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Prevalence of Optimal HbA_{1c} Levels in Type 2 Diabetes Mellitus Patients under Antidiabetic Treatment: A Cross-Sectional Study

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Abstract

Objective: Type 2 Diabetes Mellitus (T2DM) is a prevalent chronic disorder. Achieving stable, optimal HbA_{1C} levels is crucial for managing T2DM. The objective of our current study is to determine the prevalence of controlled HbA_{1C} levels among individuals who are diagnosed with T2DM and receiving antidiabetic medications.

Materials and Methods: Adult patients with T2DM and under antidiabetic medications enrolled in our study. From March 2023 to February 2024, 196 patients were recruited in this study. Data on demographic and clinical information extracted from the patient's records and HbA_{1C} levels were measured. The association between different factors and the achievement of optimal HbA_{1C} levels was evaluated among participants.

Results: Males achieved optimal HbA_{1c} levels more frequently than females (80.2% vs 78.5). Regarding the type of medication, participants with oral medications represented glycemic control 55%, compared to 45% in those receiving injectable drugs. Moreover, we observed an inverse association between the duration of diabetes onset and glycemic control status. Our study showed no significant differences in the prevalence of controlled HbA_{1C} levels based on age (P= 0.087), gender (P= 0.930), diabetes duration (P= 0.660), and medication type (P= 0.376).

Conclusion: Most of the patients with T2DM who were receiving antidiabetic medications achieved optimal HbA_{1C} levels. It is recommended that additional education and support programs be provided to improve diabetes control and reduce its complications.

Keywords: Diabetes mellitus, Glycated hemoglobin, Prevalence

QR Code:

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Introduction

Diabetes Mellitus (DM) is a significant health challenge over the past decades, with a worldwide prevalence of 10.5% in 2021 and projected to reach 12.2% by 2045(1). Diabetes has several types, and Type 2 DM (T2DM) accounts for almost 90% of all cases, affecting millions of individuals and their families. It is characterized by prolonged high blood sugar due to low tissue insulin sensitivity or inadequate insulin production by the body (2). T2DM was previously considered an adulthood disease, but today, the number of youth-onset T2DM cases is surging substantially with different geographical distributions all around the world (3).

In the pathogenesis of T2DM, various genetic and environmental factors are involved (2,4). Obesity, low physical activities, urbanization and unhealthy dietary patterns are some of the preventable risk factors contributing to the growing burden of T2DM among low to high income countries (1,5,6).

In T2DM, hyperglycemia develops gradually, consequently and patients usually do not experience key symptoms (7). Complications such as significant weight loss or diabetic ketoacidosis are relatively rare. This leads to high rates of undiagnosed individuals (8). However, microvascular and macrovascular complications such as retinopathy, coronary artery diseases, and peripheral arterial disease, can significantly worsen over time. Some of these complications might even start in the prediabetes stages and before T2DM diagnosis (9) and longer diabetes duration usually coexists with higher risks of complications (4,10).

Various indices used to assess glycemic levels, such as fasting blood glucose, random plasma glucose, and postprandial blood glucose, glycated hemoglobin (HbA_{1C}) was introduced and approved in 2009 as a reliable laboratory measure for the diagnosis and monitoring of diabetes (11). HbA_{1C} is a valuable parameter that shows an average blood sugar related to the previous 2 to 3 months and is less affected by short-term fluctuations in an individual's daily routine. It offers a precise point of view in assessing the risk of DM-related complications. Although having preferred HbA_{1C} levels is a multi-dimensional decision that depends on each individual's clinical status, based on the American Diabetes Association (ADA), any individual who has $HbA_{1C}\geq$ 6.5% is categorized as a diabetic person (12). Moreover, among non-pregnant adult diabetic patients, an HbA_{1C}<7% is considered the primary goal of treatment, as it is associated with significantly lower complications (13).

T2DM management needs a comprehensive dual approach that includes medical therapy and lifestyle modifications. Given the important role of appropriate treatment and maintaining normal blood glucose levels in reducing the risk of diabetes complications, injectable drugs may be added to the treatment regimen for complicated cases. Additionally, the effective role of weight loss and lifestyle changes in reducing disease complications (14) or reversing T2DM in its early stages should be given substantial attention (6,15).

This study aims to determine the prevalence of optimal HbA_{1C} levels among individuals with T2DM who receive antidiabetic medications. This research provides a comprehensive understanding of glycemic control and helps identify individuals at higher risk of future diabetes complications. The findings can be used to improve the development of therapeutic strategies, the design of targeted interventions and the enhancement of healthcare management among diabetic patients. Despite the large burden of T2DM, updated real-world data on glycemic control among treated patients in Iran remain limited, particularly in populations without advanced complications. Moreover, few studies have simultaneously evaluated demographic factors, disease duration and type of pharmacologic therapy in relation to HbA1c control in routine clinical settings. Therefore,

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this study aimed to assess the prevalence of optimal HbA1c levels in populations without advanced complications and its associated factors among treated T2DM patients in Tehran.

Materials and methods

We conducted this cross-sectional study to evaluate the prevalence of controlled HbA_{1C} levels among T2DM patients, who were under treatment with antidiabetic medications.

From patients with T2DM undergoing treatment with antidiabetic medications who attended the Farhikhtegan outpatient department in Tehran from March 2023 to February 2024, 196 cases were enrolled in this study using a non-random, convenience sampling method. Eligible participants included those with a confirmed diagnosis of T2DM by a physician and currently under antidiabetic medications, at the time of enrollment. Participants with incomplete medical records, those with any comorbidity or complications, prediabetes individuals and those younger than 35 years old were excluded. Participation was entirely voluntary and all the patients received detailed information about the study's purpose and procedures before their inclusion. Informed consent was taken from all cases and their confidentiality rights were ensured.

We measured HbA_{1C} levels in local standard laboratories. HbA1c was measured using high-performance liquid chromatography (HPLC) in NGSP-certified laboratory. Glycemic control was assessed using glycated hemoglobin (HbA1c), which reflects the average blood glucose level over the preceding 2–3 months and is widely accepted as the standard indicator of long-term glycemic control. HbA1c levels were measured in certified local laboratory using routine standardized methods. The most recent HbA1c result available within the study period was recorded.

Since the participants did not experience any complications or morbidity related to diabetes, targeted HbA_{1C} levels lower than 7% were considered indicative of controlled diabetes.

All data, including patient's demographics, type of medications (oral or injection), diagnosis date and HbA_{1C} levels were obtained using either the individual's medical reports or data collecting forms.

Data Analysis

Data analysis was performed using SPSS version 26.0 (IBM, Chicago, USA). Quantitative variables were reported as mean ± standard deviations (SD), while qualitative variables were reported as percentages and frequencies. For quantitative variables (e.g., age, disease duration), independent t-test or Mann–Whitney U test was used depending on the normality of data. Categorical variables were analyzed using Chi-square test .Normality was assessed via Kolmogorov–Smirnov tests. A p-value <0.05 was considered statistically significant.

Ethical considerations

The study received approval from the Ethics Committee of Tehran Medical Sciences Islamic Azad University, Tehran, Iran: IR.IAU.PS.REC.1402.363.

Results

Between March 2023 and February 2024, 196 individuals with T2DM and receiving either oral or injectable antidiabetic drugs were recruited for this current study. Of these, 67% (n= 131) were men and 33% (n= 65) were women with a mean age of 55.3 (± 14.3) (Table 1). The mean duration of onset of the disease was 120.4 (± 69.8) months and 55% of the participants were under oral antidiabetic medications while the other 45% were using injectable forms. Controlled HbA_{1C} was reported among 78% (n= 153) of the patients while the remaining 22% (n= 43) had abnormally high HbA_{1C} levels.

We divided the participants into five different age groups and analyzed the prevalence of stable HbA_{1C} levels without a statistically significant difference (P= 0.087) (Table 2).

Moreover, in the subgroup analysis on the basis of gender, we observed a slight

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difference in HbA_{1C} levels between males (80.2%) and females (78.5%) (Table 2), that was not statistically significant (*P*= 0.930, chi^2= 0.01).

The duration of onset varied among the participants. We categorized the patients into four distinct groups: less than 5 years, 5-10 years, 10-15 years and 15-20 years. We observed a downward trend in the prevalence of having controlled HbA_{1C} levels among these groups with a slight rebound in the last group. It started at 85.7% in individuals diagnosed less than five years prior, decreased to 80.9% for those diagnosed 5-10 years ago and then to 76.2% for those diagnosed 10-15 years ago, before slightly rising to 76.9% among patients diagnosed 15-20 years prior (Table 2).

No statistically significant difference was found in the prevalence of controlled HbA_{1C} levels, based on the duration of T2DM diagnosis (*P*= 0.660, chi^2= 1.62). No statistically significant difference was found in the prevalence of controlled HbA_{1C} levels, based on the duration of T2DM diagnosis (*P*= 0.660, chi^2= 1.62). We found that 82.7% of individuals who were taking oral ant diabetic medications had stable HbA1C levels, while 76.5% of those who were taking injectable medications had controlled HbA1C levels. However, we could not find a statistically significant difference between these two groups (*P*= 0.376, chi^2= 0.79).

Discussion

T2DM affects the lives of millions of people and their families worldwide. Despite global efforts to enhance understanding of DM, to utilize novel therapies, and to develop new diagnostic tools, the IDF Diabetes Atlas (1) suggested that more than one in ten adults suffer from T2DM and the prevalence of this disease will continue to rise in the future.

In addition to preventive approaches such as regular physical activity, reducing body weight and adherence to healthy dietary styles, several oral and injectable drugs are available for T2DM treatments (2).

Table1. Demographic features of participants

Variable		*N*	Percent	Mean ± SD**
Age		196		55.3 ± 14.3 (Y)
Gender	Male	131	67%	
	Female	65	33%	
Type of medication	Oral	108	55%	
	Injecting	88	45%	
HbA_{1C}* Levels	< 7	153	78%	
	> 7	43	22%	

***HbA_{1C}= Glycated hemoglobin**
****SD= Standard Deviation**

Table2- HbA_{1C} levels in different gender, mean age groups and different duration of onset

Variable	HbA_{1C} < 7 N (%)	HbA_{1C} >7 N (%)	*P*-value
Gender			
Male	105 (80.2%)	26 (19.8%)	0.930
Female	51 (78.5%)	14 (21.5%)	
Age			
30-40	25 (78.3%)	5 (21.7%)	
40-50	40 (88.6%)	10 (11.4%)	
50-60	50 (84.4%)	20 (15.6%)	0.087
60-70	28 (82.4%)	7 (17.6%)	
70-80	10 (65%)	1 (35.0%)	
Duration of Onset(y)			
<5	45 (85.7%)	10 (14.3%)	
5-10	62 (80.9%)	18 (19.1%)	0.660
10-15	28 (76.2%)	8 (23.8%)	
15-20	18 (76.9%)	7 (23.1%)	

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Among adult, non-pregnant patients, an HbA_{1C} of less than 7% is considered ideal for reducing organ damage and diabetes-related complications according to different guidelines.

Furthermore, maintaining stable HbA_{1C} levels with minimal variability has been shown to reduce diabetes-related complications and all-cause mortalities, significantly (3).

In the current study of 196 individuals with T2DM undergoing medical therapy, we assessed the prevalence of controlled HbA_{1C} levels. A significant portion of the participants showed HbA_{1C} at controlled levels. However, increased HbA_{1C} levels were significantly associated with older ages, female sex, prolonged disease duration and injectable medications. These groups are at greater risk of developing high HbA_{1C} which can result in future diabetes complications.

Several previous studies have investigated the association between age and glycemic control. Similarly, our study indicated that the level of HbA_{1C} varies among different age groups. Participants aged 40 to 50 had the best results in HbA_{1C} management, followed by those aged 50 to 60. Our findings align with previous studies suggesting that middle-aged patients could benefit more from a balanced approach to behavioral and physiological factors that improves their glycemic control (4). However, both the older and younger age groups in our study exhibited lower HbA_{1C} control rates. In the study of Miyazawa et al,(5) younger adults (aged≤ 44) were reported to have lower glycemic control. This phenomenon results from lower adherence to medication and dietary recommendations among younger adults (6) and lifestyle priorities that can affect diabetes self-management.

We observed that individuals over 70 years old experienced a significant reduction in glycemic control, with only 65% of them achieving optimal HbA_{1C} levels. Age-related physiological changes, polypharmacy and other comorbid disorders are some of the important factors that create this multifaceted challenge in obtaining good diabetes care among elderlies. This highlights the urgent need for extra support and personalized treatment among this age group (7).

A difference in optimal HbA_{1C} levels was observed between men and women (80.2% vs 78.5%) in this study which was congruent with previous investigations (8). Although this difference is slight, it is important to further explore gender differences in diabetes care. One potential explanation for this sex-specific discrepancy is the role of sex hormones in insulin sensitivity and glucose metabolism. High testosterone levels in men decrease the risk of diabetes. Moreover, low estrogen, particularly among postmenopausal women, is associated with impaired glycemic control and higher risks for cardiovascular disorders in diabetic patients (8,9). Psychosocial factors are other contributors to these sex-related differences. Women with diabetes have been reported to experience higher levels of diabetes-related distress, anxiety and depression that can affect their adherence to medication and self-care management (10).

Glycemic control tends to worsen with increasing years after diagnosis. Insulin is the key component for metabolism regulation, and insulin resistance starts to develop even years before T2DM diagnosis. Skeletal muscles, which are one of the main sites for insulin-mediated glucose uptake, become less efficient at absorbing glucose-especially postprandial-when insulin resistance occurs. This reduced uptake leads to elevated postprandial blood glucose levels, contributing to persistent hyperglycemia (11). On the other hand, in hepatic cells, low insulin sensitivity disrupts glycemic control as well as lipid regulatory processes and contributes to broader metabolic dysfunctions (12).

In the early stages, pancreatic β cells enhance insulin production to compensate for this hyperglycemic state. However, As the chronic phase of diabetes progresses, pancreatic β cells become exhausted, resulting in inadequate insulin production to preserve normo-glycemia (13). Our findings revealed an inverse association between the years after

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diagnosis and glycemic control among patients. 85.7% of the participants with less than 5 years since diagnosis had optimal HbA_{1C} levels while it decreased to 76.9% among individuals with 15 to 20 years post diagnosis. In the study of Juarez et al. (14) It was reported that people who had diabetes for less than 5 years, exhibited better glycemic control rates compared to those who had diabetes for more than 10 years.

In addition to physiological changes, many diabetic patients gradually become less adherent to recommended dietary regimens and physical activity guidelines. Medication adherence is another factor that declines over several years after diagnosis, contributing to lower glycemic control rates (15). Additionally, psychological burdens like depression, anxiety and diabetes burnout can progress over the years and potentially affect glycemic control (16) highlighting the ongoing need for effective education and continuous support for individuals with prolonged disease to maintain ideal HbA_{1C} levels (17).

The significant role of oral antidiabetic medications, such as monotherapy or a combination of several drugs, in maintaining therapeutic HbA_{1C} levels has been extensively investigated (18). Our analysis revealed that individuals with oral medications had higher glycemic control rates (82.7%) compared to those with injectable drugs (76.5%). Despite the high potential of injectable insulin in lowering blood glucose, this discrepancy might seem controversial and several factors contribute to it. First, in general, using oral medications is more convenient and it is more acceptable among patients to simply use a pill rather than inject a drug (19). Additionally, oral medications do not need any specific storage equipment, unlike many injectable drugs, making them even easier to use. Second, fear of self-injection and anxiety related to injectable drugs is another cause that can lead to a significant reduction in medication adherence (20). Third, there is a stigma around injectable drugs among patients and many people feel embarrassed about injection processes and see it as a sign of severe disorder. In the study by Polonsky et al. (21) a significant number of diabetic patients perceived insulin therapy as a sign of self-management failure and showed strong hesitancy. Furthermore, injectable antidiabetic medications are often more expensive and less accessible, especially in resource-limited regions, compared to oral medications. This cost disparity creates significant challenges for adhering to the appropriate medication (22). On the other hand, complicated cases -hose that often have comorbidity or prolonged disease duration- are mostly under treatment with injectable drugs and these people generally have a poorer prognosis (23). Many patients experienced gastrointestinal discomfort, local pain and bruising at the injection site which hindered their proper adherence to medication (24). Moreover, the prevalence of hypoglycemia is significantly higher among patients using injectable drugs and fear of hypoglycemia can further decrease patients' satisfaction and adherence to medication(25,26).

Conclusion

Our findings indicate the complex interplay between various factors and T2DM management. While many patients achieved suggested HbA_{1C} levels, there is still room for improvement, particularly among high-risk patients. The results highlight the need for self-practice and personalized approaches to ensure long-term glycemic stability.

The present study has several strengths, including a diverse array of patient populations that includes different age groups with varying durations of disease onset. Our relatively large sample size and its conduction in clinical settings further support the generality of the results, making findings more applicable in standard diabetes care.

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Conflict of Interest

The authors declare no conflict of interests.

Author contributions

All authors were involved in writing the manuscript; however, A.A. M.Sh were mainly responsible for conceptualization and supervision. Gh.Sh. was mostly responsible for data collection and writing the manuscript. P.B. was mostly responsible for writing and editing the manuscript. All authors reviewed the manuscript.

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