



Resolving Medication-Related Problems in Older Adults through a Multidisciplinary Approach in Korea's Hospital-Based Polypharmacy Program

Hyunwoo Chae^{1*}, Young-Mi Ah^{2*}, Sunmee Jang³, Suhyun Jang⁴,
Hye Jun Lee⁵, Jung-Ha Kim⁵, and Ju-Yeun Lee^{1,6}

¹College of Pharmacy, Seoul National University, Seoul;

²College of Pharmacy, Yeungnam University, Gyeongsan;

³College of Pharmacy and Gachon Institute of Pharmaceutical Sciences, Gachon University, Incheon;

⁴College of Pharmacy, Woosuk University, Wanju;

⁵Department of Family Medicine, Chung-Ang University Medical Center, Chung-Ang University College of Medicine, Seoul;

⁶Research Institute of Pharmaceutical Sciences, Seoul National University, Seoul, Korea.

Purpose: Polypharmacy in older adults is a significant public health challenge. A hospital-based, multidisciplinary Polypharmacy Management Program (PMP) was initiated nationally. We evaluated this team-based program's initial performance, identifying factors associated with medication-related problems (MRPs) prompting prescription changes.

Materials and Methods: We retrospectively analyzed 2021 PMP data from 1740 patients (33 hospitals). Medication review records, intervention outcome records, and patient demographics were examined. MRPs were identified, classified, and documented alongside prescription modifications. Multivariable logistic regression was used to determine factors associated with prescription modifications.

Results: MRPs were found in 73.5% of patients (average 2.7/patient). Common types were potentially inappropriate medications (PIMs, 58.7%), interactions (46.9%), and adverse drug reactions (ADRs, 26.2%). Pharmacists recommended modifications for 32.4% of MRPs, with 92.2% physician acceptance. Discontinuation (59.2%) was the most common modification, often due to lack of indication or ADRs. Significant predictors for modification included age ≥ 85 years [adjusted odds ratio (aOR)=2.34], ≥ 20 medications (aOR=2.46), and use of anticholinergics, multiple oral hypoglycemics, duplicate gastrointestinal agents/proton pump inhibitors or antimentia agents, and certain antidepressants/corticosteroids.

Conclusion: Hospital-based multidisciplinary teams effectively identify and rectify MRPs in older Korean adults with polypharmacy. Targeting interventions towards high-risk subgroups (very elderly, high medication count, specific drugs) could optimize PMP efficiency. Long-term clinical and economic outcome studies are needed.

Key Words: Multidisciplinary care team, polypharmacy, medication therapy management, adverse drug reaction

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Co-corresponding authors: Jung-Ha Kim, MD, PhD, Department of Family Medicine, Chung-Ang University Medical Center, Chung-Ang University College of Medicine, 102 Heukseok-ro, Dongjak-gu, Seoul 06973, Korea.

E-mail: girlpower219@cau.ac.kr and

Ju-Yeun Lee, PhD, College of Pharmacy and Research Institute of Pharmaceutical Sciences, Seoul National University, 1 Gwanak-ro, Gwanak-gu, Seoul 08826, Korea.

E-mail: jypharm@snu.ac.kr

*Hyunwoo Chae and Young-Mi Ah contributed equally to this work.

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INTRODUCTION

Polypharmacy, defined as the concurrent use of five or more medications, is a growing concern in healthcare. It can be classified as either appropriate or inappropriate polypharmacy, depending on the appropriateness of medication use.¹ Inappropriate polypharmacy is particularly problematic, as it is linked with adverse drug events, harmful drug interactions, and increased hospitalizations, highlighting the need for effective strategies to manage polypharmacy.^{2,3} With the global population aging and multimorbidity rising, polypharmacy has become a significant health issue.¹ A recent meta-analysis reported the overall prevalence of polypharmacy at 37% [95% confidence interval (CI): 31%–43%], with an even higher prevalence of 45% (95% CI: 37%–54%) among older adults.⁴

To address these issues, many countries have implemented various medication review and management programs. In the United States, the Medication Therapy Management program has been available since 2006.⁵ Australia provides Home Medicine Review for community-dwelling individuals and Residential Medication Management Review services for long-term care facility residents.⁶ In the United Kingdom, the pharmacist-led Medicine Use Review was recently replaced by the Structured Medication Review under the National Health Service Primary Care Network Contract to enhance patient care and medication optimization.⁷ These programs provide medication management services to a diverse patient population, with polypharmacy often serving as a key eligibility criterion. Research has shown that such services effectively address drug-related problems, minimize inappropriate medication use, and contribute to decreased hospitalizations and lower healthcare expenditures.^{8,9}

South Korea, one of the fastest-aging countries, faces growing concerns about polypharmacy among its older adults.¹⁰ As of 2019, 41.8% of older adults were taking five or more medications, while 14.4% were taking 10 or more medications.¹¹ To address medication-related problems (MRPs) in this demographic, the Korean National Health Insurance Service (NHIS) implemented the “Polypharmacy Management Program (PMP)” in 2018.¹² This nationwide, multidisciplinary initiative is aimed at identifying and resolving MRPs linked to polypharmacy, particularly among older patients with chronic conditions who require multiple medications. The PMP operates through two models: a community-based model, initially launched, and a hospital-based model, added in 2020 to provide multidisciplinary care.

Globally, numerous studies have examined the outcomes of medication management programs.^{13–16} However, research evaluating PMP in Korea remains limited.^{12,17} Existing studies have primarily focused on the initial community-based model or have used qualitative methods to explore the experiences and perceptions of patients and healthcare providers involved in the program.

In this study, we aimed to optimize medication management

strategies for patients experiencing polypharmacy by identifying the types and characteristics of MRPs and exploring factors influencing prescription modifications by a multidisciplinary team within the hospital-based model of the PMP in Korea.

MATERIALS AND METHODS

Data source and participants

We analyzed de-identified records from the hospital-based model of the PMP for 2021, provided by the Korean NHIS. In 2021, 33 hospitals participated in the program. The hospital-based model of PMP primarily targets patients who meet the following criteria: 1) are insured in the National Health Insurance; 2) have at least one diagnosed chronic condition; and either 3) are taking ten or more active ingredients on a regular basis; or 4) are taking five or more medications requiring clinical medication management (e.g., anticoagulants, opioid analgesics, and insulins). The participating departments and specific operational plans are determined individually by each hospital. The PMP records include medication review record, patient functional assessments, intervention outcome, and monitoring records. The overall variables included in each dataset used in the PMP are provided in Supplementary Table 1 (only online). Since patient functional assessments and monitoring are optional, we focused on medication reviews and intervention outcome records for our analysis. Medication review records contain details on prescribed medications, MRPs, and pharmacists' interventions and recommendations. Intervention outcome records include physicians' responses to pharmacists' recommendations and any resulting medication changes. To identify factors associated with medication interventions and modifications, we included only patients with both medication reviews and intervention outcome records.

The characteristics of the hospital-based model can be summarized as follows: it involves a multidisciplinary team—including pharmacists, physicians, and nurses—that provides medication management services. Depending on the patient's treatment setting, the model is divided into two submodels: inpatient and outpatient. The inpatient submodel targeted hospitalized patients and provided medication management services until discharge. Conversely, the outpatient submodel focused on patients visiting outpatient departments. For eligible patients, the multidisciplinary team explained the program, confirmed their willingness to participate, and obtained written consent. The NHIS reimbursed participating institutions for PMP services on a per-service basis, ensuring that patients incurred no out-of-pocket costs.

The medication management service began with a comprehensive medication review, including all medications patients were taking—prescription drugs, over-the-counter (OTC) drugs, and nutritional supplements. In the PMP service, the multidisciplinary team used both hospital records and NHIS claims data

to gain a complete understanding of the patient's prescribed medications and diagnostic history across all visited medical institutions.

During the medication review process, the team comprehensively identified the patient's MRPs in two stages. First, they conducted a comprehensive assessment of MRPs, categorizing them into potentially inappropriate medications (PIMs), drug interactions, adverse drug reactions (ADRs), medication duplication, adherence issues, storage methods, and administration methods. These categories were aligned with established drug-related problem classification frameworks cited in the literature,¹⁸⁻²⁰ but were further refined and adapted by the NHIS to capture practical medication use issues more effectively. Using these tailored categories, pharmacists identified and recorded MRPs by selecting from predefined classification options embedded in the PMP data entry system. Next, they identified MRPs requiring prescription modifications, which were further classified into categories such as "no indication," "inappropriate dose/frequency," and "drug-disease interaction." For MRPs requiring modifications, pharmacists documented their recommendations, which physicians reviewed to determine whether to modify prescriptions.

The prescription modifications were categorized into five types—discontinuation, medication change, dose/formulation change, medication additions, and changes in administration methods. Medication reviews and interventions were conducted for all participating patients, with postintervention monitoring performed when necessary. This study was approved by the Institutional Review Board of Gachon University (IRB No. 1044396-202205-HR-107-01).

Outcomes and variables

In this study, we aimed to identify the types of MRPs, prescription modifications, and factors associated with MRPs that led to prescription modifications. MRPs and modification types were analyzed at two levels—patient and medication.

The PMP service records included variables such as patient demographics (age, sex), medication use (prescribed medications, OTC drugs, nutritional supplements), comorbidities, healthcare utilization (number of healthcare facilities visited, frequency of visits, emergency room visits, hospitalization history), and hospital characteristics (type, department). OTC drugs and nutritional supplements were identified through patient consultations, while other data were obtained from medical records and NHIS claims data for the year preceding patient registration.

Statistical analysis

The analysis was conducted for the entire hospital-based model and separately for the inpatient and outpatient submodels. Descriptive statistics were used to summarize the baseline characteristics of the study population. To compare the inpatient and outpatient groups, chi-square tests or Fisher's exact

tests were performed for categorical variables, and t-tests were used for continuous variables. To identify factors associated with prescription modifications, a multivariable logistic regression model was applied. All variables considered clinically relevant based on literature review and clinical expertise, as well as factors systematically collected in the PMP, were included in the multivariable logistic regression model, regardless of their statistical significance in univariable analysis. The model included the following variables: sex, age, hospital type, comorbidities, number of medications, and drug categories of prescribed medications [anticholinergics, central nervous system (CNS) depressants, oral hypoglycemic agents (OHAs), insulin, antithrombotic agents, renin-angiotensin system inhibitors, beta-blockers, calcium channel blockers, diuretics, alpha-blockers, proton pump inhibitors (PPIs), inhalers, opioids, benzodiazepines, tricyclic antidepressants, sedatives, antipsychotics, anticancer agents, immunosuppressants, nonsteroidal anti-inflammatory drugs, steroids, and antidementia drugs].

All statistical analyses were conducted using SAS Enterprise Guide software, Version 8.3 (SAS Institute, Inc., Cary, NC, USA). A 95% CI was used, and a *p*-value of <0.05 was considered statistically significant.

RESULTS

Baseline characteristics

In 2021, a total of 1824 patients participated in the hospital-based model of the PMP. Of these, 1740 patients had both medication review and intervention outcome records available for analysis. Among the analyzed patients, 82.9% were part of the inpatient submodel, while 17.1% were included in the outpatient submodel (Table 1).

Nearly half of the patients were aged 75 years or older, with 10% being 85 years or older. The mean age of the study population was 72.3 years. Patients in the outpatient submodel were older than those in the inpatient submodel (75.6 years vs. 71.6 years). Services were primarily provided in tertiary hospitals, with nearly 90% of outpatient submodel services delivered in these settings.

The primary departments participating in the program were internal medicine and neurology, accounting for 65.1% and 12.6% of the study population, respectively. On average, patients in the program took 11.6 prescribed medications, with 64.6% taking 10 or more. Patients had an average of three chronic diseases, with diabetes being the most prevalent (33.3%), followed by hypertension (26.3%) and chronic ischemic heart disease (19.0%). In terms of healthcare utilization, patients visited tertiary or secondary hospitals an average of 10.8 times annually, while total visits to all healthcare centers, including primary care clinics, averaged 24.8 visits annually.

Table 1. Baseline Characteristics of Patients in the Polypharmacy Management Program

Characteristic	Total (n=1740)	Outpatient model (n=298)	Inpatient model (n=1442)	p
Age, yr	72.3±11.0	75.6±9.3	71.6±11.2	<0.001
<65	359 (20.6)	39 (13.1)	320 (22.2)	<0.001
65–74	574 (33.0)	86 (28.9)	488 (33.8)	0.096
75–84	628 (36.1)	121 (40.6)	507 (35.2)	0.075
≥85	179 (10.3)	52 (17.4)	127 (8.8)	<0.001
Sex, male	949 (54.5)	145 (48.7)	804 (46.2)	0.025
Hospital type				
Tertiary hospital	1183 (68.0)	261 (87.6)	922 (63.9)	<0.001
Secondary hospital	552 (31.7)	37 (12.4)	515 (35.7)	<0.001
Other	5 (0.3)	0 (0.0)	5 (0.4)	0.595*
Department type				
Internal medicine	1132 (65.1)	226 (75.8)	906 (62.8)	<0.001
Neurology	219 (12.6)	2 (0.7)	217 (15.0)	<0.001
Surgery	173 (9.9)	1 (0.3)	172 (11.9)	<0.001
Others	94 (5.4)	3 (1.0)	91 (6.3)	<0.001
No records	122 (7.0)	66 (22.1)	56 (3.9)	<0.001
Number of total medications	12.5±5.1	14.1±5.6	12.2±4.9	<0.001
<5	20 (1.1)	0 (0.0)	20 (1.4)	0.036*
5–9	463 (26.6)	63 (21.1)	400 (27.7)	0.019
10–14	753 (43.3)	118 (39.6)	635 (44.0)	0.159
15–19	335 (19.3)	67 (22.5)	268 (18.6)	0.120
≥20	157 (9.0)	48 (16.1)	109 (7.6)	<0.001
No records	12 (0.7)	2 (0.7)	10 (0.7)	>0.999*
Number of prescribed medications	11.6±4.9	12.8±5.3	11.4±4.9	<0.001
<5	38 (2.2)	1 (0.3)	37 (2.6)	0.017
5–9	565 (32.5)	87 (29.2)	478 (33.1)	0.185
10–14	731 (42.0)	118 (39.6)	613 (42.5)	0.354
15–19	279 (16.0)	56 (18.8)	223 (15.5)	0.154
≥20	115 (6.6)	34 (11.4)	81 (5.6)	<0.001
No records	12 (0.7)	2 (0.7)	10 (0.7)	>0.999*
Number of over-the-counter	0.1±0.6	0.2±0.6	0.1±0.6	0.052
Number of nutritional supplements	0.8±1.4	1.2±1.8	0.7±1.3	<0.001
Number of comorbidities	3.4±1.9	3.8±1.9	3.2±1.9	<0.001
Comorbidities				
Diabetes	580 (33.3)	109 (36.6)	471 (32.7)	0.160
Hypertension	458 (26.3)	60 (20.1)	398 (27.6)	0.008
Chronic ischemic heart disease	330 (19.0)	81 (27.2)	249 (17.3)	<0.001
Cancer	290 (16.7)	34 (11.4)	256 (17.8)	0.008
Benign prostatic hypertrophy	214 (12.3)	41 (13.8)	173 (12.0)	0.376
Asthma/COPD	209 (12.0)	38 (12.8)	171 (11.9)	0.638
Chronic stroke	173 (9.9)	32 (10.7)	141 (9.8)	0.589
Renal failure	167 (9.6)	43 (14.4)	124 (8.6)	0.002
Dementia	135 (7.8)	32 (10.7)	103 (7.1)	0.031
Arrhythmia	133 (7.6)	24 (8.1)	109 (7.6)	0.748
Healthcare utilization frequency				
Overall	24.8±24.6	25.6±23.8	24.7±24.8	0.553
Secondary or tertiary hospital	10.8±14.7	12.4±15.4	10.4±14.5	0.057
ED visit history	6 (0.3)	1 (0.3)	5 (0.3)	>0.999*
Hospitalization history	11 (0.6)	6 (2.0)	5 (0.3)	0.005*

SD, standard deviation; COPD, chronic obstructive pulmonary disease; ED, emergency department.

Data are presented as mean±standard deviation or n (%).

*p-values calculated using Fisher's exact test instead of chi-square test due to sparse data.

Table 2. Type of Medication-Related Problems Identified in the Hospital-Based Polypharmacy Management Program Model

	Total		Outpatient model		Inpatient model		<i>p</i>	
	Patient	Case	Patient	Case	Patient	Case	Patient	Case
PIM for older adults	751 (58.7)	1748 (37.7)	155 (62.8)	318 (31.0)	596 (57.8)	1430 (39.7)	0.001	0.474
Drug interaction	600 (46.9)	1036 (22.4)	156 (63.2)	241 (23.5)	444 (43.0)	795 (22.0)	<0.001	0.001
Adverse drug reaction	335 (26.2)	684 (14.8)	94 (38.1)	196 (19.1)	241 (23.4)	488 (13.5)	<0.001	<0.001
Duplication	239 (18.7)	326 (7.0)	61 (24.7)	89 (8.7)	178 (17.2)	237 (6.6)	<0.001	<0.001
Poor adherence	207 (16.2)	482 (10.4)	52 (21.1)	112 (10.9)	155 (15.0)	370 (10.3)	0.001	0.066
Wrong administration method	196 (15.3)	184 (4.0)	36 (14.6)	52 (5.1)	160 (15.5)	132 (3.7)	0.625	0.128
Inappropriate storage	47 (3.7)	113 (2.4)	3 (1.2)	13 (1.3)	44 (4.3)	100 (2.8)	0.048	0.093
Total	1279	4631	247	1025	1032	3606	<0.001	<0.001

PIM, potentially inappropriate medication.

Data are presented as n (%).

Medication review and MRPs

Following medication reviews conducted by the multidisciplinary team, 1279 out of 1740 patients (73.5%) were identified with at least one MRP. A total of 4631 MRPs were documented, averaging 2.7 MRPs per patient. Outpatients had a higher average number of MRPs than inpatients (3.4 vs. 2.5 MRPs per patient). The most common MRPs included the use of PIMs in older adults (58.7%), drug interactions (46.9%), and ADRs (26.2%). These trends were consistent across both outpatient and inpatient submodels. Excluding wrong administration methods and inappropriate storage, most MRP categories were more frequently observed in the outpatient submodel, particularly for drug interactions, including drug–drug, drug–food, and drug–disease interactions (63.2% vs. 43.0%) (Table 2).

Among the identified MRPs, pharmacists intervened for 636 patients, resulting in 1500 interventions. Of these, 1383 interventions involving 552 patients were accepted by physicians. This indicates that prescription modifications were considered for 32.4% of the identified MRPs, with 92.2% of the pharmacists' proposed interventions accepted by physicians. Accepted interventions included 1040 cases from the inpatient submodel and 343 from the outpatient submodel.

The most common MRPs leading to prescription modifications were medications with no indication (21.4%), followed by ADRs (13.9%) and therapeutic duplications (11.1%). In the inpatient submodel, dosage and frequency errors were the third most common MRPs leading to prescription modifications (11.1%), while these were significantly rare in the outpatient submodel (1.7%). The most common prescription modifications included medication discontinuation (59.2%), medication switching (14.2%), and formulation changes (13.1%) (Table 3). Frequently modified medications categorized by MRPs are presented in Supplementary Table 2 (only online).

Patient-level data on MRPs resulting in prescription modifications are presented in Supplementary Table 3 (only online). Over 20% of patients had medications associated with ADRs, and 55.7% (78/140) of these patients discontinued their medications following the intervention. Other MRPs leading to prescription modifications included medications with no in-

dication, medication duplications with similar effects, and PIMs for older adults.

Factors associated with MRPs leading to prescription modifications

After adjusting for demographic factors, comorbidities, and medication effects, several factors were identified as being associated with an increased risk of MRPs resulting in prescription modifications. Unadjusted odds ratios are provided in Supplementary Table 4 (only online).

In the overall patient population, significant factors included sex [female; adjusted odds ratio (aOR)=1.34, 95% CI: 1.04–1.74], age, number of prescribed medications, and the use of OHAs, gastrointestinal (GI) medications, PPIs, anticholinergics, nontricyclic antidepressants, steroids, and dementia treatments.

Older age was strongly associated with a higher likelihood of MRPs resulting in prescription modifications. Compared to patients under 65 years, the odds increased with age: aOR=1.57 for 75–84 years, and 2.34 for ≥85 years. Similarly, patients taking ≥20 medications were 2.5 times more likely to require medication modifications than those taking <10 medications. Hospital type was identified as a significant factor also. Tertiary hospitals demonstrated significantly higher medication adjustment rate compared to secondary-level hospitals (aOR=2.14, 95% CI: 1.64–2.80). Specific drug classes also significantly contributed to MRPs. The use of anticholinergics (aOR=1.64, 95% CI: 1.21–2.23), nontricyclic antidepressants (aOR=1.67, 95% CI: 1.13–2.47), and corticosteroids (aOR=1.58, 95% CI: 1.07–2.33) significantly increased the risk of prescription modifications. For OHAs, the risk of modifications increased with the number of medications, with an aOR of 1.5 for 1–2 OHAs and nearly 2 for ≥3 OHAs. Additionally, duplication within drug classes significantly increased the likelihood of modifications for GI medications (aOR=1.78, 95% CI: 1.12–2.83), PPIs (aOR=1.90, 95% CI: 1.05–3.42), and antidementia agents (aOR=4.06, 95% CI: 1.02–16.28) (Table 4).

In submodel analyses, distinct patterns emerged between the inpatient and outpatient groups. For the inpatient submodel, significant factors included age ≥85 years, tertiary hospital

Table 3. Types of MRPs and Prescription Modifications in the Polypharmacy Management Program: Medication-Level Analysis

	Discontinuation	Drug change	Dose/ formulation change	Drug addition	Administration method change	Others	Subtotal [†] (%)	Total (%)	<i>p</i>
No indication								296 (21.4)	0.411
Outpatient	58	0	10	0	0	0	68 (19.8)		
Inpatient	223	1	3	0	0	1	228 (21.9)		
Adverse drug reaction								192 (13.9)	0.771
Outpatient	23	15	7	1	0	0	46 (13.4)		
Inpatient	100	24	14	3	2	3	146 (14.0)		
Therapeutic duplication								154 (11.1)	0.451
Outpatient	36	4	1	0	0	1	42 (12.2)		
Inpatient	101	6	1	0	0	4	112 (10.8)		
PIM for older adults								145 (10.5)	0.412
Outpatient	15	13	10	0	0	2	40 (11.7)		
Inpatient	81	15	5	0	0	4	105 (10.1)		
Inappropriate dose/frequency								121 (8.7)	<0.001
Outpatient	0	1	5	0	0	0	6 (1.7)		
Inpatient	10	16	73	0	10	6	115 (11.1)		
Drug–drug interaction								87 (6.3)	0.257
Outpatient	15	2	1	0	5	3	26 (7.6)		
Inpatient	23	22	3	0	9	4	61 (5.9)		
Duplication of the same drugs								41 (3.0)	0.501
Outpatient	10	0	1	1	0	0	12 (3.5)		
Inpatient	27	1	1	0	0	0	29 (2.8)		
Drug–disease interaction								45 (3.3)	0.089
Outpatient	7	2	6	0	0	1	16 (4.7)		
Inpatient	15	9	5	0	0	0	29 (2.8)		
Omission								40 (2.9)	0.010
Outpatient	0	0	0	3	0	0	3 (0.9)		
Inpatient	0	0	0	36	0	1	37 (3.6)		
Poor adherence								34 (2.5)	0.529
Outpatient	8	0	0	0	0	2	10 (2.9)		
Inpatient	18	3	1	0	1	1	24 (2.3)		
Untreated indication								30 (2.2)	0.851
Outpatient	0	0	0	7	0	0	7 (2.0)		
Inpatient	0	0	0	22	0	1	23 (2.2)		
Inappropriate effect								16 (1.2)	0.140*
Outpatient	0	1	0	0	0	0	1 (0.3)		
Inpatient	4	10	0	1	0	0	15 (1.4)		
Others								182 (13.2)	<0.001
Outpatient	5	25	19	14	0	3	66 (19.2)		
Inpatient	40	27	15	8	4	22	116 (11.2)		
Subtotal modifications by submodels [‡] (%)								1383 (100)	
Outpatient	177 (51.6)	63 (18.4)	60 (17.5)	26 (7.6)	5 (1.5)	12 (3.5)	343		
Inpatient	642 (61.7)	134 (12.9)	121 (11.6)	70 (6.7)	26 (2.5)	47 (4.5)	1040		
Total modifications (%)	819 (59.2)	197 (14.2)	181 (13.1)	96 (6.9)	31 (2.2)	59 (4.3)			

PIM, potentially inappropriate medication; MRP, medication-related problem.

**p*-values calculated using Fisher's exact test instead of chi-square test due to sparse data; [†]Percentage represents the proportion of each MRP within the total for the respective submodel; [‡]Percentage represents the proportion of each modification within the total for the respective submodel.

Table 4. Factors Associated with Medication Interventions in the Polypharmacy Management Program

Variables	Total aOR (95% CI)	Outpatient aOR (95% CI)	Inpatient aOR (95% CI)
Sex			
Male	Ref.	Ref.	Ref.
Female	1.34 (1.04–1.74)	1.74 (0.80–3.81)	1.33 (1.00–1.77)
Age, yr			
<65	Ref.	Ref.	Ref.
65–74	1.31 (0.92–1.87)	1.97 (0.56–6.93)	1.23 (0.84–1.80)
75–84	1.57 (1.10–2.25)	2.82 (0.76–10.45)	1.42 (0.96–2.10)
≥85	2.34 (1.48–3.72)	4.74 (1.20–18.73)	1.91 (1.12–3.25)
Hospital type			
Secondary level*	Ref.	Ref.	Ref.
Tertiary level	2.14 (1.64–2.80)	0.44 (0.16–1.25)	2.75 (2.05–3.71)
Comorbidities			
Hypertension	0.78 (0.59–1.03)	0.47 (0.20–1.10)	0.90 (0.66–1.23)
Diabetes	0.98 (0.72–1.34)	0.71 (0.29–1.75)	1.10 (0.78–1.56)
Chronic ischemic heart disease	1.12 (0.83–1.52)	1.46 (0.66–3.24)	1.04 (0.74–1.48)
Arrhythmia	0.80 (0.50–1.28)	1.23 (0.32–4.73)	0.74 (0.44–1.26)
Chronic stroke	0.75 (0.51–1.10)	1.10 (0.39–3.10)	0.76 (0.49–1.16)
Renal failure	1.38 (0.95–2.02)	1.63 (0.66–4.03)	1.29 (0.82–2.01)
Asthma/COPD	0.70 (0.46–1.04)	1.38 (0.38–4.95)	0.61 (0.39–0.96)
Dementia	0.79 (0.50–1.23)	0.60 (0.18–1.98)	0.90 (0.54–1.50)
Cancer	1.28 (0.94–1.75)	1.19 (0.44–3.20)	1.31 (0.93–1.85)
Benign prostatic hypertrophy	0.95 (0.65–1.39)	1.29 (0.47–3.52)	0.87 (0.57–1.33)
Number of prescribed medications			
<10	Ref.	Ref.	Ref.
10–14	1.27 (0.96–1.68)	0.99 (0.42–2.36)	1.36 (0.99–1.86)
15–19	1.19 (0.80–1.75)	0.92 (0.31–2.69)	1.46 (0.94–2.28)
≥20	2.46 (1.43–4.24)	1.25 (0.28–5.53)	3.43 (1.81–6.52)
Number of CNS medications			
0	Ref.	Ref.	Ref.
1–2	1.39 (0.98–1.95)	1.16 (0.40–3.34)	1.47 (1.01–2.16)
≥3	1.03 (0.56–1.90)	2.65 (0.44–16.01)	0.89 (0.44–1.81)
Number of oral hypoglycemic agents			
0	Ref.	Ref.	Ref.
1–2	1.46 (1.07–2.00)	1.53 (0.63–3.73)	1.37 (0.96–1.94)
≥3	1.98 (1.36–2.88)	3.80 (1.30–11.12)	1.67 (1.09–2.55)
Number of antihypertension agents			
0	Ref.	Ref.	Ref.
1	1.27 (0.77–2.09)	3.88 (0.89–16.90)	0.99 (0.56–1.72)
2	1.54 (0.72–3.29)	2.94 (0.29–29.46)	1.21 (0.52–2.83)
≥3	1.34 (0.48–3.78)	9.08 (0.46–179.13)	0.91 (0.28–2.92)
Number of diuretics			
0	Ref.	Ref.	Ref.
1	1.07 (0.78–1.48)	0.63 (0.26–1.54)	1.20 (0.84–1.72)
≥2	0.95 (0.64–1.42)	0.99 (0.29–3.40)	0.94 (0.60–1.46)
Number of gastrointestinal agents			
0–1	Ref.	Ref.	Ref.
≥2	1.78 (1.12–2.83)	0.65 (0.10–4.37)	2.00 (1.21–3.31)
Number of proton pump inhibitors			
0–1	Ref.	Ref.	Ref.
2	1.90 (1.05–3.42)	9.17 (0.52–160.34)	1.59 (0.85–2.99)

Table 4. Factors associated with Medication Interventions in the Polypharmacy Management Program (continued)

Variables	Total aOR (95% CI)	Outpatient aOR (95% CI)	Inpatient aOR (95% CI)
Number of benzodiazepines			
0	Ref.	Ref.	Ref.
1	1.28 (0.90–1.84)	0.49 (0.17–1.44)	1.55 (1.03–2.33)
≥2	1.23 (0.58–2.62)	5.59 (0.38–81.69)	0.92 (0.39–2.18)
Number of antimentia agents			
0–1	Ref.	Ref.	Ref.
≥2	4.06 (1.02–16.28)	>99.99 (<0.001–>99.99)	2.76 (0.62–12.19)
Number of NSAIDs			
0–1	Ref.	Ref.	Ref.
≥2	1.23 (0.52–2.92)	>99.99 (<0.001–>99.99)	1.01 (0.39–2.56)
Medication use			
Anticoagulants	0.92 (0.66–1.29)	0.68 (0.25–1.85)	1.12 (0.77–1.65)
Antiplatelets	1.06 (0.81–1.39)	0.64 (0.31–1.35)	1.14 (0.84–1.53)
Insulins	1.07 (0.71–1.61)	1.19 (0.36–3.95)	0.96 (0.61–1.52)
RAS inhibitors	0.73 (0.47–1.14)	0.71 (0.19–2.68)	0.71 (0.43–1.16)
Beta blockers	0.93 (0.63–1.37)	0.47 (0.16–1.39)	1.06 (0.69–1.65)
Calcium channel blockers	0.99 (0.65–1.50)	0.66 (0.19–2.27)	1.10 (0.69–1.76)
Alpha blockers	1.04 (0.53–2.04)	0.61 (0.07–5.48)	1.29 (0.62–2.71)
Inhalers	0.73 (0.47–1.14)	0.69 (0.18–2.73)	0.66 (0.40–1.08)
Anticholinergics	1.64 (1.21–2.23)	1.20 (0.50–2.87)	1.80 (1.28–2.55)
Opioids	1.11 (0.79–1.55)	0.85 (0.28–2.61)	1.12 (0.76–1.63)
Tricyclic antidepressants	1.06 (0.64–1.74)	1.71 (0.46–6.38)	1.09 (0.62–1.92)
Nontricyclic antidepressants	1.67 (1.13–2.47)	3.27 (1.16–9.24)	1.51 (0.94–2.41)
Sedatives	0.86 (0.56–1.31)	0.57 (0.19–1.75)	0.97 (0.59–1.60)
Antipsychotics	1.40 (0.89–2.19)	1.32 (0.25–6.89)	1.35 (0.82–2.20)
Anticancer agents	1.05 (0.55–1.99)	0.83 (0.10–7.17)	1.07 (0.53–2.17)
Immunosuppressants	0.60 (0.31–1.18)	0.54 (0.09–3.16)	0.72 (0.33–1.58)
Corticosteroids	1.58 (1.07–2.33)	0.86 (0.27–2.77)	1.76 (1.14–2.70)

aOR, adjusted odds ratio; CI, confidence interval; COPD, chronic obstructive pulmonary disease; CNS, central nervous system; NSAID, nonsteroidal anti-inflammatory drug; RAS, renin-angiotensin system.

*Secondary level includes secondary hospitals and hospitals.

level, prescription of ≥20 medications, use of ≥3 OHAs, GI duplication, and use of anticholinergics or steroids. Single benzodiazepine use and CNS medication use were also significant factors among the inpatient group. In the outpatient submodel, significant risk factors included age ≥85 years, use of ≥3 OHAs, and use of nontricyclic antidepressants (Table 4).

DISCUSSION

In this study, we analyzed records from the hospital-based model of the PMP service, a nationwide medication management service in South Korea. Approximately 80% of patients receiving the service were aged 65 years or older, with an average of 11.6 prescription medications per patient. When OTC drugs and nutritional supplements were included, the average number of medications increased to 12.5, slightly lower than the 13.8 medications reported in the community-based model of

the PMP for community-dwelling older adults.¹² The multidisciplinary team identified over 4600 MRPs in over two-thirds of the patients, averaging 2.7 MRPs per patient across the study population and 3.6 MRPs per patient among those with identified MRPs. These findings align with levels reported in previous studies.^{21,22}

Pharmacists recommended prescription modifications for 32.4% of the identified MRPs, with a 92.2% acceptance rate by physicians. The acceptance rate in this study was comparable to or higher than that reported in previous studies. For example, an Australian study found an average acceptance rate of 70%, ranging from 51% to 100%, depending on the pharmacist.²² A French hospital study reported an 83.4% acceptance rate, while a Chinese study noted a rate exceeding 90%, consistent with our findings.^{21,23} These differences may stem from institutional characteristics. Studies with lower acceptance rates were conducted in community or primary care settings, whereas higher rates were observed in tertiary teaching hospitals, as in our

study. The high acceptance rate in our study may also reflect the willingness of participating physicians. Only hospitals that voluntarily applied to the PMP and physicians who were already open to multidisciplinary team care participated. Consequently, these physicians may have been more inclined to accept recommendations. These findings underscore the importance of an integrated approach to identifying and managing complex MRPs in older adults.

Most non-adjusted MRPs were resolved through patient education or deemed clinically insignificant. For instance, 10% of the 482 medication adherence-related MRPs led to prescription modifications. In most adherence-related cases, patients fail to take their prescribed medications due to a lack of understanding or misconceptions. In such situations, pharmacist-led education plays a key role in improving adherence, and modifying the prescription is often unnecessary. However, in the inpatient submodel, formulary restrictions within hospitals (e.g., limited access to fixed-dose combinations) may have led to an underestimation of prescription changes intended to improve adherence. The most frequent MRP identified during the screening stage was the use of PIMs in older adults, observed in 58.7% of patients, reflecting trends observed in earlier studies.²⁴ However, PIM ranked fourth among MRPs leading to prescription modifications, suggesting that the appropriateness of PIMs often depends on individual clinical circumstances. Drug interactions were the second most common MRP, identified at a slightly higher rate than in previous studies.^{25,26} This may be due to the broader definition of our study, which included not only drug-drug interactions but also drug-food and drug-disease interactions. Additionally, the inclusion of prescription data from all healthcare institutions likely contributed to the higher rate of detection. However, only one in eight cases of identified drug interactions led to prescription modifications, primarily because the clinical significance of drug interactions varied. Among MRPs leading to prescription modifications, the most frequent was “no indication,” consistent with findings from previous studies.²² This highlights the need for regular medication reviews to prevent inappropriate continued use. ADRs and medication duplications were the next most frequent MRPs leading to modifications. Prescription modifications were made in nearly 60% of medication duplication cases, likely because these issues have clearer criteria for appropriateness, facilitating proactive modifications. In Korea, a nationwide Drug Utilization Review system has been implemented since 2013. This system screens for drug-drug interactions, PIMs in older adults, and medication duplications, providing alerts to physicians or pharmacists. Nevertheless, these issues persist and often require active interventions.²⁷ This highlights the importance of a well-coordinated, multidisciplinary approach to effectively manage polypharmacy.²⁷

Factors associated with MRPs leading to prescription modifications included age, sex, number of medications, hospital type, and specific medication classes. Older age, particularly ≥ 85

years, was strongly associated with a higher likelihood of prescription modifications. Female patients and those taking ≥ 20 medications also had higher intervention rates, consistent with previous studies. For example, a French study found that female patients were more likely to receive medication interventions more frequently accepted by physicians.²³ Also, a Dutch study reported that patients taking ≥ 20 medications were over twice as likely to undergo prescription modifications.²⁸ MRPs identified in tertiary care hospitals were more likely to result in prescription interventions than those identified in secondary care hospitals, potentially due to the greater clinical severity and complexity of patients typically managed in tertiary care settings. Consistent with our findings, a systematic review reported that ADR-related readmissions were more prevalent in teaching hospitals than in non-teaching hospitals (8.1% vs. 3.3%), and such readmissions are considered a key clinical outcome of MRPs.²⁹ Additionally, specific drug classes, including anticholinergics, OHAs, GI agents, PPIs, antidepressants, steroids, and antimentia drugs, were linked to higher intervention rates. Anticholinergics, a well-known category of PIMs, are frequently associated with MRPs in older adults.^{20,30} Duplication of GI agents and PPIs likely prompted interventions to address unnecessary multiple prescriptions. Similarly, the use of multiple OHAs increased the risk of hypoglycemia, compounded by differing glycemic targets for older adults.^{20,31} These findings can inform more targeted and cost-effective implementations of the PMP. By identifying subgroups of older adults most susceptible to MRPs, healthcare systems can allocate resources more efficiently and optimize patient outcomes.

This study is the first to comprehensively analyze the hospital-based, multidisciplinary PMP model in South Korea. Using a robust multicenter dataset of 1740 patients from 33 hospitals, we provided valuable insights into medication use, MRPs, and pharmacist interventions. The high acceptance rate of pharmacist interventions showed the effectiveness of the multidisciplinary PMP model in Korea. These findings offer practical guidance for refining the PMP, such as narrowing the target population to improve clinical and financial outcomes.

However, this study has several limitations. First, the analysis was limited to 1 year (2021), as the hospital-based PMP was only implemented in late 2020. Moreover, healthcare utilization patterns in 2020 may have been influenced by the COVID-19 pandemic. Second, the voluntary participation of healthcare providers in the hospital-based PMP may have introduced selection bias, potentially affecting the acceptance rate. Third, while the study focused on MRPs and pharmacist interventions, we did not assess long-term clinical outcomes, such as readmission rates, adverse events, or mortality. Future studies should evaluate these outcomes to better understand the broader impact of the PMP.

We analyzed the initial outcomes of the hospital-based model of the PMP and identified patient factors associated with medication interventions and modifications. The findings confirmed

that polypharmacy, advanced age, and the use of specific medications—such as anticholinergics and GI agents—significantly increase the likelihood of medication modification. As the PMP service is currently in the pilot phase, transitioning to a full-scale, long-term implementation will require robust evidence showing its effectiveness in improving patient outcomes and reducing healthcare expenditures. These findings provide a strategic approach for selecting the target population for the PMP, offering potential benefits for both patients and health insurance sustainability. To support the broad adoption and long-term viability of the program, future research should focus on evaluating its impact on clinical outcomes.

AVAILABILITY OF DATA AND MATERIALS

The datasets analyzed in the current study are available in the [NHIS] repository; the Chronic Disease Management Division of the Department of Medical Utilization Management at the National Health Insurance Service. All data files are available from the NHIS database.

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AUTHOR CONTRIBUTIONS

Conceptualization: all authors. **Data curation:** Hyunwoo Chae, Young-Mi Ah, and Suhyun Jang. **Formal analysis:** Hyunwoo Chae, Young-Mi Ah, and Suhyun Jang. **Funding acquisition:** Jung-Ha Kim. **Investigation:** Hyunwoo Chae, Young-Mi Ah, and Suhyun Jang. **Methodology:** Hyunwoo Chae, Young-Mi Ah, Sunmee Jang, Jung-Ha Kim, and Ju-Yeun Lee. **Project administration:** Sunmee Jang, Jung-Ha Kim, and Ju-Yeun Lee. **Resources:** Hyunwoo Chae, Young-Mi Ah, and Suhyun Jang. **Software:** Hyunwoo Chae, Young-Mi Ah, and Suhyun Jang. **Supervision:** Sunmee Jang, Jung-Ha Kim, and Ju-Yeun Lee. **Validation:** Hyunwoo Chae, Young-Mi Ah, and Suhyun Jang. **Visualization:** Hyunwoo Chae, Young-Mi Ah, and Suhyun Jang. **Writing—original draft:** Hyunwoo Chae and Young-Mi Ah. **Writing—review & editing:** all authors. **Approval of final manuscript:** all authors.

ORCID iDs

Hyunwoo Chae	https://orcid.org/0009-0004-7819-3372
Young-Mi Ah	https://orcid.org/0000-0003-1607-9828
Sunmee Jang	https://orcid.org/0000-0002-8771-8693
Suhyun Jang	https://orcid.org/0000-0002-0089-8557
Hye Jun Lee	https://orcid.org/0000-0001-5810-9787
Jung-Ha Kim	https://orcid.org/0000-0002-7630-9501
Ju-Yeun Lee	https://orcid.org/0000-0002-2261-7330

REFERENCES

1. World Health Organization. Medication safety in polypharmacy: technical report [accessed on 2025 January 2]. Available at: <https://www.who.int/publications/i/item/medication-safety-in-polypharmacy-technical-report>.
2. Masnoon N, Shakib S, Kalisch-Ellett L, Caughey GE. What is polypharmacy? A systematic review of definitions. *BMC Geriatr* 2017; 17:230.
3. Davies LE, Spiers G, Kingston A, Todd A, Adamson J, Hanratty B. Adverse outcomes of polypharmacy in older people: systematic review of reviews. *J Am Med Dir Assoc* 2020;21:181-7.
4. Delara M, Murray L, Jafari B, Bahji A, Goodarzi Z, Kirkham J, et al. Prevalence and factors associated with polypharmacy: a systematic review and meta-analysis. *BMC Geriatr* 2022;22:601.
5. Gray C, Cooke CE, Brandt N. Evolution of the Medicare Part D medication therapy management program from inception in 2006 to the present. *Am Health Drug Benefits* 2019;12:243-51.
6. Dineen-Griffin S, Benrimoj SI, Garcia-Cardenas V. Primary health care policy and vision for community pharmacy and pharmacists in Australia. *Pharm Pract (Granada)* 2020;18:1967.
7. Madden M, Mills T, Atkin K, Stewart D, McCambridge J. Early implementation of the structured medication review in England: a qualitative study. *Br J Gen Pract* 2022;72:e641-8.
8. Gudi SK, Kashyap A, Chhabra M, Rashid M, Tiwari KK. Impact of pharmacist-led home medicines review services on drug-related problems among the elderly population: a systematic review. *Epidemiol Health* 2019;41:e2019020.
9. Abbott RA, Moore DA, Rogers M, Bethel A, Stein K, Coon JT. Effectiveness of pharmacist home visits for individuals at risk of medication-related problems: a systematic review and meta-analysis of randomised controlled trials. *BMC Health Serv Res* 2020;20:39.
10. United Nations, Department of Economic and Social Affairs, Population Division. World population ageing, 2019: highlights [accessed on 2025 January 2]. Available at: <https://digitallibrary.un.org/record/3846855?v=pdf>.
11. Cho HJ, Chae J, Yoon SH, Kim DS. Aging and the prevalence of polypharmacy and hyperpolypharmacy among older adults in South Korea: a national retrospective study during 2010-2019. *Front Pharmacol* 2022;13:866318.
12. Yang SY, Jang S, Kwon SH, Lee J, Ah Y, Kang C, et al. [Effectiveness of the pilot project for polypharmacy management]. *Health Soc Welf Rev* 2020;40:563-91. Korean
13. Viswanathan M, Kahwati LC, Golin CE, Blalock SJ, Coker-Schwimmer E, Posey R, et al. Medication therapy management interventions in outpatient settings: a systematic review and meta-analysis. *JAMA Intern Med* 2015;175:76-87.
14. Du W, Gnjdjic D, Pearson SA, Hilmer SN, McLachlan AJ, Blyth F, et al. Patterns of high-risk prescribing and other factors in relation to receipt of a home medicines review: a prospective cohort investigation among adults aged 45 years and over in Australia. *BMJ Open* 2019;9:e027305.
15. Thiruchelvam K, Byles J, Hasan SS, Egan N, Kairuz T. Residential medication management reviews and continuous polypharmacy among older Australian women. *Int J Clin Pharm* 2021;43:1619-29.
16. Stewart D, Whittlesea C, Dhital R, Newbould L, McCambridge J. Community pharmacist led medication reviews in the UK: a scoping review of the medicines use review and the new medicine service literatures. *Res Social Adm Pharm* 2020;16:111-22.
17. Shin WY, Kim S, Kim JH, Song JS. [Awareness of and experience in a polypharmacy management program for older inpatients: a qualitative study of patients, caregivers, physicians, and pharma-

- cists]. *Korean J Geriatr Gerontol* 2024;25:22-38. Korean
18. Strand LM, Morley PC, Cipolle RJ, Ramsey R, Lamsam GD. Drug-related problems: their structure and function. *DICP* 1990;24:1093-7.
19. Pharmaceutical Care Network Europe Association. PCNE classification for drug related problems V9.1. Basel: Pharmaceutical Care Network Europe Association; 2020.
20. 2023 American Geriatrics Society Beers Criteria® Update Expert Panel. American Geriatrics Society 2023 updated AGS Beers Criteria® for potentially inappropriate medication use in older adults. *J Am Geriatr Soc* 2023;71:2052-81.
21. Wang X, Wang S, Yu X, Ma Z, Wang H, Yang J, et al. Impact of pharmacist-led medication therapy management in ambulatory elderly patients with chronic diseases. *Br J Clin Pharmacol* 2021;87:2937-44.
22. Benson H, Lucas C, Kmet W, Benrimoj SI, Williams K. Pharmacists in general practice: a focus on drug-related problems. *Int J Clin Pharm* 2018;40:566-72.
23. Durand A, Gillibert A, Membre S, Mondet L, Lenglet A, Mary A. Acceptance factors for in-hospital pharmacist interventions in daily practice: a retrospective study. *Front Pharmacol* 2022;13:811289.
24. Zhang X, Zhou S, Pan K, Li X, Zhao X, Zhou Y, et al. Potentially inappropriate medications in hospitalized older patients: a cross-sectional study using the Beers 2015 criteria versus the 2012 criteria. *Clin Interv Aging* 2017;12:1697-703.
25. Chan DC, Chen JH, Kuo HK, We CJ, Lu IS, Chiu LS, et al. Drug-related problems (DRPs) identified from geriatric medication safety review clinics. *Arch Gerontol Geriatr* 2012;54:168-74.
26. Richardson TE, O'Reilly CL, Chen TF. Drug-related problems and the clinical role of pharmacists in inpatient mental health: an insight into practice in Australia. *Int J Clin Pharm* 2014;36:1077-86.
27. Oh JM, Kim DK, Kim SH, Lee E, Kim JH, Kim TW, et al. A study on the development plans for advancing the drug utilization review (DUR) [accessed on 2025 January 2]. Available at: <https://repository.hira.or.kr/handle/2019.oak/729>.
28. Zaal RJ, den Haak EW, Andrinopoulou ER, van Gelder T, Vulto AG, van den Bemt PMLA. Physicians' acceptance of pharmacists' interventions in daily hospital practice. *Int J Clin Pharm* 2020;42:141-9.
29. Prasad N, Lau ECY, Wojt I, Penm J, Dai Z, Tan ECK. Prevalence of and risk factors for drug-related readmissions in older adults: a systematic review and meta-analysis. *Drugs Aging* 2024;41:1-11.
30. Morin L, Laroche ML, Texier G, Johnell K. Prevalence of potentially inappropriate medication use in older adults living in nursing homes: a systematic review. *J Am Med Dir Assoc* 2016;17:862.e1-9.
31. American Diabetes Association Professional Practice Committee. 13. Older adults: standards of care in diabetes—2024. *Diabetes Care* 2024;47(Suppl 1):S244-57.