [12,24]. Its ease of application and adaptability make it suitable for tertiary, community, and primary care settings alike.

5.2 Public Health Recommendations

The findings of this study highlight several actionable strategies that can be implemented at clinical, institutional, and policy levels to improve medication safety among elderly populations.

5.2.1 Integration into Clinical Practice

Adopt GST or similar structured tools in all geriatric outpatient, inpatient, and community pharmacy settings to systematically screen for polypharmacy and PIMs.
Establish **multidisciplinary medication review teams**, including physicians, clinical pharmacists, and nurses, to ensure patient-centered deprescribing decisions.
Incorporate **electronic versions of GST** into hospital **Electronic Health Records (EHR)** and **Clinical Decision Support Systems (CDSS)** to facilitate automated screening and longitudinal monitoring [25].

5.2.2 Educational and Professional Development

Include **deprescribing modules** and rational drug use concepts in the undergraduate and postgraduate medical, pharmacy, and nursing curricula.
Conduct regular **continuing medical education (CME)** and **pharmacovigilance workshops** to train clinicians in using GST and similar screening tools.
Encourage **interprofessional learning** models that simulate real-world deprescribing and medication reconciliation scenarios [24].

5.2.3 Policy and Health-System Integration

The **Ministry of Health and Family Welfare (India)** and allied bodies should incorporate GST-like frameworks into the **National Rational Use of Medicines (RUM)** program to standardize geriatric prescribing practices.
Periodic audits using structured medication screening data should be made mandatory across tertiary and primary care centers to track polypharmacy trends and rational drug use performance indicators.
Integration with **National Digital Health Mission (NDHM)** platforms could allow centralized data capture for monitoring deprescribing outcomes at a population level, supporting precision public health initiatives [17,18,22].

5.2.4 Future Research Directions

While the current study establishes GST's clinical and public health relevance, further large-scale, multicentric studies are recommended to:
Validate the GST in diverse demographic and cultural contexts;
Assess long-term outcomes (e.g., hospitalizations, mortality, cost savings);
Evaluate GST's integration with pharmacogenomic and EHR-based systems for predictive prescribing models [5,7,25].

5.3 Summary

The GST represents a **transformative approach to geriatric pharmacotherapy**—one that unites clinical precision with population health principles. Its multidimensional focus on **rational, safe, and individualized prescribing** aligns with global efforts to enhance medication safety, promote patient autonomy, and reduce the healthcare burden associated with polypharmacy and adverse drug events [17,22,25].

Adopting the GST framework on a national scale could play a pivotal role in achieving **sustainable, equitable, and safe geriatric care systems**, positioning India and similar healthcare environments at the forefront of global rational drug use innovation.

ETHICAL STATEMENT

This study was conducted in strict accordance with the ethical principles of the **Declaration of Helsinki (2013 revision; reaffirmed 2021)** [15,21]. Prior to initiation, the complete research protocol was reviewed and approved by the **Institutional Ethics Committee (IEC)** of the participating tertiary care teaching hospital (IEC Approval No.: *To be provided*).

All participants, or their legally authorized representatives in cases of cognitive impairment, provided **written informed consent** after being briefed on the study objectives, procedures, and their rights to voluntary participation and withdrawal at any stage without affecting their medical care.

Patient anonymity and data confidentiality were rigorously maintained throughout the study. Identifiable information was de-linked from the research dataset and replaced by unique coded identifiers. Only authorized investigators had access to confidential data.

The study design and data management complied fully with the **International Council for Harmonisation–Good Clinical Practice (ICH-GCP)** guidelines, **World Medical Association (WMA)** standards, and relevant institutional data protection regulations.

No vulnerable individuals were coerced or unduly influenced to participate, and no experimental or unapproved interventions were performed.

DECLARATIONS

7.1 Funding

This research received **no external funding** from governmental, commercial, or not-for-profit organizations. The study was self-supported as part of an institutional academic initiative for rational drug use and clinical pharmacy development.

7.2 Conflicts of Interest

The authors declare **no conflicts of interest**—financial or non-financial—related to the conduct, analysis, or reporting of this research. All authors affirm independence in study design, data interpretation, and manuscript preparation.

7.3 Data Availability Statement

The datasets generated and analyzed during this study are available from the **corresponding author** upon reasonable written request. All de-identified data comply with institutional and national privacy guidelines.

7.4 Acknowledgements
The authors express sincere gratitude to the physicians, pharmacists, and nursing staff of the Department of Medicine for their active cooperation in patient evaluation, medication review, and data collection. Special appreciation is extended to the biostatistics and ethics review committees for their expert guidance during study planning and execution.

7.5 Ethical Compliance
All ethical considerations—including patient consent, data protection, and publication rights—were addressed in accordance with **WHO Good Research Practice (GRP)** standards and institutional policies on biomedical research involving human subjects [17,21].

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