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Original Research Article

Retrospective Evaluation of Glycemic Control Using HbA1c Levels Among Patients with Type 2 Diabetes Mellitus Attending a Tertiary Care Hospital

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Abstract:

Background: Glycemic control is essential for preventing the long-term microvascular and macrovascular complications of Type 2 Diabetes Mellitus (T2DM). Glycated hemoglobin (HbA1c) is the most reliable indicator of long-term glycemic control and is widely used to assess diabetes management.

Aim: To retrospectively evaluate glycemic control using HbA1c levels among patients with Type 2 Diabetes Mellitus attending a tertiary care hospital.

Methodology: A retrospective cross-sectional study was conducted over 3 months at a Netaji Subhas Medical College and Hospital in Bihta, Patna, Bihar, India. Medical records of 105 adult patients with T2DM were reviewed. Demographic, clinical, and laboratory data, including HbA1c values, were collected. Glycemic control was categorized as optimal (HbA1c <7%), fair (7.1–9.0%), and poor (>9.0%). Statistical analysis was performed using SPSS version 26.0, with $p < 0.05$ considered statistically significant.

Results: The mean age was 56.8 ± 10.7 years, with 59.0% male participants. The mean HbA1c level was 8.4 ± 1.6%. Optimal glycemic control was achieved by 24.8% of patients, while 45.7% and 29.5% had fair and poor control, respectively. Longer diabetes duration was significantly associated with poor glycemic control ($p = 0.002$). Hypertension, dyslipidemia, and obesity also showed significant associations with elevated HbA1c levels.

Conclusion: Most patients had suboptimal glycemic control, highlighting the importance of regular HbA1c monitoring, early intervention, and comprehensive diabetes management.

Keywords: Type 2 Diabetes Mellitus, HbA1c, glycemic control, retrospective study, diabetes management, tertiary care hospital.

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Introduction

Type 2 diabetes mellitus (T2DM) is a leading non-communicable disease and an emerging public health issue as it continues to grow rapidly in the world and is linked with a variety of complications. It is a disease of chronic hyperglycemia caused by insulin resistance and progressive dysfunction of pancreatic β cells that affect glucose metabolism. The current burden of T2DM is significantly due to rapid urbanization, sedentary lifestyle, unhealthy dietary pattern, obesity, and population ageing, especially in the low- and middle-income countries like India [1]. As per the International Diabetes Federation (IDF) Diabetes Atlas 2024, India is one of the most populous countries for people with diabetes worldwide, with the management of blood sugar levels being a significant issue in the country's healthcare system [2]. This is due to the high prevalence of long-term complications and the associated health care expenses that are being put on health care systems due to the rising numbers of diabetes cases.

The main reason for the microvascular and macrovascular complications in T2DM are due to persistent hyperglycemia. The prolonged rise in blood glucose causes damage to the vascular endothelial cells through several mechanisms: oxidative stress, chronic inflammation, formation of advanced glycation end-products (AGEs), and endothelial dysfunction [3]. Because of this, diabetic retinopathy, nephropathy, neuropathy, coronary artery disease,

cerebrovascular disease and peripheral arterial disease all occur much more frequently in people with poorly controlled diabetes [4]. Many epidemiological studies have shown that good blood sugar control greatly decreases the number and severity of these complications, thus enhancing the patient's chance of survival and quality of life [5]. Hence glycemic status needs to be monitored regularly, and this is a cornerstone of diabetes management. Glycated hemoglobin (HbA1c) is a biomarker regarded as the gold standard for assessing long-term glycemic control among the several biomarkers that are available to monitor glucose control.

HbA1c is a measure of the average blood glucose level over the last 2-3 months and is less sensitive to day-to-day fluctuations in blood glucose that occur due to meals, stress or acute illness [6] . Contrary to fasting or PP blood glucose, HbA1c gives a holistic picture of overall metabolic control and is now a key parameter in the diagnosis, monitoring and prediction of risk in diabetes mellitus. International clinical guidelines suggest targets of less than 7% for most adults with T2DM with individualized targets to be considered according to age, duration of diabetes, co-morbidities, and risk of hypoglycemia [7]. While progress has been made in the treatment of diabetes, a large population of patients remains sub optimally controlled. Recent studies reveal that almost 80% of patients with T2DM in India are not achieving the desired target HbA1C level, which depicts poor diabetes control and puts them at a higher risk of chronic complications [8]. A variety of factors can contribute to poor glycemic control, such as older age, obesity, longer diabetes duration, hypertension, dyslipidemia, family history, poor adherence to the treatment, unhealthy lifestyle habits, and poor access to health care services [9].

Also, other factors such as socioeconomic status, education level, diet, physical activity, and medication adherence play a key role in long-term glycemic control. Understanding these factors is crucial for tailoring diabetes management strategies and developing comprehensive intervention programs. Increasing focus has also been paid to glycemic variability, the extent of fluctuations in blood glucose levels over time, in the recent years. While HbA1c is still the key status indicator for glycemic control, glycemic variability has been shown to have an independent role in the development of diabetes complications through a variety of mechanisms including oxidative stress, endothelial damage, chronic inflammation, platelet activation, impaired angiogenesis and renal fibrosis [10].

Frequent glucose fluctuations can also contribute to worsening of the overall metabolic control by accelerating pancreatic β-cell dysfunction. Thus, there is a need for all diabetes management to not only attain HbA1c target levels, but also to maintain glucose control over the long term. India is disproportionately burdened with T2DM due to its genetic susceptibility and very rapid lifestyle changes. Diabetic conditions tend to be diagnosed at an early age and at lower BMI in Asian Indians when compared to the Western population, thus increasing the importance of early diagnosis and continuous monitoring [11].

There may be additional factors and variations in dietary habits, access to care, SES, and lifestyle behaviors that account for differences in glycemic control throughout the country. Diabetes and its complications have been steadily on the rise in Bihar, one of the most populous states in eastern India. Published data from hospitals, however, assessing HbA1c status in patients with T2DM in this area are still limited. It is critical to have a clear understanding of the glycemic pattern in this population to detect aspects of glycemic control that need to be addressed to enhance the management of diabetes and reduce the burden of the disease on the patient. Retrospective review of hospital medical records is a pragmatic and inexpensive tool that can be used to monitor glycemic control in routine clinical care. HbA1c levels acquired in routine clinical practice offer real-world data on the effectiveness of diabetes management and the level of glycemic control in diabetes patients attending tertiary care hospitals. This type of evidence can help clinicians identify who is at risk, track how well treatments are working and provide timely treatment that prevents diabetes complications [12].

Given the rising prevalence of T2DM and clinical significance of maintaining euglycaemia, the present study was designed to do a retrospective assessment of the glycemic control (HbA1C) in T2DM patients in a tertiary care hospital, Bihta, Patna, Bihar, India. The goals of the study are to evaluate the distribution of HbA1c levels and to identify the percentage of patients that meet recommended glycemic targets. The results are expected to generate much useful regional evidence that can help in better diabetes management, better early therapeutic interventions and in decreasing the burden of complications of diabetes in the study population.

Methodology

Study Design: This study was a retrospective cross-sectional observational study conducted to evaluate glycemic control using HbA1c levels among patients with Type 2 Diabetes Mellitus (T2DM) attending a tertiary care hospital.

Study Area: The study was conducted at the Department of Biochemistry collaboration General Medicine of Netaji Subhas Medical College and Hospital, Bihta, Patna, Bihar, India.

Study Duration: The study was conducted over a period of 3 months.

Sample Size: A total of 105 patients diagnosed with Type 2 Diabetes Mellitus who fulfilled the eligibility criteria were included in the study.

Sample Population: The study population comprised adult patients diagnosed with Type 2 Diabetes Mellitus (T2DM) attending the Medicine Outpatient Department (OPD) of the tertiary care hospital. Patients had undergone routine HbA1c testing as part of their diabetes follow-up, and complete medical records were available for retrospective evaluation.

Data Collection: Data were collected retrospectively from hospital medical records and laboratory databases. Demographic details including age and gender, duration of diabetes, associated comorbidities, treatment details, and laboratory investigations were retrieved using a structured data collection form. HbA1c values, fasting plasma glucose, random blood glucose (where available), serum creatinine, and other relevant biochemical parameters were extracted from patient records. All laboratory investigations had been performed in the hospital's central laboratory following standardized quality control procedures. HbA1c measurements were obtained using standardized laboratory methods and were used to assess long-term glycemic control.

Inclusion Criteria

- Patients aged 35 years and above.
- Patients diagnosed with Type 2 Diabetes Mellitus.
- Patients attending the Medicine OPD during the study period.
- Patients with complete medical records, including HbA1c values.
- Patients having at least three documented follow-up visits with HbA1c estimation.

Exclusion Criteria

- Patients diagnosed with Type 1 Diabetes Mellitus.
- Pregnant women with gestational diabetes.
- Patients with secondary forms of diabetes or multiple endocrine disorders.
- Patients with incomplete medical records or missing HbA1c values.
- Patients with fewer than three documented follow-up visits.

Study Procedure: After obtaining ethical approval, hospital records of patients with Type 2 Diabetes Mellitus were screened to identify eligible participants according to the predefined inclusion and exclusion criteria. Relevant demographic information, clinical history, duration of diabetes, comorbidities, treatment details, and laboratory investigations were extracted from the medical records using a standardized data collection form. HbA1c values recorded during routine follow-up visits were reviewed to evaluate glycemic control. Glycemic status was classified based on HbA1c levels as optimal control (HbA1c <7%), fair control (HbA1c 7.1–9.0%), and poor control (HbA1c >9%). The collected data were verified for completeness and accuracy before being entered into the study database for statistical analysis.

Statistical Analysis: The data collected were entered into Microsoft Excel 2021 and analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. The normality of continuous variables was assessed using the Shapiro–Wilk test. Comparisons between glycemic control categories were performed using the Independent Student's t-test for normally distributed variables and the Mann–Whitney U test for non-normally distributed variables. Associations between categorical variables were evaluated using the Chi-square test or Fisher's exact test, as appropriate. A p-value <0.05 was considered statistically significant for all analyses.

Result

Table 1 presents the demographic and clinical characteristics of the study participants. A total of 105 patients with Type 2 Diabetes Mellitus were included in the study. The majority of participants belonged to the 55–64 years age group (34.3%), followed by 45–54 years (29.5%), ≥65 years (19.1%), and 35–44 years (17.1%). The mean age of the study population was 56.8 ± 10.7 years. Male participants constituted 59.0% of the study population, while females accounted for 41.0%. Regarding the duration of diabetes, 43.8% of patients had diabetes for 5–10 years, followed by 28.6% with a duration of more than 10 years and 27.6% with diabetes for less than 5 years.

Table 1: Demographic and Clinical Characteristics of the Study Participants (N = 105)		
Variable	**Frequency (n)**	**Percentage (%)**
Age Group (years)		
35–44	18	17.1
45–54	31	29.5
55–64	36	34.3
≥65	20	19.1
Mean Age (years)	**56.8 ± 10.7**	
Gender		
Male	62	59
Female	43	41
Duration of Diabetes		
<5 years	29	27.6
5–10 years	46	43.8
>10 years	30	28.6

Table 2 summarizes the clinical and biochemical characteristics of the participants. The mean HbA1c level was 8.4 ± 1.6%, indicating suboptimal glycemic control among the study population. The mean fasting blood glucose and random blood glucose levels were 164.7 ± 42.8 mg/dL and 236.5 ± 58.9 mg/dL, respectively, both exceeding the recommended glycemic targets. The mean body mass index (BMI) was 27.1 ± 3.8 kg/m², suggesting that most participants were overweight. The average systolic and diastolic blood pressure were 136.8 ± 15.4 mmHg and 84.6 ± 9.8 mmHg, respectively, indicating that elevated blood pressure was also common among patients with Type 2 Diabetes Mellitus.

Table 2: Mean Clinical and Biochemical Parameters of the Study Participants (N = 105)	
Parameter	**Mean ± SD**
HbA1c (%)	8.4 ± 1.6
Fasting Blood Glucose (mg/dL)	164.7 ± 42.8
Random Blood Glucose (mg/dL)	236.5 ± 58.9
Body Mass Index (kg/m²)	27.1 ± 3.8
Systolic Blood Pressure (mmHg)	136.8 ± 15.4
Diastolic Blood Pressure (mmHg)	84.6 ± 9.8

Table 3 shows the distribution of glycemic control categories based on HbA1c levels. Nearly half of the participants (45.7%) had fair glycemic control (HbA1c 7.1–9.0%), while 29.5% had poor glycemic control (HbA1c >9.0%). Only 24.8% of the patients achieved optimal glycemic control (HbA1c <7.0%). These findings indicate that approximately three-fourths of the study population failed to achieve the recommended HbA1c target, reflecting inadequate long-term glycemic control among patients attending the tertiary care hospital.

Table 3: Distribution of Glycemic Control Based on HbA1c Levels (N = 105)			
Glycemic Control Category	**HbA1c (%)**	**Frequency (n)**	**Percentage (%)**
Optimal Control	<7.0	26	24.8
Fair Control	7.1–9.0	48	45.7
Poor Control	>9.0	31	29.5

Table 4 demonstrates the relationship between the duration of diabetes and glycemic control. Patients with a diabetes duration of less than 5 years showed the highest proportion of optimal glycemic control (48.3%), whereas those with a duration of more than 10 years exhibited the highest proportion of poor glycemic control (53.3%). The association between duration of diabetes and glycemic control was found to be statistically significant (p = 0.002), indicating that longer disease duration was significantly associated with poorer glycemic control.

Table 4: Association Between Duration of Diabetes and Glycemic Control (N = 105)					
Duration of Diabetes	**Optimal n (%)**	**Fair n (%)**	**Poor n (%)**	**Total**	**p-value**
<5 years	14 (48.3)	11 (37.9)	4 (13.8)	29	
5–10 years	10 (21.7)	25 (54.3)	11 (23.9)	46	
>10 years	2 (6.7)	12 (40.0)	16 (53.3)	30	
Total	**26**	**48**	**31**	**105**	**0.002***

Table 5 presents the association between common comorbidities and poor glycemic control. Hypertension was present in 51.4% of patients and showed a significant association with poor glycemic control (p = 0.018). Similarly, dyslipidemia was observed in 43.8% of participants and was significantly associated with poor glycemic control (p = 0.031). Obesity (BMI ≥30 kg/m²) was identified in 27.6% of patients and also demonstrated a statistically significant association with poor glycemic control (p = 0.044). These findings suggest that the presence of comorbid conditions is associated with worsening glycemic status among patients with Type 2 Diabetes Mellitus.

Table 5: Association of Comorbidities with Poor Glycemic Control (N = 105)

Comorbidity	Present n (%)	Absent n (%)	p-value
Hypertension	54 (51.4)	51 (48.6)	**0.018***
Dyslipidemia	46 (43.8)	59 (56.2)	**0.031***
Obesity (BMI ≥30 kg/m²)	29 (27.6)	76 (72.4)	0.044*

Discussion

The present retrospective study showed that glycemic control in Type 2 Diabetes Mellitus (T2DM) patients who were attended in a tertiary care hospital in Bihta, Patna, Bihar was found to be poor overall. Only 24.8 percent of the patients had optimal glycemic control (HbA1c <7%), 45.7 percent had fair glycemic control and 29.5 percent had poor glycemic control (HbA1c >9%). In general, about 75.2% of all participants did not meet the recommended HbA1c target, underscoring the ongoing difficulties of achieving good long-term glycemic control. These are similar results to those found by Anjana et al. [13] who reported that almost 77-80% of patients with T2DM in India were non-attainers of the HbA1c target. Likewise, Khattab et al. found that about 65% of the diabetic patients in Jordan were poorly controlled, and Alzaheb and Altemani [14] found that 74% of patients in Saudi Arabia were poorly controlled".

A number of reasons, such as lack of patient education, ineffective adherence to treatment, poor dietary habits, physical inactivity and delayed therapeutic intensification, may be responsible for the high prevalence of uncontrolled diabetes in developing countries. The present study demographics showed that the mean age was 56.8 ± 10.7 years, and the highest number of patients were in the age group 55-64 years (34.3%). The male patients accounted for 59.0% of the study population. We found that poor glycemic control was not limited to older people, despite age being associated with poor glucose metabolism. In a similar study, Ali et al. [15] did not find any significant correlation between age and HbA1c level in T2DM patients. Similarly, Khattab et al. found that age was not an independent predictor of glycemic control, when controlling for other clinical parameters.

The present results suggest that the effect of various factors such as treatment adherence and lifestyle changes, as well as duration of the disease, is a greater determinant for glycemic outcomes than chronological age itself. The present study also showed that there was a significant association between diabetes duration and glycemic control (p = 0.002). Patients with diabetes duration of less than five years had the highest rate of optimal glycemic control (48.3%), while 53.3% of those with diabetes duration greater than 10 years had poor glycemic control. The results are in keeping with those of Yang et al. [16] who showed that HbA1c was independently associated with longer duration of diabetes, and complexity of treatment.

It is likely that progressive pancreatic β-cell dysfunction, progressive insulin resistance, and a progressive decrease in insulin production over time are responsible for worsening glycemic control. The same was found in the United Kingdom Prospective Diabetes Study (UKPDS) [17] that demonstrated a gradual deterioration of glycemic control with treatment and a loss of β-cell function with time. The HbA1c level measured in the present study was 8.4 ± 1.6%, which is suboptimal for long-term glycemic control. Fasting blood glucose (164.7 ± 42.8 mg/dL) and random blood glucose (236.5 ± 58.9 mg/dL) were also both above optimal therapeutic limits, suggesting that a significant percentage of patients were hyperglycemic. This was also found by Anjana et al. who reported that the average HbA1c level for patients with T2DM in India is between 8% and 9% of their total blood sugar. Similarly, the American Diabetes association (ADA) guidelines [18] state that keeping HbA1c levels under 7% will greatly lower microvascular and macrovascular complication risks.

The high levels of HbA1c found in the current study therefore suggest that there is a greater risk of long-term complications from diabetes if control is not optimized. Another relevant finding in the current study was the strong association that has been observed between the most common metabolic comorbidities and poorer glycemic control. 51.4% of patients had hypertension, 43.8% had dyslipidemia and 27.6% of patients had obesity, all of which were statistically significant with elevated HbA1c. These results agree with the findings of Saydah et al. [19] who showed that obesity and hypertension often occur in poorly controlled diabetes and are associated with a heightened cardiovascular risk. Chronic

inflammation and changes in adipokines secretion, hypertension and dyslipidemia, further impair endothelial function and vascular complications, which are exacerbated by excess adiposity.

The simultaneous occurrence of these metabolic disturbances highlights the need for thorough management of cardiac risk factors in T2DM patients, not only metabolic parameters such as the control of blood glucose. The mean BMI of 27.1 ± 3.8 kg/m², observed in the overweight patients, also reinforces the close link between obesity and poor glycemic control. There were no specific assessments of lifestyle behaviors in the present study, but a variety of prior investigations have demonstrated that poor dietary habits, physical inactivity, poor medication adherence, and poor diabetes self-management all significantly affect HbA1c levels. Structured lifestyle interventions and personalised pharmacotherapy with regular follow-up of HbA1C levels have been shown to have a significant impact on long-term glycemic control, Davies et al noted. Moreover, there has been evidence that improvements in diabetes knowledge and adherence to treatment have led to clinically significant HbA1c reduction in various populations [20].

The results of the present study need to be considered against the background of some limitations. The retrospective study design was also dependent on the hospital records, restricting our ability to collect information on dietary habits, physical activity, socioeconomic status, medication adherence and psychosocial factors which could affect the glycemic control. This may also be due to the relatively small sample size and single-center design, which could affect the generalizability of the results to the broader diabetic population. However, the findings of the study are of great clinical relevance as far as glycemic control among patients of T2DM in a tertiary care hospital in Bihar, India is concerned. These results emphasize the need for regular HbA1c monitoring, early therapeutic optimization, patient-centered diabetes education, and multidisciplinary diabetes management strategies to promote long-term glycemic control and diabetes-related outcomes. Larger sample size future prospective multicenter studies with lifestyle, behavioral and genetic determinants are recommended to better understand the factors associated with glycemic control in Indian population.

Conclusion

The present retrospective study showed that the glycemic control of Type 2 Diabetes Mellitus (T2DM) patients in a tertiary care hospital of Bihta, Patna, Bihar was found to be suboptimal with only 24.8% of patients having achieved the recommended HbA1c level whereas 75.2% of patients showed fair or poor glycemic control. Poor glycemic control was significantly related to a long duration of diabetes and the existence of comorbidities like hypertension, dyslipidaemia, and obesity, which played an important role in the process of diabetes and the deterioration of their metabolic processes. The results highlight the importance of periodic HbA1c testing, early screening of high-risk individuals, personalized approaches, and intensive lifestyle interventions for better long-term glycemic control. The study, although retrospective, conducted in a single center and with a relatively small sample size, offers valuable regional evidence on glycemic control among T2DM patients in Bihar. Additional determinants such as medication adherence, dietary pattern, physical activity, and socioeconomic factors should be explored in larger prospective multicenter studies to enhance the strategies for better diabetes management and long-term diabetes complications.

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