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A Cross-Sectional Retrospective Study Assessing Potentially Inappropriate Medications for Elderly Diabetic Patients in a Tertiary Care Hospital in Saudi Arabia

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Background: The aging global population presents challenges in medication management, particularly among diabetic elderly patients vulnerable to potentially inappropriate medications (PIM). PIM can lead to adverse outcomes like hypoglycemia, falls, cognitive decline, and hospitalizations, affecting quality of life and survival. This study aimed to assess PIM prevalence among diabetic elderly patients in a tertiary care hospital in Saudi Arabia, using the American Geriatrics Society 2023 Updated Beers Criteria.

Methods: A cross-sectional retrospective study was conducted among 480 diabetic adults aged 60 years or older at a tertiary care hospital over 3 months. Data, including demographics, comorbidities, and medication use, were extracted from Electronic Health Records. 2023 AGS Updated Beers Criteria® was followed.

Results: The median age was 66 years with a male predominance (62.7%). Peripheral vascular disease (42.7%) and prior myocardial infarction (22.7%) were prevalent comorbidities. Inappropriate insulin use was observed in 17.7% of insulin users, mainly short-acting insulin without basal/long-acting insulin. Approximately 39.2% of patients were prescribed antidiabetic drugs deemed inappropriate by Beers Criteria, with Gliclazide being the most common (35.6%). Despite potential drug–disease interactions, such as urogenital infections, half of the patients received cautioned drugs, while only 4.2% experienced such infections.

Conclusion: The study highlights the prevalence of PIMs among diabetic elderly patients in Madinah, Saudi Arabia. Adherence to Beers Criteria guidelines is crucial to optimize therapy for this population. Age and congestive heart failure were significant predictors of PIM use.

Keywords: beers criteria, elderly, diabetes, insulin, PIM, Saudi Arabia

Introduction

The global elderly population is rapidly expanding, with projections indicating a significant rise in the percentage of individuals aged 65 years and older. Presently, approximately 8.5% of the world's population falls within this demographic, a figure anticipated to double to 17% by the year 2050.[1] Saudi Arabia is experiencing a demographic shift characterized by a rapidly growing aging population.[2] Saudi Arabia predicts that by 2050, the proportion of people aged 60 and above will rise to make up 20% of the total population, indicating a substantial increase from earlier years.[3] The changing demographics pose unique challenges for healthcare systems, necessitating a focused approach to address the specific healthcare needs of the elderly.

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As the older adult population grows, the prevalence of chronic comorbid health disorders is projected to increase due to the unavoidable nature of aging.[4] One of the highly prevalent chronic conditions in Saudi Arabia is diabetes.[5] Diabetes ranks among the top ten leading causes of illness and death globally.[6] According to the International Diabetes Federation, Saudi Arabia has one of the highest prevalence rates of diabetes in the Middle East. By 2035, it is estimated that diabetes will affect 27% of adults in Saudi Arabia.[7] Thus, older individuals are frequently disproportionately affected.

Managing diabetes in older adults proves challenging for several reasons, including the prevalence of comorbidities, polypharmacy, and the physiological changes that are associated with aging.[8] Elderly patients are at a higher risk of exposure to potentially inappropriate medications (PIMs) due to age-related changes in pharmacokinetics and pharmacodynamics, which may increase adverse drug reactions and reduce treatment efficacy. Moreover, older individuals tend to have multiple chronic degenerative conditions, resulting in the use of more medications compared to younger populations. The use of PIMs in this group can lead to preventable adverse drug events such as falls, fractures, and delirium, and is linked to higher rates of hospitalization and mortality.[9,10] This may lead to an increase in polypharmacy to effectively manage these comorbidities and prevent associated complications. Polypharmacy is commonly defined as the concurrent use of multiple medications. The exact minimum number of drugs used to define "polypharmacy" is variable but generally, ranges from five to ten.[11] A recent cross-sectional study in Saudi Arabia among 8932 diabetic patients reported that the prevalence of polypharmacy among patients with diabetes was 78%.[12]

The major consequences of polypharmacy for a patient, besides non-adherence to prescribed regimens, include a much higher risk of adverse drug effects, drug interactions, and an increased risk of PIMs.[8] PIMs are defined as

> medications that should be avoided due to their risk which outweighs their benefit and when there are equally or more effective but lower risk alternatives are available[13]

As a result of the prevalence of polypharmacy among older individuals, the risk of PIMs use is increased for this population. Particularly, diabetic patients are more threatened by complications that include microvascular and macrovascular effects. Microvascular problems encompass neuropathy, nephropathy, and retinopathy. Macrovascular problems include cardiovascular disease, stroke, and peripheral vascular disease.[8] These complications increased vulnerability to PIMs and adverse drug reactions in the elderly. Identification and management of PIMs is crucial in diabetic elderly patients. They encounter many challenges that necessitate a careful evaluation of their medication regimens.

Various criteria have been developed by expert panels in different countries to assess the quality of prescribing practices and medication use in older adult individuals. The most frequently cited criteria for inappropriate medications are the Beers criteria and STOPP/START criteria (Screening Tool of Older Persons Prescriptions/Screening Tool to Alert doctors to the Right Treatment).[14] Beers Criteria, developed by expert consensus and regularly updated, provides a valuable tool for identifying medications that should be avoided or used with caution in the elderly population.[15]

Although numerous studies have examined the use of PIMs among older adults abroad following the American Geriatric Society (AGS) Beers criteria, few studies have examined the factors associated with PIM use among older adults in Saudi Arabia.[3] A recent systemic review showed there were 8 studies conducted in Saudi Arabia most of them based on the central region data.[3] A recent study in Riyadh city revealed that the prevalence of older adults who have been prescribed at least one PIM in their lifetime varies within the range of 45–66%.[16] The predominant emphasis of these studies was on general PIMs, with limited attention given to the implementation of PIMs in particular disease clusters. A single study examined elderly patients with diabetes and hypertension, revealing that 56% of older adults with both conditions were using potentially inappropriate medications.[17]

Therefore, this study endeavors to shed light on the prevalence of PIMs among diabetic elderly patients in a tertiary care hospital, Madinah, Saudi Arabia, using the Beers Criteria as a guide. The study will contribute to the enhancement of medication management practices for this vulnerable population, ultimately improving health outcomes and ensuring a higher quality of life for the elderly with diabetes in Saudi Arabia.

Materials and Methods

This cross-sectional retrospective study was conducted among outpatients at a tertiary care hospital in Madinah, Saudi Arabia over a period of three months from January 2024. Data were extracted from the Electronic Health Record (EHR). The study included 480 diabetic adults aged 60 years or more.

A data collection form was used for retrieving information about participants' demographic characteristics such as age, gender, education level, residence area, and smoking habits. Information on the patients' chronic diseases, Charlson comorbidity index (CCI) data and prescribed antidiabetic medications. The American Geriatrics Society 2023 Updated Beers Criteria were used to determine potentially inappropriate antidiabetic medication use.

The data were thoroughly reviewed and analyzed by two clinical pharmacists and an associate professor of clinical pharmacy. PIMs were identified according to the American Geriatrics Society 2023 updated AGS Beers Criteria® for potentially inappropriate medication use in older adults.[18] PIMs in the Beers criteria included the following categories: medications to be avoided in elderly patients regardless of medical conditions; medications to be avoided in combination with specific diseases or syndromes; medications that should be used with caution; medications that should be avoided or have their dose adjusted based on kidney function; and selected clinically significant drug–drug interactions documented to be associated with harmful effects in older adults.

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Ethical approval was obtained from the institutional review board (IRB) of the general directorate of health affairs in Madinah (H-03-M-84) with the approval number 23–044 with a waiver of consent. No personal data, which makes patients identifiable were used. The sample size was calculated using an online calculator, namely Raosoft, with a 5% margin of error and 95% confidence interval. Statistical analysis was done by SPSS version 28 (IBM Co., Armonk, NY, USA). Quantitative data were presented as median and interquartile range (IQR), analyzed by Mann–Whitney-test. Categorical data were presented as frequency and percentage, analyzed using Chi-square test or Fisher's exact test when appropriate. Logistic regression analysis was performed to assess different factors associated with PIM prescription. A two tailed P value <0.05 was considered statistically significant.

Results

Demographic Data and Characteristics of Participants

This study was conducted on 480 elderly outpatients, with a median age of 66 years. The age distribution was 67.7%, 26.5%, and 5.8% for the 60–69, 70–79, and ≥80 age ranges, respectively. There was a male predominance representing 62.7% of individuals. [Table 1]

Table 1 Characteristics of the Studied Patients (n = 480)

	N	%
Age (years)		
60–69	325	67.7
70–79	127	26.5
≥80	28	5.8
Median (IQR)	66 (62–72)	
Sex		
Male	301	62.7
Female	179	37.3

Charlson Comorbidity Index (CCI)

The most frequently reported comorbidities among the studied patients were peripheral vascular disease and patients who reported prior incidence of myocardial infarction, elicited by 42.7% and 22.7%, respectively. Based on the mentioned comorbid conditions, the median CCI was 4 (IQR between 3 and 5) [Table 2, Figure 1].

Appropriateness of Use of Insulin Preparations Among Elderly Population

Out of the total sample size (n = 480), 271 individuals (56.5%) were using insulin. Among insulin users, 223 patients (46.5%) were using long-acting basal insulin such as degludec, glargine, or detemir, while 164 individuals (34.2%) were using short or intermediate acting insulin of all types. According to beers criteria, short acting Insulin should not be used on its own without a basal/long-acting insulin to avoid hypoglycemic events. Inappropriate use of insulin was observed in 48 individuals out of the total sample (10.0%), while among insulin users specifically, 48 out of 271 individuals (17.7%) were identified as inappropriately using insulin. [Table 3, Figure 2]

Appropriateness of Use of Antidiabetic Drugs

Most patients (85%) were using antidiabetic drugs, while 15% were maintained only on insulin preparations [Table 4]. According to 2023 updated AGS Beers Criteria, a few antidiabetic drugs should be avoided in geriatrics. Looking at these specific drugs in patients' records, it was found that Gliclazide, Glimepiride, and Glyburide were administered at rates of 35.6%, 3.5%, and 0.2%, respectively. Other antidiabetic drugs deemed safe for elderly patients represented 72.5%. The median frequency of antidiabetic drugs per patient was 2 drugs (IQR between 1 and 3). More than one-third of all patients (39.2%) were using inappropriate antidiabetic drugs, including drugs that should be avoided in the elderly, according to Beers criteria. Those represent 46.1% of users of antibiotic drugs [Figure 3, Table 4].

Table 2 Comorbidities of the Study Participants (n = 480)

	N	%
Peripheral vascular disease	205	42.7
Prior myocardial infarction	109	22.7
Congestive heart failure	62	12.9
Chronic pulmonary disease	42	8.8
Renal disease	41	8.5
Rheumatologic disease	35	7.3
Liver disease	25	5.2
Mild	19	4.0
Moderate or severe	6	1.3
Cancer	13	2.7
Cerebrovascular disease	9	1.9
Peptic ulcer	8	1.7
Paralysis	8	1.7
Dementia	4	0.8
AIDS	2	0.4
Age score		
Score 2 (60–69 years)	325	67.7
Score 3 (70–79 years)	127	26.5
Score 4 (≥80 years)	28	5.8
CCI		
Median (IQR)	4 (3–5)	
Range	2–14	

Abbreviation: AIDS: Acquired immunodeficiency syndrome.

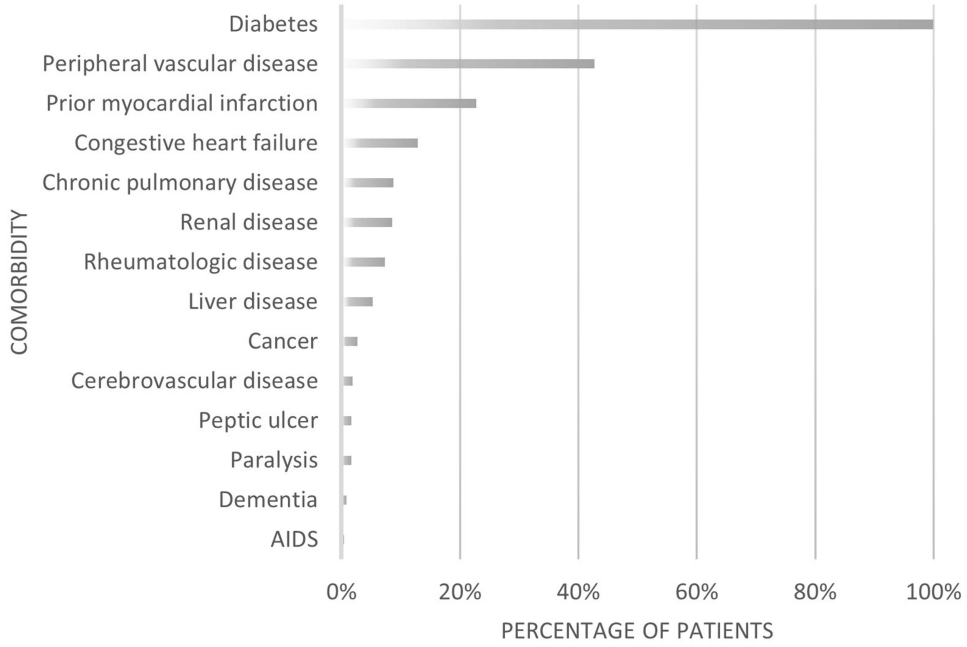

Figure 1 Comorbidities of the studied patients indicate comorbidity percentages according to Charlson comorbidity index (CCI). The horizontal column represents comorbidities as percentage from the total patients' number (n = 480).

Drug–Disease Interactions in the Elderly

According to the updated version of Beers Criteria (2023), a number of drugs were assigned as "use with caution" for those who are 60 years old or older. Those drugs include Canagliflozin, Dapagliflozin Empagliflozin, and Ertugliflozin. Additionally, when using these drugs, patients should be investigated for urogenital infections and ketoacidosis. Drug–diseases interactions between the aforementioned drugs and relevant diseases according to Beers criteria will result in classifying these drugs as "inappropriate" for diabetic elderly patients. The SGLT-2 inhibitors Canagliflozin, Dapagliflozin, Empagliflozin, and Ertugliflozin were prescribed to around half of the patients (49.6%). However, only 4.2% of our patients had urogenital infection or ketoacidosis and 10.8% elicited symptomatic heart failure. The use of pioglitazone may carry a risk for cardiovascular disease; however, our results showed that pioglitazone was not prescribed to any of the patients in this study. This can be because of the unavailability of the drug in the ministry of health hospital during the study period. The overall drug–disease interaction reported here was as high as 50.6% of patients [Table 5].

Factors Potentially Affecting the PIM Use of Antidiabetic Medications

Analysis of the results showed that the patients with congestive heart failure were on appropriately prescribed medications (P = 0.001), suggesting that those patients are better monitored and controlled. Moreover, CCI was significantly lower in patients using PIMs than those who were not (P = 0.008). This means that less comorbidities, as judged by CCI, were associated with lower PIM, which is a positive indicator [Table 6].

Table 3 Insulin Use for the Studied Patients (n = 480)

	N	%
Insulin use	271	56.5
Long-acting basal insulin (Degludec/Glargine/Detemir)	223	46.5
Short and intermediate acting insulin (all types)	164	34.2
Inappropriate use (of all patients)	48/480	10.0
Inappropriate use (of insulin users)	48/271	17.7

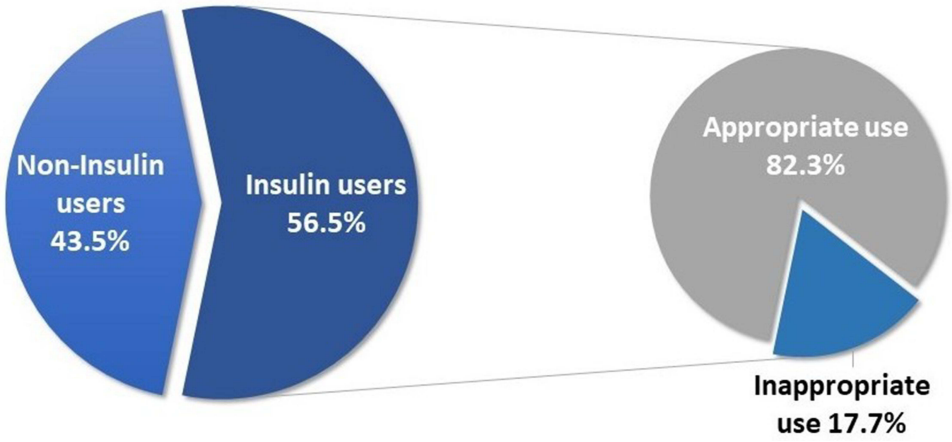

Figure 2 Appropriateness of insulin use among the studied patients. The pie chart illustrates the distribution of insulin usage among the study sample.

Factors Affection Potentially Inappropriate Antidiabetic Medications

To study the association between PIM prescription and drug–disease interactions, appropriate medication use was significantly associated with symptomatic heart failure (P = 0.017) as shown in Table 7. Among the total sample, consisting of 248 individuals without PIM prescription and 232 individuals with PIM prescription, the use of specific medications like Canagliflozin, Dapagliflozin, Empagliflozin, and Ertugliflozin was observed in 50% and 49.1%, respectively, with no significant difference observed (P = 0.85). Regarding specific diseases, urogenital infection or ketoacidosis was present in 4.8% of individuals without PIM prescription and 3.4% of those with PIM prescription (P = 0.446). Symptomatic heart failure was identified in 14.1% of individuals without PIM prescription and 7.3% of those with PIM prescription, with a statistically significant difference noted (P = 0.017). Overall, drug–disease interactions were observed in 52% of individuals without PIM prescription and 49.1% of those with PIM prescription, showing no significant association (P = 0.529). Data are presented as frequency (%) with statistical significance set at $P < 0.05$.

Logistic Regression Analysis for Factors Associated with PIM

In univariate regression analysis, age and congestive heart failure were independent predictors of PIM use among patients. The eighty-year-old patients and older had significantly lower odds of PIM prescription than the 60–69 age group (OR = 0.37, 95% CI: 0.16 to 0.86, P = 0.021). Patients with congestive heart failure had significantly lower odds of PIM prescription than those with no such condition (OR = 0.39, 95% CI: 0.22 to 0.7, P = 0.001).

Table 4 Antidiabetic Drug Use of the Studied Patients

	N	%
Antidiabetic drugs use	408	85.0
Number of antidiabetic drugs per patient Median (IQR)	2 (1–3)	
Antidiabetic drugs		
Gliclazide	171	35.6
Glipizide	0	0.0
Glimepiride	17	3.5
Glyburide (Glibenclamide)	1	0.2
Other	348	72.5
Inappropriate use (of total)	188/480	39.2
Inappropriate use (of antidiabetics users)	188/408	46.1

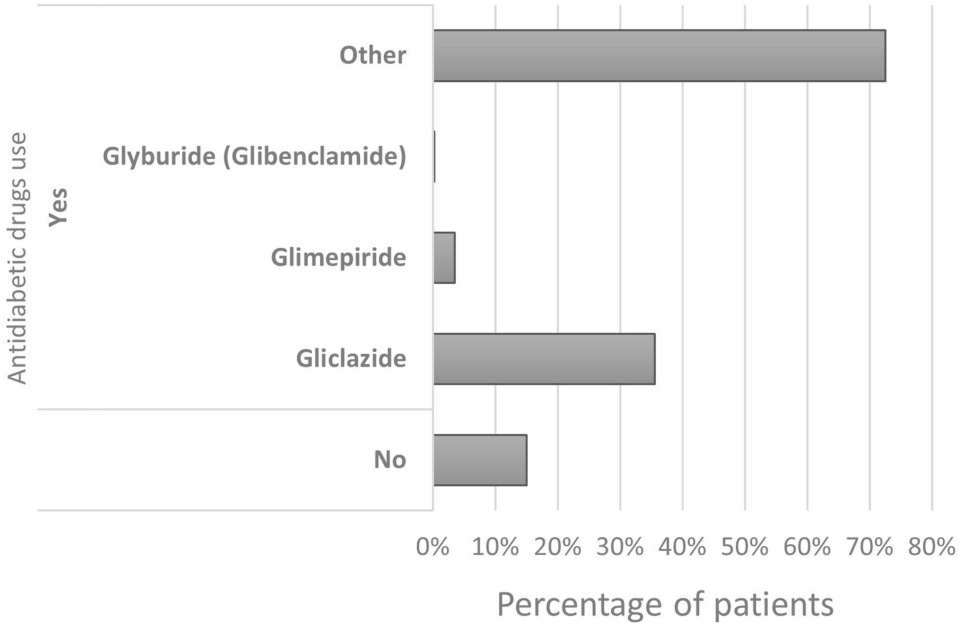

Figure 3 The use of antidiabetic drugs inappropriately prescribed for elderly patient according to Beers criteria.

Based on multiple regression analysis, patients with congestive heart failure had significantly lower odds of PIM prescription than those with no such condition (OR = 0.45, 95% CI: 0.25 to 0.83, P = 0.01) [Table 8].

Discussion

This study explored the prevalence and factors associated with potentially inappropriate medications (PIMs) usage among elderly diabetic patients in Madinah, Saudi Arabia, utilizing the American Geriatrics Society 2023 Updated Beers Criteria. Among the 480 studied elderly diabetic patients, the coexistence of other chronic conditions was highly prevalent. This finding is consistent with the findings from previous studies indicating that 86% of patients with diabetes had at least one coexisting chronic condition.[12] Peripheral vascular disease and prior myocardial infarction were highly prevalent among the studied diabetic patients. Studies suggest diabetes mellitus significantly heightens the risk of

Table 5 Drug–Disease Interaction Among the Studied Patients (n = 480)

	N	%
Medication		
Pioglitazone	0	0.0
Canagliflozin, Dapagliflozin Empagliflozin, Ertugliflozin	238	49.6
Disease		
Urogenital infection or ketoacidosis	20	4.2
Symptomatic heart failure	52	10.8
Risk of Pioglitazone + symptomatic heart failure	0	0.0
Risk of sulfonylurea + UTI		
No risk	237	49.4
Use with caution	228	47.5
Drug-disease interaction	15	3.1
Overall drug-disease interaction	243	50.6

Abbreviation: UTI: Urinary tract infection.

Table 6 Association Between Patients' Characteristics and PIM Prescription

	PIM Prescription		P value
	No (n=248)	Yes (n=232)	
Age (years)	66 (61–74)	66 (63–70)	0.645
Sex			
Male	158 (63.7%)	143 (61.6%)	0.639
Female	90 (36.3%)	89 (38.4%)	
Prior myocardial infarction	62 (25%)	47 (20.3%)	0.215
Congestive heart failure	44 (17.7%)	18 (7.8%)	**0.001**
Peripheral vascular disease	107 (43.1%)	98 (42.2%)	0.841
Cerebrovascular disease	4 (1.6%)	5 (2.2%)	0.745
Dementia	3 (1.2%)	1 (0.4%)	0.624
Chronic pulmonary disease	27 (10.9%)	15 (6.5%)	0.087
Rheumatologic disease	16 (6.5%)	19 (8.2%)	0.464
Peptic ulcer	6 (2.4%)	2 (0.9%)	0.287
Liver disease	16 (6.5%)	9 (3.9%)	0.205
Paralysis	6 (2.4%)	2 (0.9%)	0.287
Renal disease	27 (10.9%)	14 (6%)	0.057
Cancer	6 (2.4%)	7 (3%)	0.687
AIDS	1 (0.4%)	1 (0.4%)	>0.999
CCI	4 (4–6)	4 (3–5)	**0.008**

Notes: Data are presented as frequency (%) or median (IQR) as appropriate. Statistical significance with *P* values<0.05 are shown in bold.

Table 7 Association Between Drug–Disease Interaction and PIM Prescription

	PIM Prescription		P value
	No (n=248)	Yes (n=232)	
Medication			
Canagliflozin, Dapagliflozin Empagliflozin, Ertugliflozin	124 (50%)	114 (49.1%)	0.85
Disease			
Urogenital infection or ketoacidosis	12 (4.8%)	8 (3.4%)	0.446
Symptomatic heart failure	35 (14.1%)	17 (7.3%)	**0.017**
Drug-disease interaction	129 (52%)	114 (49.1%)	0.529

Notes: Data are presented as frequency (%), statistical significance with *P* values<0.05 are shown in bold.

peripheral artery disease and accelerates its progression, exposing diabetic patients more vulnerable to ischemia events and impaired functional status compared to patients without diabetes.[19–21]

In our study, a concerning finding was the inappropriate use of insulin therapies. About 17.7% of insulin users were found to be using insulin inappropriately. This included the use of short-acting insulin without concomitant basal insulin, which can lead to poor glycemic control and risk of hypoglycemic events. Numerous studies from different countries consistently show that short-acting insulin is the most prescribed PIM in older adults with diabetes.[22–24] This finding is concerning because, while short or rapid-acting insulin is an approved treatment for managing diabetes, it poses a significant risk of severe and prolonged hypoglycemia in older adults.

The use of Gliclazide or Glimepiride in older adults with diabetes in Saudi Arabia can be associated with PIM concerns.[25,26] According to the beer criteria, sulfonylureas (all, including short- and longer-acting) Gliclazide and Glimepiride have a higher risk of cardiovascular events, all-cause mortality, and hypoglycemia than alternative agents.[15] Sulfonylureas may increase the risk of cardiovascular death and ischemic stroke. Among older adult patients, the recommendation is to avoid sulfonylureas as first- or second-line monotherapy or add-on therapy unless there are

Table 8 Logistic Regression Analysis for Factors Associated with PIM Prescription

	Univariate Analysis			Multivariable Analysis		
	Unadjusted OR	**95% CI**	**P value**	**Adjusted OR**	**95% CI**	**P value**
Age (years)						
60–69	Ref			Ref		
70–79	0.71	0.47 to 1.07	0.097	0.8	0.52 to 1.25	0.333
≥80	0.37	0.16 to 0.86	**0.021**	0.53	0.21 to 1.3	0.164
Sex						
Male	Ref			Ref		
Female	1.09	0.75 to 1.58	0.639	1.02	0.69 to 1.51	0.93
Prior myocardial infarction	0.76	0.5 to 1.17	0.216	0.8	0.5 to 1.27	0.34
Congestive heart failure	0.39	0.22 to 0.7	**0.001**	0.45	0.25 to 0.83	**0.01**
Peripheral vascular disease	0.96	0.67 to 1.38	0.841	1.01	0.68 to 1.5	0.953
Cerebrovascular disease	1.34	0.36 to 5.07	0.663	2.71	0.54 to 13.53	0.223
Dementia	0.35	0.04 to 3.42	0.369	0.83	0.07 to 9.52	0.881
Chronic pulmonary disease	0.57	0.29 to 1.09	0.09	0.71	0.35 to 1.44	0.345
Rheumatologic disease	1.29	0.65 to 2.58	0.465	1.42	0.67 to 2.99	0.359
Peptic ulcer	0.35	0.07 to 1.76	0.202	0.47	0.09 to 2.47	0.371
Liver disease						
No	Ref			Ref		
Mild	0.48	0.18 to 1.29	0.144	0.54	0.19 to 1.54	0.249
Moderate or severe	1.04	0.21 to 5.21	0.962	1.4	0.26 to 7.66	0.699
Paralysis	0.35	0.07 to 1.76	0.202	0.28	0.04 to 1.84	0.184
Renal disease	0.53	0.27 to 1.03	0.061	0.64	0.31 to 1.31	0.222
AIDS	1.07	0.07 to 17.19	0.962	1.03	0.06 to 17.2	0.981

Notes: Statistical significance with *P* values<0.05 are shown in bold.
Abbreviations: OR: Odds ratio, CI: Confidence interval.

substantial barriers to the use of safer and more effective agents.[15] The findings discussed indicate a high utilization of Gliclazide among patients. Furthermore, the high rate of inappropriate use of these medications (39.8% of patients, representing 45.7% of all antidiabetic users) highlights a critical area for improvement. In addition, the median frequency of two antidiabetic drugs per patient underscores a significant reliance on polypharmacy, potentially increasing the risk of adverse drug interactions and complications. These findings highlight the importance of carefully considering the choice of antidiabetic medications in older adults with diabetes in Saudi Arabia to minimize the risk of PIMs.

The focus of our investigation encompassed the drug–disease or drug–syndrome interactions listed in Beer's criteria, which have the potential to exacerbate the existing disease or syndrome. Older adults using Sodium-Glucose Co-Transporter-2 (SGLT2) inhibitors, such as Canagliflozin, Dapagliflozin, Empagliflozin, and Ertugliflozin, may have an increased risk of urogenital infections. Older adults have also shown an elevated risk for euglycemic diabetic ketoacidosis. Despite nearly half of the participants utilizing SGLT2 inhibitors, the risk of urogenital infection or ketoacidosis was minimal. The findings align with previous trials conducted in Saudi Arabia, indicating that SGLT2 inhibitors were generally well tolerated over 12 months, with no significant safety concerns reported.[27,28] However, a meta-analysis including data from various trials indicated that SGLT2 inhibitors increase the risk of genital infections and urinary tract infections, with a higher odds ratio in diabetic patients compared to non-diabetic individuals.[29] Therefore, although SGLT2 inhibitors are generally safe, it is important to be cautious about the potential risks of urogenital infections and ketoacidosis especially in older adults.

Furthermore, the findings indicated that when sulfonylureas are used in the context of a urinary tract infection (UTI), more than half of the patients are at some level of risk, as indicated by the combination of the "Use with caution" and "Drug-disease interaction" categories. Although sulfonylureas were not directly linked to UTIs, studies have shown that diabetic patients can predispose individuals to UTIs due to factors like high glycosuria, hypertension, and insulin therapy.[30,31] Polypharmacy, common among adult patients in Saudi Arabia, can also complicate UTI management.[32]

While sulfonylureas were not associated with UTI risk, the use of multiple medications, including those for diabetes treatment, can increase the complexity of treatment and potentially lead to adverse drug events.[33] Therefore, while sulfonylureas themselves may not directly contribute to UTIs, the overall management of diabetes and comorbidities, including medication regimens, should be carefully considered to prevent UTIs in Saudi diabetic patients.

In addition, a noteworthy finding of the current study is the presence of certain chronic conditions such as congestive heart failure in older patients is associated with the increased chance of appropriate use of medication. This intriguing finding contrasts with earlier research on using PIMs in Saudi Arabia, suggesting a possible shift in prescribing practices or patient management strategies that warrants further investigation.[16,17] However, another study supports our findings, as it revealed that diabetic patients with congestive heart failure in Saudi Arabia had a lower prevalence of PIM prescriptions due to the involvement of geriatric pharmacists in their care.[34] This was supported by a study that found a high prevalence of drug-related problems (DRPs) and PIMs in elderly cardiac patients, with interventions by clinical pharmacists significantly reducing the occurrence of DRPs and PIMs by almost 50%.[35] This could reflect a heightened awareness and careful consideration in the prescription practices for this vulnerable patient group, indicating a positive shift toward safer and more effective medication management. This study reinforces the significance of engaging multidisciplinary healthcare teams, such as geriatric pharmacists, to optimize medication management for diabetic patients with congestive heart failure for instance. In Saudi Arabia, a study involving 270 patients, the prevalence of PIM was estimated at 60.7% in a tertiary hospital in Riyadh.[36] In a larger study carried out in Buraidah (Saudi Arabia), among 1123 patients, the prevalence was 66.25%,[37] while an interventional study carried out in Riyadh, reported a prevalence of PIM of 61%.[38] However, these figures represented PIM in elderly population in general, and not in diabetic patients specifically.

The study implication supports that healthcare providers and pharmacists play crucial roles in reducing PIMs among older adult diabetic patients in Saudi Arabia. Pharmacists, as part of multidisciplinary teams, can tailor medications for older adults, including those with diabetes, to improve clinical outcomes.[39,40] Studies show a high prevalence of PIMs among older adults in Saudi Arabia, with factors like the number of dispensed medications and diagnoses influencing PIM prescription.[41] Clinical pharmacist care has been proven to significantly improve diabetes outcomes, including reducing HbA1c levels and optimizing medication therapy for diabetic patients.[42,43] This study illuminates the need for a deeper understanding of how to mitigate the risks and economic impacts associated with unnecessary use of PIMs, particularly in the care of diabetic older adults. The findings highlight the importance of carefully selecting antidiabetic medications in older adults with diabetes in Saudi Arabia to minimize the risk of PIMs. Additionally, older patients could gain significantly from a multidisciplinary collaborative care model, where pharmacists play a key role in monitoring and optimizing medication use to reduce inappropriate prescriptions. Moreover, continuous educational initiatives for healthcare providers are essential to enhance their understanding of the guidelines and criteria for appropriate medication prescribing for the elderly, benefiting both providers and policymakers.

The study has some limitations. This cross-sectional design captures a single moment in time, which may not accurately reflect changes in PIM prevalence among older adults in the Madinah region over time. Furthermore, this study was conducted at a tertiary hospital in Madinah city. As a result, the findings of this study cannot be generalized to primary care settings or other regions in Saudi Arabia. Further, assessing any causal relationship is challenging because of the cross-sectional nature of the data. In addition, utilizing EHR data does not completely eradicate the potential for bias, as there is a possibility of encountering erroneous information or missing data from the usage of EHR. Despite these limitations, the findings in this study remain important because it was designed to apply the newest Beers criteria, which are widely used for PIMs in older adults in clinical settings. To our knowledge, no previous study has specifically explored the use of PIMs among diabetic patients in Madinah City. This study is particularly useful as it uncovers the prevalence and practices of PIM use in this vulnerable population, contributing valuable insights into their healthcare management.

In conclusion, this study has effectively enlightened the prevalence and complexities surrounding the use of PIMs among elderly diabetic patients in Madinah, Saudi Arabia. Utilizing the American Geriatrics Society 2023 Updated Beers Criteria, the research provides a crucial insight into the medication management practices that could be optimized to enhance health outcomes and improve the quality of life for this vulnerable population. The results emphasize the

importance of vigilant medication review, specifically concerning the difficulties presented by polypharmacy and the related risks of PIMs. The study emphasizes the need for multidisciplinary teams, which include pharmacists, to mitigate these risks by tailoring medication regimens to meet the complex demands of older patients with diabetes. This research ultimately enhances our comprehension of geriatric pharmacotherapy and emphasizes the necessity for ongoing education and advancement of policies to guarantee safe as well as effective utilization of medication in older populations.

Disclosure

The authors report no conflicts of interest in this work.

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