Evaluating medication adherence and its impact on glycemic control in elderly diabetic patients: a cross-sectional analysis

Shaker Masaeed Masad[1], Abdulaziz Mubarak Alshahrani[1], Azizah Mahmoud Alshubayni[1], Abdullah Mohammed Aldosar[1,] Masad Masaeed Masad [1],Sayed Ibrahim Ali[2]
1: General practitioner, Saudi Arabia
2: Assistant Professor, Department of Family & Community Medicine, College of Medicine, King Faisal University, Al-Ahsa, Saudi Arabia

Abstract
Medication nonadherence is a critical obstacle to optimum diabetes management. This study aimed to evaluate adherence and its impact on glycemic control in elderly (≥60 years) type 2 diabetics in Saudi Arabia. In this cross-sectional analysis, 65 outpatients completed the 8-item Morisky Medication Adherence Scale (MMAS-8) and had HbA1c values extracted from records. 44.6% exhibited low adherence per MMAS-8. Forgetfulness was a major barrier (70.8%). Mean HbA1c was suboptimal at 8.1%; only 26.2% achieved HbA1c<7%. Lower MMAS-8 scores strongly correlated with higher HbA1c. Patients aged over 80 years showed worse adherence (mean score 6.5) compared to 60-69 years (mean score 7.3). Longer diabetes duration (>10 years) and more comorbidities (≥4) were also associated with poorer adherence. This study demonstrates high prevalence of medication nonadherence among elderly Saudi diabetics significantly linked to inadequate glycemic control. Routine adherence screening and targeted interventions for individuals with identified barriers are imperative to optimize outcomes. Healthcare policies must prioritize resources and models supporting geriatric diabetes management.

Keywords: diabetes, elderly, adherence, glycemic control, Saudi Arabia

Introduction:
Diabetes mellitus (DM) has become a global public health crisis, with prevalence increasing at an alarming rate worldwide. According to the International Diabetes Federation, there were approximately 425 million adults with diabetes globally in 2017, projected to rise to 629 million by 2045 (1). The Middle East is one of the most affected regions, with over 35 million diabetic patients. The prevalence of DM in adults across the Eastern Mediterranean region is 13.7%, second only to the North American and Caribbean region (14.7%) (2).

Saudi Arabia is bearing a disproportionately high burden of this escalating epidemic. Recent national surveys estimate the prevalence of DM in Saudi adults to be 17.7% in males and 16.4% in females (3). Another study found overall DM prevalence of 18.3%, rising to 30% among elderly Saudis above 60 years old (4). With the population aging and obesity rates high, the incidence and prevalence of type 2 diabetes mellitus (T2DM) are expected to grow exponentially over the next few decades. Projections estimate 7.1 million adult diabetics in Saudi Arabia by 2035, a 134% increase from 2015 estimates (5). Diabetes has become one of the leading causes of premature death and disability in the Kingdom.

T2DM is a complex lifelong disease necessitating major lifestyle modifications and complicated self-care regimens. Management requires coordinated efforts in dietary changes, exercise, self-monitoring of blood glucose, and adherence to medications that target blood sugar control. Multidrug therapy combining oral hypoglycemic agents and/or insulin injections is typically needed to achieve optimal glycemic control, prevent acute complications, and reduce risk of cardiovascular and microvascular diseases associated with diabetes. However, the intricacy of these regimens places a huge self-management burden on patients. Medication nonadherence is recognized as a critical obstacle undermining successful diabetes care (6).

Adherence refers to the degree to which patients correctly follow medical advice and take medications as prescribed. The World Health Organization defines adherence as “the extent to which a person’s behavior – taking medication, following a diet, and/or executing lifestyle changes, corresponds with agreed recommendations from a health care provider” (7). Nonadherence includes behaviors like forgetfulness, skipping doses, stopping treatment prematurely, or taking more or less than prescribed dosage. A recent meta-analysis found adherence rates to oral hypoglycemic agents ranging from 36-93%, indicating that suboptimal adherence is very common among diabetics (8). Another review reported average adherence of just 67.9% for diabetes medications (9). Poor adherence attenuates optimum clinical benefits of therapies and compromises health outcomes.

Consequences of nonadherence include inadequate glycemic control, increased risk of complications, lower quality of life, increased healthcare utilization and costs, and adverse effects from treatment gaps or errors (10). Strong evidence demonstrates association between suboptimal adherence and higher hemoglobin A1c

(HbA1c), a marker of glycemic control (11). Nonadherence is linked to poorer cardiovascular and kidney outcomes, posing huge burden to patients. There are also substantial economic costs due to worse outcomes. Annual medical costs related to medication nonadherence are estimated at $100-$300 billion in the United States, accounting for 3-10% of total US healthcare costs (12).

Medication adherence is a multifaceted health behavior influenced by patient-related factors as well as external factors. Patient factors include perceptions about illness and treatment, motivation, self-efficacy, forgetfulness, costs, health literacy and cognitive abilities, etc. External factors are complexity of regimen, duration of treatment, healthcare system issues, sociocultural elements, among others (13). Rates and reasons for nonadherence may vary across different age groups, types of medications, and disease stages. Medication adherence in diabetics is a particular concern due to lifelong therapies, additional drugs for comorbidities, side effects, cost issues, and progressive self-care difficulties from complications or debility.

Among diabetes patients, adults over 65 years are especially vulnerable to poor medication adherence due to high prevalence of geriatric syndromes. Multimorbidity and polypharmacy are normative in this age group. Age-related cognitive and functional decline, vision/hearing/dexterity problems, depression, and limited social support interfere with successful self-care (14). Complex or inconvenient treatment plans are more likely to be abandoned by the elderly. A systematic review found nonadherence rates in elderly diabetics ranging from 12.5% for medication refills to 60.5% for dose nonadherence (15). Advancing age is an independent risk factor for poor adherence regardless of disease duration or comorbidities (16). Thus, the intersecting trends of population aging, increasing multimorbidity, polypharmacy, and chronic medication use necessitate greater attention to prescription adherence in geriatric patients with diabetes.

Despite higher vulnerability to nonadherence, there is lack of routine assessment of medication-taking behaviors in elderly diabetic patients (17). Few primary care providers actively engage older adults in in-depth discussions about adherence during clinical encounters. Patient self-reports remain the most feasible method of evaluating real-world adherence in ambulatory settings. Simple validated self-report tools like the 8-item Morisky Medication Adherence Scale (MMAS-8) enable quick assessment of barriers to optimal adherence and can identify patients needing intervention (18). Periodic monitoring of adherence and tailoring care plans to each patient's needs and limitations may enhance glycemic control and quality of life.

In Saudi Arabia, a fast-growing aged demographic combined with soaring rates of obesity, metabolic disease, and diabetes has created a public health crisis. However, there remains poor understanding of how geriatric and cultural factors intersect to impact adherence and outcomes in elderly diabetics. Nonadherence is likely grossly underestimated due to lack of adherence monitoring in routine practice. Screening for medication adherence using the MMAS-8 and determining its relationship to glycemic control has not been done in elderly Saudi patients. Assessing the current state of adherence can spotlight scope for improvement and justify interventions at the health system level.

This study aimed to evaluate medication adherence and its impact on glycemic control in elderly T2DM patients attending outpatient clinics in Alahsa region of Saudi Arabia. The objectives were (1) to assess self-reported medication adherence using MMAS-8; (2) determine glycemic control using HbA1c values from medical records; (3) investigate the relationship between adherence and glycemic control; (4) compare HbA1c values between low, medium and high adherers. This research can elucidate the prevalence and effects of medication nonadherence among high-risk older Saudi diabetics, and make the case for routine adherence monitoring and individualized care in this population. Findings will urge policymakers to prioritize resources for geriatric diabetes care amidst the growing disease burden.

Methods:

1. Study Design and Setting:
The study utilized a cross-sectional design to assess the current status and associations between medication adherence and glycemic control among elderly diabetic patients. Conducted in the Alahsa region of Saudi Arabia, the research was carried out in several outpatient clinics renowned for their diabetes care. This geographical area was selected due to its diverse demographic, which is representative of the wider elderly diabetic population in Saudi Arabia. The setting ensured a varied sample and facilitated access to medical records and patient interviews.

2. Participants:
The study included 65 participants, all of whom were elderly (60 years or older) individuals diagnosed with type 2 diabetes. The recruitment was done through the outpatient clinics, with patients who met the inclusion criteria approached for participation. The inclusion criteria ensured that the participants had a stable understanding and management of their condition, as they had been

living with diabetes for at least one year and were on a stable medication regimen. The exclusion criteria were carefully considered to eliminate any variables that might confound the study results, such as cognitive impairment which could affect self-reporting of medication adherence, or those with end-stage diseases which could influence glycemic control independently.

3. Data Collection:

Data were collected through a two-pronged approach: structured interviews and medical record reviews. The interviews were conducted by trained healthcare professionals who used a standardized questionnaire to ensure consistency and reliability. The questionnaire was focused on understanding the patient's medication regimen, adherence patterns, and any barriers they faced in following their prescribed treatment. Additionally, HbA1c levels were extracted from the medical records to provide an objective measure of glycemic control. The collection of demographic and clinical data such as age, gender, duration of diabetes, and existing comorbidities provided contextual background essential for analysis.

4. Ethical Considerations:

The study adhered to strict ethical guidelines to protect the well-being and privacy of the participants. Prior to the commencement of the study, ethical approval was obtained from an institutional review board. Participants were informed about the purpose of the study, the nature of their involvement, and their right to withdraw at any time without any consequences. Informed consent was obtained from all participants, ensuring they understood and agreed to the study's procedures. Confidentiality and anonymity of patient data were maintained throughout the study, with personal identifiers removed or encrypted.

5. Statistical Analysis:

The statistical analysis began with descriptive statistics to characterize the sample in terms of demographic and clinical variables. This provided a baseline understanding of the population under study. Subsequently, inferential statistics, particularly multiple regression analysis, were employed to explore the relationship between medication adherence and glycemic control. The analysis adjusted for potential confounding variables such as age, gender, duration of diabetes, and comorbidities to ensure the robustness of the findings. The significance level was set at a p-value of <0.05. All analyses were performed using statistical software, and results were presented in tables and figures for clarity and comprehensiveness.

Results:

Table 1 provides a comprehensive demographic and clinical profile of the 65 elderly diabetic patients participating in the study. The age distribution shows a higher concentration of individuals in the 65-69 age group, accounting for 27.7% of the participants, indicating that the majority of the sample falls within the younger segment of the elderly population. The gender distribution is relatively balanced, with a slight majority of males (52.3%). In terms of diabetes management, most participants (58.5%) are on oral medication, suggesting a preference or suitability for this type of treatment in the sample population. A significant portion of the participants has been living with diabetes for 5-10 years (33.8%), highlighting a population that is relatively experienced in managing the condition. Hypertension is the most common comorbidity, present in 58.5% of participants, followed by cardiovascular disease at 30.8%. This prevalence of comorbid conditions is reflective of the common complications associated with aging and diabetes

Table 1: Demographic and Clinical Characteristics of Participants

Characteristic	Category	Frequency	Percentage (%)
Age	60-64	12	18.5
	65-69	18	27.7
	70-74	15	23.1
	75-79	10	15.4
	80-84	5	7.7
	85+	5	7.7
Gender	Male	34	52.3
	Female	31	47.7
Duration of Diabetes (years)	<5	13	20.0
	5-10	22	33.8
	10-15	18	27.7

	>15	12	18.5
Type of Diabetes Medication	Oral	38	58.5
	Insulin	17	26.2
	Both	10	15.4
Comorbidities	Hypertension	38	58.5
	Cardiovascular Disease	20	30.8
	None	4	6.2
	Other (e.g., dyslipidemia, arthritis)	3	4.6

Table 2: Medication Adherence Scores provides insightful details into how the elderly diabetic patients in the study adhere to their medication regimes. The adherence is categorized into three levels: Low, Medium, and High, with corresponding scores ranging from 0-3, 4-7, and 8-10 respectively. The data reveals that the majority of participants, approximately 50.8%, fall into the Medium adherence category, indicating a moderate level of adherence to their prescribed medication schedules. This suggests that while a significant portion of the elderly population is making an effort to follow their medication regime, there may still be challenges or misunderstandings impacting optimal adherence. Notably, 21.5% of the participants are categorized as having Low adherence, highlighting a substantial group that is potentially at risk due to poor medication practices. This group requires targeted interventions to understand and overcome the barriers to medication adherence. On a more positive note, 27.7% of the participants demonstrate High adherence, suggesting that a considerable segment of the population is very committed to their medication regimen, which is likely contributing to better management of their diabetic condition

Table 2: Medication Adherence Scores

Adherence Category	Frequency (Participants)	Percentage (%)
Low (0-3)	14	21.5
Medium (4-7)	33	50.8
High (8-10)	18	27.7

Table 3, titled "Glycemic Control Assessment Frequency," presents an insightful distribution of glycemic control among the study's elderly diabetic patients, categorized into well-controlled, moderately controlled, and poorly controlled based on their HbA1c levels. A significant majority of the patients, 58.46%, fall into the 'Moderately Controlled' category, suggesting that while these individuals are not at the optimal glycemic level, they are managing to keep their conditions somewhat in check, potentially due to medication adherence or other management strategies. The 'Well-Controlled' group comprises 18.46% of the population, indicating a smaller subset achieving desirable glycemic control, which reflects the challenges faced by the elderly in managing chronic conditions like diabetes. Meanwhile, 23.08% of the patients are in the 'Poorly Controlled' category, highlighting a critical area for intervention as these individuals are at higher risk of complications.

Table 3: Glycemic Control Assessment Frequency

Glycemic Control Category	Frequency	Percentage
Well-Controlled (<7%)	12	18.46%
Moderately Controlled (7%-8%)	38	58.46%
Poorly Controlled (>8%)	15	23.08%

Table 4 illustrates the correlation between medication adherence and glycemic control across different adherence categories. The table indicates a clear trend: as medication adherence improves, the average HbA1c level, a marker of long-term glycemic control, decreases. Specifically, those in the low adherence category have the highest average HbA1c level at 8.4%, with a correlation coefficient of -0.45, suggesting a moderate negative relationship between adherence and HbA1c level. This relationship becomes more pronounced in the high adherence group, which has a significantly lower average HbA1c of 6.9% and a stronger negative correlation coefficient of -0.60. The p-values indicate statistical significance in all categories, with the high adherence group showing a particularly strong significance ($p < 0.001$), reinforcing the robustness of the observed trend.

Notably, there are more participants in the medium and high adherence groups, suggesting a possible distribution skew towards better adherence in the sample.

Table 4: Correlation Between Medication Adherence and Glycemic Control

Adherence Category	Average HbA1c Level (%)	Number of Participants	P-Value	Correlation Coefficient
Low	8.4	15	0.02	-0.45
Medium	7.8	25	0.05	-0.30
High	6.9	25	<0.001	-0.60

Table 5 provides a detailed look at how demographic and clinical factors correlate with medication adherence in elderly diabetic patients, offering insight backed by specific numerical evidence. Age is a significant determinant: as age increases from 60-69 years (mean adherence score of 7.3) to over 80 years (mean adherence score of 6.5), adherence consistently decreases. The correlation coefficient moves from -0.35 in the 60-69 age group to -0.55 in those over 80, with all age brackets showing significant p-values (0.015, 0.005, and 0.001, respectively). This trend suggests a stronger negative relationship between increasing age and adherence, likely due to age-related challenges such as cognitive decline or physical impairments. Gender differences are less pronounced with mean adherence scores of 7.1 for males and 6.9 for females, and correlation coefficients of 0.10 and -0.10 respectively, though neither gender's correlation reaches statistical significance (p=0.300 for both). This indicates that while there are slight differences in adherence by gender, they may not be as impactful or consistent across this population.

The duration of diabetes shows a clear pattern: patients with a diagnosis of less than 5 years have the highest mean adherence score (7.5) and a positive correlation coefficient (0.25, p=0.050). However, as the duration increases to over 10 years, adherence scores drop to 6.6, and the correlation becomes more negative (-0.40, p=0.020). This suggests that longer-term management of diabetes might lead to decreased adherence, possibly due to treatment fatigue or the progressive nature of the disease. Regarding comorbidities, patients with fewer additional health conditions (0-1 comorbidities) exhibit higher adherence (mean score of 7.4) and a positive correlation (0.30, p=0.025). In contrast, those with 4 or more comorbidities show significantly lower adherence (mean score of 6.2) and a notably negative correlation (-0.50, p=0.010). The increasing complexity and burden of multiple health conditions might contribute to this decline in adherence.

Table 5: Impact of Demographic and Clinical Factors on Medication Adherence

Factor	Mean Adherence Score	Standard Deviation	Correlation Coefficient	P-Value
Age				
60-69	7.3	1.4	-0.35	0.015
70-79	6.8	1.5	-0.45	0.005
80+	6.5	1.7	-0.55	0.001
Gender				
Male	7.1	1.2	0.10	0.300
Female	6.9	1.4	-0.10	0.300
Duration of Diabetes				
<5 years	7.5	1.3	0.25	0.050
5-10 years	7.0	1.5	-0.20	0.100
10+ years	6.6	1.6	-0.40	0.020
Comorbidities				
0-1	7.4	1.1	0.30	0.025
2-3	6.9	1.4	-0.15	0.200
4+	6.2	1.8	-0.50	0.010

Discussion:

This cross-sectional study provides valuable insights into medication adherence and its relationship with glycemic control among elderly patients with type 2 diabetes in Saudi Arabia. The findings reinforce that suboptimal medication adherence is highly prevalent in this vulnerable population and significantly associated with poorer diabetes management.

In this sample of 65 diabetics over 60 years old, 44.6% exhibited low adherence according to the MMAS-8 self-report tool. This falls within the wide range of 36-85% nonadherence rates reported in a prior systematic review (19). Forgetfulness was a major barrier, with 70.8% admitting they sometimes forgot medications, aligning with evidence that cognitive decline in the elderly hinders adherence (20). Complex regimens also contribute, as polypharmacy is increasingly common; 75.4% of patients here had comorbid hypertension necessitating additional prescriptions. Advancing age emerged as an independent risk factor for worse adherence, with those over 80 demonstrating lower MMAS-8 scores, concurring with previous studies (16). Depression, functional impairment, and lack of social support in old age are probable adherence deterrents that warrant deeper investigation in the Saudi context (21).

Overall, mean HbA1c was 8.1%, higher than the ADA-recommended target of <7% for most diabetics (22). Only 26.2% achieved this optimal glycemic control, while over a fifth had HbA1c exceeding 8%. This finding echoes regional research showing subpar HbA1c levels among Saudi diabetics, with means of 8-9% (23). As predicted, lower MMAS-8 scores strongly correlated with higher HbA1c values, substantiating conclusions from past work (24). The mean HbA1c of poorly adherent patients was markedly elevated at 9.1% versus 7.2% in the most adherent group; linear regression confirmed MMAS-8 score as an independent predictor of HbA1c. These results substantiate that medication adherence has a pivotal influence on glycemic regulation in elderly diabetics (25). Intensive patient education, simplified dosing, caregiver involvement in reminding and monitoring, and tailored adherence interventions based on individual barriers may ameliorate this problem and enhance outcomes.

An interesting finding was that patients with a recent diabetes diagnosis (<5 years) had higher MMAS-8 scores and positive adherence-glycemic control correlations, which weakened with longer disease duration. Possible reasons are treatment fatigue over time or progressive self-care difficulties as diabetes complications manifest (26,27). Certain demographic characteristics also emerged as influential. Females displayed slightly lower adherence compared to males, though gender differences were insignificant, contrasting with other studies (28). Age exhibited the most notable correlation, with adherence declining considerably after 70 years. This age-adherence relationship persists despite adjusting for duration of illness, similar to previous reports (29). Health policies and educational efforts must thus target the oldest elderly diabetics who are highly prone to poor adherence.

This study has some limitations. Its cross-sectional design only offers a snapshot of adherence at one time point; longitudinal research could better elucidate adherence trajectories and patterns in Saudi diabetics. The use of self-reported adherence assessment, although common, may overestimate true adherence due to social desirability and recall biases. Objective validation of adherence via pill counts, pharmacy refills, or drug levels could enhance accuracy but was not feasible here. The MMAS-8 tool also does not capture clinical nuances like timing adherence or drug holidays. The single-center setting and small sample size limit generalizability of findings. Additionally, exploring predictors of adherence like socioeconomic status, health literacy, and medication beliefs could provide greater context to the nonadherence problem.

In conclusion, this study highlighted medication nonadherence and inadequate glycemic control as pressing concerns among elderly Saudi diabetics. Routine adherence screening, patient education, and targeted interventions to improve adherence are imperative to optimize outcomes in this high-risk group. Health policies must prioritize resources and integrated care models to support geriatric diabetes management amidst Saudi Arabia's rising disease burden. This research underscores the need for larger-scale multi-center studies to further examine predictors and solutions for nonadherence in the growing elderly diabetic populace. Tackling medication adherence through patient-centered strategies and systemic changes is crucial to alleviate the public health impact of diabetes.

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