

# Addressing medication safety in the elderly: prevalence of potentially inappropriate medications in outpatient geriatrics by Beers criteria 2023

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**Objective.** The global elderly population is anticipated to surpass 1.5 billion by the year 2050. Within the population covered by the Iran Health Insurance Organization (IHIO), approximately 8% consists of individuals aged 65 and above, amounting to over 3.5 million people. A critical concern in the elderly is the prevalent use of potentially inappropriate medications (PIM), leading to adverse drug reactions and hospitalizations. This study aimed to assess the prevalence of PIM prescriptions and polypharmacy among outpatient geriatrics in Tehran.

**Methods.** In this cross-sectional study, electronic medical records of geriatric patients ( $\geq 65$  years), covered by IHIO were collected from outpatient clinics over one year in Tehran. The evaluation of PIM was conducted with the Beers Criteria 2023, and analysis was performed utilizing the CRISP data mining methodology.

**Results.** This study analyzed 1,273,622 prescription medications from 327,295 patients. Approximately 57.14% of prescriptions were for female patients, and 60.27% of prescriptions were for the age group of 65 to 74 years. Polypharmacy was found in 36.95% of prescriptions. 21.04% (267,954 prescriptions) had at least one PIM. Ketorolac was the most often prescribed PIM. Psychiatrists exhibited a high PIM-prescribed prevalence. Linear regression analysis showed there was no association between patient age ( $\beta = -0.021$ ) or gender ( $\beta = -0.038$ ) and the prevalence of PIM prescriptions.

**Conclusions.** The notable prevalence of PIM and polypharmacy in Tehran's geriatric population raises the imperative for healthcare professionals, policymakers, and the IHIO to collaborate closely to enhance the prescription safety of the elderly population.

**Key words:** elderly, potentially inappropriate medications, Beers criteria, prescriptions

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## INTRODUCTION

The worldwide elderly population is growing rapidly. The proportion of individuals aged 65 and older in the world is expected to reach 12% by the year 2030, which is a significant increase from the 9% observed in 2019. This percentage is estimated to further rise to 16% by 2050 and potentially reach 23% by 2100<sup>1</sup>. Similarly, Iran is also experiencing an increase in its geriatric

population. In 2006, the General Population and Housing Census indicated that 2.5% of the country's population was 65 years or above. However, it is estimated that by 2051, this percentage will reach to 25%. Elderly persons have been divided into three distinct groups: the youngest-old, defined as those who are 65 to 74 years old; the middle-old, defined as those who are 75 to 84 years old; and the oldest-old, defined as those who are beyond 85 years old <sup>2</sup>. Concerns about the healthcare system and the distribution of resources for elderly people have been raised by the population's increase.

The use of many medications by one person, or polypharmacy, is a serious challenging issue that affects the health of the elderly <sup>3</sup>. Multiple studies have given varying figures for polypharmacy. The prescription of at least five drugs is the most often-used definition of polypharmacy <sup>4</sup>. Aging is accompanied by an increased risk of chronic diseases, which often require the use of multiple medications <sup>5</sup>. However, pharmacokinetics-the body's reaction to drugs-and pharmacodynamics-the biochemical and physiological effects of drugs on the body-change with age <sup>6</sup>. Additionally, physiological changes brought on by aging, such as diminished liver and kidney function, can raise the elderly's risk of going through adverse drug reactions <sup>7</sup>.

Choosing the right medicines for older patients is essential to ensuring their safety, effectiveness, and reduction of side effects. Accordingly, to lower medication-related damage, the World Health Organization has launched a global patient safety challenge <sup>8</sup>.

In the last two decades, several screening tools have been developed to evaluate the suitability of medications prescribed for older adults. The most well-known set of specific criteria for determining whether a medicine is acceptable is the Beers criteria, which were initially published in 1991 <sup>9</sup>. The Beers criteria were created as a research tool to improve clinical practice and assess possibly inappropriate drugs and drug-drug interactions in the elderly. The American Geriatrics Society carried out the most recent update in 2023 <sup>10</sup>. The aforementioned criteria are classified into five distinct categories:

Medications deemed potentially unsuitable, Medications potentially unsuitable in patients suffering from specific diseases or syndromes, medications ensuring cautious utilization, medications with potential for inappropriate drug interactions, and Medications necessitating dosage adjustments contingent upon renal function.

Prescriptions with polypharmacy are more likely to include potentially inappropriate medications, which pose greater risks than benefits <sup>11</sup>. The prevalence of potentially inappropriate medications varies greatly between countries, with rates ranging from 8.6% to 81% <sup>12</sup>. These pharmaceutical treatments have potential impacts on the neurological, mental, cardiovascular, and gastrointestinal systems. These medications raise the possibility of drug-drug interactions <sup>13</sup>, which can result in malnutrition, falls, cognitive decline, and even death in geriatrics <sup>14</sup>. They additionally impose a heavy financial burden on the healthcare system, increasing hospitalization costs and the cost of managing medication-related adverse events <sup>15</sup>.

Assessing the rate of elderly people receiving inappropriate drug prescriptions is essential in reducing side effects, enhancing quality of life, and saving healthcare expenses. This study aims to investigate the prevalence of potentially inappropriate medication prescriptions for the elderly under Iran Health Insurance Organization (IHIO) coverage in Tehran province throughout a one year. This study focuses only on medications that shouldn't be prescribed to the elderly due to access issues to diagnoses of conditions that weren't documented in the prescriptions.

## METHODS

In this cross-sectional study, the Cross Industry Standard Process for Data Mining (CRISP) <sup>16</sup> was employed to analyze prescription medication data for elderly individuals (65 years and older) covered by the IHIO. The study included all medicine prescriptions from outpatient healthcare centers in Tehran province over a one

**Table 1.** The characteristics of variables in the final data set.

Variable	Type-scale	Description
Prescription ID	String-nominal	Unique ID of each prescription
Age	Numeric-discrete	Patient's age
Sex	String-nominal	Patient's sex
Physician specialty	String-nominal	The specialty of each provider
Medicine name	String-nominal	Name of the prescribed medicine
Medicine number	Numeric-discrete	Number of the prescribed medicine
Medicine cost	Numeric-discrete	Payment made by IHIO for each medicine

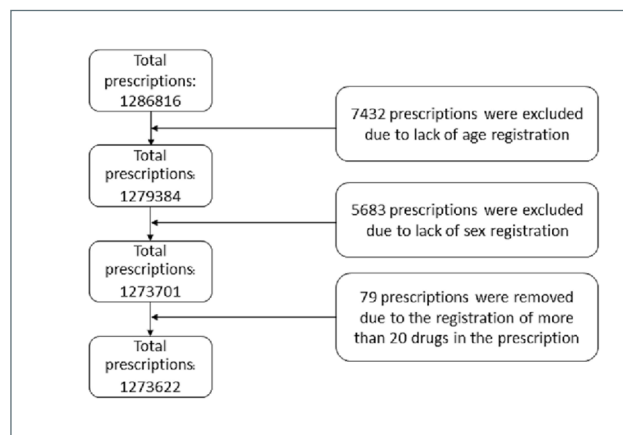
IHIO: Iran Health Insurance Organization.

year from March 21, 2022, to March 20, 2023. Tehran province, the capital of Iran, has the highest population of elderly individuals among provinces, with over 500,000 elderly individuals covered by IHIO in 2022. Clinical and demographic data of patients are recorded in electronic prescription systems. The data was obtained from the Information Technology Department of the IHIO following the necessary legal procedures. The required data includes prescription ID, patient's age and gender, names of prescribed medications, payment made by IHIO for the medications, and the prescribing physician's specialty. The dataset was created based on the collected information (Tab. I).

The dataset was carefully processed and cleaned. Prescriptions with missing or incomplete patient age and gender information were removed. Each medication has a unique generic code based on its form (tablet, capsule, or syrup), so the medications were sorted according to their ATC codes. Ultimately, the dataset, consisting of 1,273,622 prescribed prescriptions, was stored in CSV format. The list of PIMs, as defined by Beers criteria<sup>10</sup>, which includes 60 different drugs, was identified. Each prescribed medication in the electronic prescriptions was labeled as either a PIM or non-PIM. The patients were divided into three groups based on their age. Group 1 consisted of patients aged 65-74, Group 2 of patients aged 75-84, and Group 3 of patients aged 85 and above<sup>2</sup>.

#### STATISTICAL ANALYSIS

Investigations were conducted into the frequency and percentage of PIM prescriptions, as well as the patient's age, sex, number of medications (1-4, 5-10, and > 10 medications), and the prevalence of PIMs among physicians. To ascertain the patient characteristics (age and sex) that were correlated with PIMs, multiple logistic



**Figure 1.** Specific procedures of inclusion and exclusion of patient prescription.

regression analysis was conducted. Statistical analyses were performed using Python software, version 3.12.2.

## RESULTS

This study analyzed 1,273,622 prescription medications from 327,295 patients (Fig. 1). The prescriptions' demographic features are displayed in Table II. Approximately 57.14% (727,723 prescriptions) were for female patients, and 60.27% (767,600 prescriptions) were for the age group of 65 to 74 years. Every patient was prescribed 3.89 times on average, with an average of 4.09 medications per prescription. Polypharmacy was found in 36.95% of prescriptions (470,726 prescriptions). Of all the prescriptions, 21.04% (267,954 prescriptions) had at least one PIM, and PIMs had been prescribed to 40.25% of the patients. IHIO paid 96,800,321,750 Iranian Rials in total for these PIMs, which accounted

**Table II.** Basic characteristics of prescriptions and the prevalence of PIMs.

Characteristics	Total (n = 1,273,622)	Non-PIM (n = 1,005,668)	PIM (n = 267,954)
<b>Patient N (%)</b>	327,295	195,557 (59.74)	131,738 (40.25)
<b>Sex N (%)</b>			
<b>Male</b>	545,895 (42.86)	445,931 (44.34)	99,964 (37.30)
<b>Female</b>	727,723 (57.14)	559,733 (55.65)	167,990 (62.69)
<b>Age (y) N (%)</b>			
<b>65-74</b>	767,600 (60.27)	602,405(59.90)	165,195 (61.65)
<b>75-84</b>	388,183 (30.48)	309,012 (30.72)	79,171 (29.55)
<b>≥ 85</b>	117,839 (9.25)	94,251 (9.37)	23,588 (8.80)
<b>Polypharmacy (medications) N (%)</b>			
<b>1-4</b>	802,896 (63.04)	375,239 (67.14)	127,657 (47.64)
<b>5-10</b>	434,473 (34.11)	314,077 (31.23)	120,396 (44.93)
<b>&gt; 10</b>	36,253 (2.85)	16,352 (1.63)	19,951 (7.43)

N: number, y: year, PIM: potentially inappropriate medication.

**Table III.** Five specialties with the most frequency of the PIM prescriptions.

Physician	Total prescriptions (N, %)	PIM prescriptions (N, %)	Drug (%)
General practitioner	393,966 (30.93)	142,446 (53.16)	Ketorolac
Internist	292,189 (22.94)	37,750 (14.09)	Insulin (short- or rapid-acting insulin)
Cardiologist	144,392 (11.34)	15,636 (5.84)	Chlordiazepoxide
Neurologist	56,787 (4.46)	13,676 (5.10)	Clonazepam
Orthopedist	56,474 (4.43)	9,229 (3.44)	Ketorolac

PIM: potentially inappropriate medication, N: number.

**Table IV.** Five specialties with the most prevalence of the PIM prescriptions.

Specialty	Total prescriptions (N)	PIM prescriptions (N, %)	Drug
Psychiatry	23,629	10,614 (44.92%)	Clonazepam
General practitioner	393,966	142,446 (36.16%)	Ketorolac
Emergency medicine specialist	31,970	11,431 (35.76%)	Diphenhydramine
Family medicine	1,569	440 (28.04%)	Insulin (short- or rapid-acting insulin)
Neurologist	56,787	13,676 (24.08%)	Clonazepam

PIM: potentially inappropriate medication, N: number.

for 3.18% of the overall cost of the medications. With 51.03% of prescriptions, ketorolac was the most often prescribed PIM for all age groups and both genders combined.

Psychiatrists exhibited a high PIM prescribed prevalence, despite general practitioners having the greatest number of PIM prescriptions (53.16% of all PIM prescriptions). But while clonazepam was the most often recommended medicine by psychiatrists, ketorolac was the most commonly prescribed prescription overall. The five physicians who prescribed PIMs at the greatest frequency and prevalence, as well as the most often prescribed medication, are shown in Tables III and IV. The results of logistic regression analysis showed that the prescription of PIMs was not related to the female sex ( $\beta = -0.021$ , 95% CI = (-0.018-(-0.014)) or older age ( $\beta = -0.038$ , 95% CI = (-0.036-(-0.034)).

## DISCUSSION

This study aimed to investigate the prevalence of PIMs prescribed in outpatient settings in Tehran, the capital of Iran, over a one year. We observed a high prevalence of PIM prescriptions, particularly among women and the young elderly population. The most frequently prescribed PIM was Ketorolac. These findings underscore the importance of improving prescribing practices, especially in pain management for the elderly. While general practitioners had the highest frequency of PIM

prescriptions, psychiatric physicians had the highest prevalence of PIM prescriptions.

Several studies have investigated the prevalence of PIM prescriptions in different patient populations. The high prevalence of PIM prescriptions in this study aligns with research from other countries, emphasizing the global significance of this issue. In a study conducted in Jordan, the prevalence of PIM prescriptions based on the Beers 2015 criteria was reported as 62.5% among 4,622 elderly patients attending outpatient clinics<sup>17</sup>. In South Korea, a study of 7,132 elderly patients from a healthcare center reported a prevalence of 27.6% based on the Beers 2012 criteria<sup>18</sup>. A study in New Zealand found a prevalence of 40.9% using the Beers 2012 criteria<sup>19</sup>. In China, a study involving 12,005 elderly patients reported a prevalence of 30.98% and 34.39% based on the Beers 2015 and 2019 criteria, respectively<sup>20</sup>. The variations in findings are due to different Beers criteria, participant characteristics, prescription patterns, and sample sizes. In the present study, the latest update of the Beers criteria (2023) was used, and the data related to all elderly patients attending outpatient clinics in Tehran province. Specifically, PIMs are avoided for the elderly as defined by the Beers criteria and were analyzed using data mining techniques.

Consistent with the study of Al-Azayzih et al.<sup>17</sup> the results of this study also indicated that Ketorolac is the most commonly prescribed PIM. Within the class of medications known as nonsteroidal anti-inflammatory drugs (NSAIDs), Ketorolac is used to treat moderate to

severe acute onset pain<sup>21</sup>. One of the major contributing factors to disability in geriatric is chronic pain. Therefore, the daily use of NSAIDs has been reported in a majority of geriatrics with chronic musculoskeletal pain<sup>21</sup>. A study conducted by Zeinali et al.<sup>22</sup> in Iran in 2017 showed that in 19.3% of prescriptions, at least one NSAID was prescribed. With the increasing aging population, the use of painkillers is expected to rise<sup>23</sup>. NSAIDs are the most commonly used analgesics in these patients, serving as alternatives to opioid analgesics<sup>21</sup>. Although initially considered safer alternatives in this specific population, evidence suggests that the side effects of NSAIDs often outweigh their analgesic benefits<sup>23</sup>. Side effects such as hypertension, heart failure, gastrointestinal toxicity, renal dysfunction, cardiovascular problems, and stroke have been reported in the elderly following NSAID use<sup>21</sup>. Moreover, the treatment costs associated with cardiovascular and gastrointestinal side effects of NSAIDs may outweigh their cost-effectiveness in comparison to quality-adjusted life years<sup>24</sup>.

Furthermore, the findings of the present study indicated that general practitioners are the highest prescribers of PIMs, possibly due to their larger numbers and patients contacting them in the first line of treatment. Psychiatrists also had a high prevalence of PIM prescriptions, with the most commonly prescribed medication being Clonazepam. This finding is consistent with previous studies<sup>20,23</sup>. Clonazepam belongs to the class of benzodiazepines. The high rate of benzodiazepine prescriptions can be attributed to the high prevalence of insomnia and anxiety in the geriatrics<sup>25,26</sup>. With increasing age, the structure and functioning of brain regions involved in sleep changes, leading to sleep problems such as insomnia, reduced deep sleep and decreased sleep duration<sup>27</sup>. Evidence shows that the use of benzodiazepines has side effects in geriatric patients and increases the risk of gait instability, balance problems, psychomotor impairment, cognitive impairment, and forgetfulness<sup>28</sup>. Association between Alzheimer's disease and the use of benzodiazepines have been revealed in some studies<sup>29</sup>. Most clinical practice guidelines recommend pharmacological treatment if cognitive-behavioral therapy and non-pharmacological treatments for insomnia are unsuccessful<sup>30</sup>.

Age and gender were not significantly associated with PIM prescriptions in this study. This finding aligns with findings from previous research conducted in Japan and India<sup>31,32</sup>. It is important to consider the specific characteristics of the study population, sample size, and contextual factors when interpreting these results. Further research with larger sample sizes like ours and diverse populations is needed to explore the complex factors influencing PIM prescriptions.

The study had several limitations that should be

considered when interpreting the results. Firstly, the data used in the study were specific to patients covered by IHIO. Although IHIO covers approximately half of the country's population, we lack information on other healthcare insurances as well as data on over-the-counter medications. This limitation restricts the generalizability of the findings to the entire population. Secondly, since the registration of disease diagnosis in electronic prescriptions is not mandatory, we were unable to establish a relationship between the type of disease and the prescription of PIMs. Furthermore, we only focused on the first criterion of the Beers criteria, which pertains to medications that are generally contraindicated for the elderly and did not examine other criteria that require a disease-specific diagnosis. This limitation limits our understanding of the association between specific diseases and the prescription of PIMs. Thirdly, due to the exclusive use of electronic prescriptions, we lacked information on the overall health status and comorbidities of the patients. Although PIMs are often associated with chronic diseases, we were unable to analyze their relationship with any specific disease in our study. Lastly, as this was a retrospective study, we were unable to provide evidence of causality between the variables under investigation. Retrospective studies are valuable for generating hypotheses, but further prospective studies are needed to establish causal relationships.

## CONCLUSIONS

In conclusion, this study highlights the importance of addressing the prevalence of PIM prescriptions in outpatient settings. Healthcare providers need to be aware of the potential risks and side effects associated with PIMs, especially in vulnerable populations. Patient education and advocacy for safe and appropriate medication use are essential to promote better prescribing practices.

### Conflict of interest statement

The authors declare no conflict of interest.

### Funding

The sponsor has not been specifically involved in the research.

### Author contributions

LGh, MGh: contributed to the research concept; MGh: supervised the entire study; LGh: performed the analysis; NA: conducted literature search; LGh, NA: wrote the manuscript. All authors contributed to the article and approved the submitted version.

### Ethical consideration

This study was approved by the Research Ethics Committees of National Institute for Health Research-Tehran University of Medical Sciences (approval ID: IR.TUMS.NIHR.REC.1402.022). The Declaration of Helsinki's tenets, as well as national and international ethical standards, guided the conduct of this study. On a secure server set up for this purpose, data integration and analysis were performed by the study team's analytical plan. Participants' privacy and confidentiality were protected. No reports of this study that have been published identify the participants. All created material, including reports, study protocols, paperwork, and data, will be kept strictly confidential.

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