RESEARCH REPORTS

Factors Affecting Glycemic Control in Patients with Type 2 Diabetes Mellitus Presented a Large Tertiary Hospital in Male'

FATHMATH NADHA, MAARIYATH MAANIAA, AISHATH RUWAIDHA HASSAAN, MARYAM MIFZA MOOSA, FATHMATH YUMAN HABEEB & MARIYAM ZAHA ZAHIR

The Maldives National University

ABSTRACT *Diabetes has now become increasingly prevalent worldwide, with South Asians at a higher risk of developing type 2 diabetes mellitus. Maldives itself has a recorded prevalence of diabetes at 6.7% in 2021. Given the increasing morbidity and mortality associated with diabetes-related complications, there is a critical need for improved glycemic control strategies. This study aimed to determine the status of glycemic control and identify key factors influencing the glycemic control of patients with type 2 diabetes mellitus presenting to Indira Gandhi Memorial Hospital (IGMH). This, hospital-based retrospective cohort study included 440 participants with type 2 diabetes mellitus who presented to IGMH, between 01st January to 31st December 2024. Data on all the variables considered in the study were obtained through direct patient interviews using a structured questionnaire and hospital medical records by employing a census sampling method. Statistical analyses were conducted using IBM® SPSS® version 30.0. The Chi-square test of independence was used to assess associations between variables and glycemic control, followed by logistic regression models for further analysis. Poor glycemic control, defined as HbA1c >7% or FBS >130 mg/dL, was observed in 51% of patients based on FBS and in 22% based on HbA1c. The findings of the study showed that, there was a strong association between poor glycemic control and non-adherence to diet [OR=3.16, p<0.001, CI:1.66-6.01], exercise [OR=1.85, p=0.006, CI:1.20-2.85], long duration of illness [OR=1.99, p=0.003, CI:1.26-3.15], combination therapy with oral hypoglycemic agents and insulin [OR=23.22, p<0.001, CI:8.34-64.63] and compliance to treatment [OR=3.03, p<0.001, CI:1.62-5.65]. These results highlighted the importance of compliance to treatment, lifestyle modifications, and early intervention in managing glycemic control among type 2 diabetes mellitus patients presenting to IGMH. Addressing these factors, therefore, could lead to improved disease management and better long-term health outcomes.*

Keywords: Type 2 Diabetes Mellitus, Glycemic control, HbA1c, Fasting Blood Sugar, Maldives.

Introduction

Once considered a condition predominantly affecting affluent nations, diabetes has now become increasingly prevalent worldwide (Ogurtsova et al., 2017). Research indicates that South Asians are at a higher risk of developing type 2 diabetes mellitus (T2DM) due to their predisposition to visceral obesity, which is strongly associated with insulin resistance (Hussain, 2018). Poor glycemic control has been consistently documented among T2DM patients in this region, highlighting a significant challenge in diabetes management (Krishnakumar et al., 2021).

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If left unmanaged, diabetes mellitus can lead to severe complications, including blindness, kidney failure, limb amputations, myocardial infarctions, and strokes (WHO, 2019). Therefore, achieving and maintaining optimal glycemic control is crucial in delaying disease progression and reducing the incidence of these complications. Identifying the factors that influence glycemic control is essential for improving diabetes management and patient outcomes (Yigazu et al., 2017; Rakhis et al., 2022).

The International Diabetes Federation (IDF) estimated the prevalence of diabetes in the Maldives to be at 6.7% in 2021 (Magliano & Boyko, 2021). Despite this significant disease burden, research on the factors affecting glycemic control among Maldivian population remains limited. Studies conducted in other countries have identified various determinants of glycemic control, such as disease duration, prescribed medications and coexisting medical conditions. (Li et al., 2018 ; Sendekie et al., 2022).

This study aims to identify the status of glycemic control and analyze the key factors influencing the glycemic control of patients with T2DM presented to IGMH, the country's largest tertiary hospital, and ultimately contribute to the optimization of diabetes management strategies The results of this study can provide further scientific insights that can aid in the development of intervention plans to improve glycemic control.

Diabetes mellitus (DM) is a metabolic disorder characterized by chronic hyperglycemia or elevated blood glucose levels (WHO, 2019). T2DM, in particular, involves insulin resistance, decreased insulin secretion, and increased glucose production (Loscalzo et al., 2022). Globally, diabetes has reached epidemic levels, affecting 537 million adults, with projections rising to 783 million by 2045 (Magliano & Boyko, 2021). Although once primarily associated with affluent nations, diabetes is now prevalent in both high and middle-income countries (Ogurtsova et al., 2017). South Asians are particularly vulnerable due to a higher tendency for visceral obesity, a key factor in insulin resistance (Hussain, 2018). Uncontrolled diabetes can lead to severe complications, including blindness, kidney failure, amputations, heart attacks, and strokes (WHO, 2019). Effective diabetes management focuses on maintaining optimal glycemic control to prevent complications (Rakhis et al., 2022). Poor glycemic control accelerates disease progression, whereas stable blood glucose levels improve outcomes and quality of life (Fiseha et al., 2018; Rakhis et al., 2022). Factors such as age, BMI, disease duration, and treatment adherence influence glycemic control, making targeted interventions essential (Hassan et al., 2021; Abdissa & Hirpa, 2022).

Multiple studies have shown that glycemic control is well controlled in older age groups when compared to younger age groups. A study conducted in Malaysia showed that younger patients had poor glycemic control compared to patients aged 65 and above (Ahmad et al., 2013). Another research done in Tabuk, Saudi Arabia, also revealed that glycemic control was better in older populations rather than middle-aged or younger populations of age (Ghabban et al., 2020). In addition to age, studies show that the gender of patients also had an effect on glycemic control. In a study conducted in Turkey, 52% females were found to have poor glycemic control, while only 47.9% of males had poor glycemic control

(Sakin A & Alay, 2021). This however, contradicts another study conducted in Jordan, which showed that male sex was significantly associated with poor glycemic control (Qarem et al., 2022). In addition, body mass index or BMI, is also found to influence glycemic control, according to multiple studies. Obesity is a major factor associated with poor glycemic control and patients who had a BMI higher than 30 Kg/m^2 had a higher mean value of HbA1c (Almalki et al., 2021). A study done in Manipal, India, reports that BMI as a factor was impacting on HbA1c level and that it could be explained by the impaired insulin resistance and insulin secretion. (Haghighatpanah, M., et al. 2018). A study conducted among T2DM patients in South China, also showed that people who are overweight and obese had poorer diabetic control, which was attributed to the fact that the accumulation of body fat reduces glucose tolerance (Zhai et al., 2023). Diets low in fats and carbohydrates have also been proven to decrease glycated hemoglobin (HbA1c) by 0.8-2.8% in patients with T2DM (Wang et al., 2018). While the maintenance of a low BMI (a healthy weight) and a good diet is essential to maintaining good glycemic control, other studies have shown that physical activity is another important factor that plays a vital role in balancing blood sugar levels in an optimal state. Studies reveal that intermittent high-intensity exercises for a short duration (about 20 mins) improve insulin action, thereby reducing risk of T2DM as well as controlling blood sugar levels (Colberg et al., 2016). Lack of regular exercise and physical activity is one of the strongest predictors of uncontrolled glycemic levels (Azzam et al., 2021).

A prolonged duration of diabetes can negatively affect glycemic control, potentially due to the gradual decrease in insulin secretion caused by β-cell dysfunction (Yigazu & Desse, 2017). According to research done at Universiti Kebangsan Malaysia, each one year increase in the duration of diabetes was found to have a 5% reduction in the odds of achieving a target glycemic control (Ahmad et al., 2013). A recent study conducted in Thailand found a highly significant association between having T2 DM for over 10 years and poor glycemic control (Phuwilert, P., et al. 2024). Another study conducted among Moroccan patients with T2DM also indicated that the duration of diabetes correlates with inadequate glycemic control, where participants diagnosed with diabetes for over seven years were shown to be twice as likely to exhibit poor glycemic control compared to those with a lesser duration (Chetoui et al., 2020). A tertiary care diabetes center in Ningbo, China, reported that patients with the condition for longer than four years had a twofold increased risk of poor glycemic control compared to those with the disease for less than a year (Li, J et al., 2018). This study was comparable with another study conducted among diabetic patients receiving care in Ethiopian public hospitals, which found that compared to individuals with diabetes who had had the disease for less than four years, those with diabetes mellitus for longer periods of time were more likely to have poor glycemic control (Oluma, A et al., 2021). An additional Indonesian study also found that having the illness for longer than five years raised the odds ratio scores and had a substantial impact on poor glycemic management (Pamungkas, R et al., 2017).

The presence of other underlying diseases such as hypertension and hyperlipidemia also leads to hyperglycemia causing uncontrolled diabetes. In a study conducted in South China, it showed that patients diagnosed with diabetes along with hyperlipidemia had poor glycemic control compared to patients with

no underlying comorbidities (Zhai et al., 2023). This is consistent with a study conducted in Baghdad which revealed that the prevalence of hyperlipidemia was high in Type 2 diabetic patients with poor glycemic control (Al-Bahrani and Yassin 2022).

In terms of therapeutic approach, individuals who utilized insulin treatment alone or in conjunction with oral agents were two or three times more inclined towards inadequate glycemic control compared to those solely reliant on oral agents (Chetoui et al., 2020). This statement is also supported by another study which was done in India, where patients receiving insulin with oral hypoglycemic agent or insulin as monotherapy were more likely to have poor glycemic control compared to the patients who were on multiple oral regimens (Haghighatpanah M,. et al., 2018) Another study showed that patients who took a combination of insulin and oral anti-diabetic medication had a higher risk of poor glycemic control than patients on oral antidiabetic medicine only (Nigusse et al., 2021 & Ghabban et al., 2020). While patients who are not compliant to any form of medication were found to have poor glycemic control, patients with strict adherence to medication achieved optimal glycemic control at a higher rate compared to those who were not compliant (Traoré et al., 2021 & Ahmad et al., 2013).

Objectives

The objective of this study includes the following:

1. To describe the status of glycemic control in patients with Type 2 Diabetes Mellitus presenting to Indira Gandhi Memorial Hospital (IGMH) from 01st January 2024 to 31st December 2024
2. To analyze the association between patient-related factors in relation to the glycemic control of patients with Type 2 Diabetes Mellitus presented to IGMH from 01st January 2024 to 31st December 2024.
3. To analyze the association between disease-related factors in relation to the glycemic control of patients with Type 2 Diabetes Mellitus presented to IGMH from 01st January 2024 to 31st December 2024.
4. To analyze the association between treatment-related factors in relation to the glycemic control of patients with Type 2 Diabetes Mellitus presented to IGMH from 01st January 2024 to 31st December 2024.

Methodology

Study design, Setting and period

A hospital-based retrospective cohort study using census sampling was carried out at Indira Gandhi Memorial Hospital (IGMH), the largest tertiary hospital in the Greater Male' region. This quantitative research was conducted on patients who received care from IGMH, within the stipulated study period, which was from 1st January, 2024 to 31st December, 2024.

Study participants, Sample size and sampling technique

The population for this clinical study were all patients with type 2 diabetes mellitus presented to IGMH as outpatients during the study period. Based on data from the medical records of IGMH, a total population of 6443 patients was identified

as the target population. A census sampling technique was employed based on the inclusion and exclusion criteria (Figure 1) to finalize the final sample size. The total number of individuals who were eligible for the study was found to be 543, out of which 440 participants consented and were enrolled in the study, thus giving a response rate of 81%.

Figure 1. Enrollment criteria for the study

Inclusion criteria
- Individuals aged between 18-65 years who are citizens of Maldives.
- Individuals with a confirmed diagnosis of Type 2 Diabetes Mellitus under ICD 10 code E11 who are currently on treatment.
- Individuals presented to outpatient clinicals of Internal Medicine Department and National Diabetes Centre of IGMH from 1st January 2024 to 31st December 2024 with at least three visits within the study period.
Exclusion criteria
- Individuals diagnosed with Type 1 Diabetes Mellitus and other types of Diabetes other than T2DM.
- Individuals with a diagnosed psychiatric illness and neurological conditions which can affect their ability to take part and comply in the study.
- Women who are pregnant.
- Individuals with severe medical conditions which affect their glycemic control, like active cancer, liver cirrhosis and end-stage renal disease.
- Individuals with less than three visits in the study period.

Data collection tools and procedures

An interviewer-administered structured questionnaire was created and used to collect primary data. In addition to this, secondary data for the enrolled population was obtained through HINAI Web, the hospital information management system of IGMH. The data collection was conducted in two stages. During the initial phase, relevant clinical and laboratory data from HINAI Web was extracted. In order to ensure accuracy of the data being collected, this data was cross checked from the original source. In the second phase of data collection, phone interviews were conducted with the participants. These interviews were carried out in order to obtain the patient-related data regarding their exercise, diet, duration of illness and treatment compliance that was not available in the hospital records.

To obtain the above data, an interviewer guide in Dhivehi, the official language of Maldives, was utilized to ensure linguistic consistency and to maintain standardized question delivery. All collected data were compiled, cross-checked and entered into a secure spreadsheet for further analysis.

Quality assurance, data management and analysis

To maintain the integrity and ensure the reliability of the study, several quality measures were implemented. The data collected were thoroughly checked and verified during each stage of data collection. Once verified, all patient identification information was replaced with unique codes and were securely stored in password-

protected files, accessible only to the research team. The data will remain secured and confidential until the research is published.

The data was processed using IBM® SPSS® software version 30.0 after verifying its accuracy. Descriptive statistics were run to identify the patient factors (age, gender, body mass index, exercise and compliance to diet), disease factors (duration of illness and other underlying metabolic diseases) and treatment factors (type of treatment and compliance to treatment) which affect glycemic control of patients. These were expressed as frequency and percentages. Chi-square test (X^2) was done to find the association between those factors and the glycemic control. Variables with a p value less than 0.05 were considered statistically significant and the variables were further analyzed using binary logistic regression models. The odds ratio (OR) and 95% confidence intervals (CIs) were estimated for each independent variable to assess the strength and direction of the association with the dependent variable. The fitness of the model was evaluated using Hosmer-Lemeshow goodness-of-fit and the statistical significance for the study was set at $p<0.05$.

Results

Table 1 represents the descriptive data on the characteristics of the final study sample. Among the 440 participants, 62% were females and 38% were males More than half of the participants were between 45-59 years (59%, with the remaining participants falling into the two extremes of age, with 22%] falling into the group of young adults aged between 18-44 years and 19%] being the older adults who were aged between 60-65 years.

The majority of the participants were overweight (45%,), and only a small proportion of participants had a normal BMI (22%,), with 33% () being obese. Among the 440 participants, more than half of them were advised to follow a diabetic diet (68%,), of which 31%) were always compliant to the diet, while the majority (45%,) only followed the diet sometimes, with a few participants (24%,) rarely following the diet. The remaining 32% of the study population () said that they were not advised to follow a diabetic diet. Thirty eight percent of the participants were always involved in at least 30 minutes of physical activity 5 times a week and another 38% were never involved in any form of physical activity

Thirty three percent of the participants had been diagnosed with type 2 diabetes mellitus for less than 5 years (while 36% were found to be having the disease for more than 10 years. The remaining 31% had diabetes for a duration of 5-10 years. Looking into the other existing metabolic diseases, more than half of the participants had hypertension (53%, while almost the entire study sample had underlying dyslipidemia (91%, Our results showed that the usage of multiple oral hypoglycemic agents was high (67%, while participants who used a combination of both insulin and oral hypoglycemic agents was low (14%, Additionally, only 19% of the participants were on hypoglycemic monotherapy, with either insulin or an oral hypoglycemic agent. The maximum number of participants were always compliant with the treatment (85%, while only 2% were found to be rarely adhering to the treatment

Out of the 440 participants, 44% had good HbA1c control and 22% had poor HbA1c control. Glycemic control based on FBS was found to be poor in more

than 51% of the participants, while the remaining 49% of the participants had a good glycemic control (Table 1).

Table 1. Descriptive statistics of the study sample

Characteristics of Participants	***n***	*%*
Age (n=440)		
Young Adults (18-44 years)	95	22
Middle Aged Adults (45-59 years)	261	59
Older Adults (60-65 years)	84	19
Gender (n=440)		
Male	166	38
Female	274	62
BMI (n=440)		
Normal	96	22
Overweight	200	45
Obese	144	33
Adviced for Diabetic Diet (n=440)		
Yes	301	68
No	139	32
Compliance to Diet (n=301)		
Always	94	31
Sometimes	136	45
Rarely/Never	71	24
Exercise 30 min x 5 / week (n=440)		
Always	168	38
Sometimes	105	24
Rarely/Never	167	38
Duration of Illness (n=440)		
< 5 Years	145	33
5 - 10 Years	135	31
> 10 Years	160	36
Hypertension (n=440)		
Yes	234	53
No	206	47
Dyslipidemia (n=440)		

Yes	401	91
No	39	9
Type of Treatment (n=440)		
Hypolycemic Monotherapy (Oral/Insulin)	82	19
Multiple Oral Hypoglycemic Agents	296	67
Oral Hypoglycemic Agents with Insulin	62	14
Compliance to Treatment (n=440)		
Always	375	85
Sometimes	56	13
Rarely/Never	9	2
HbA1c Control (n=440)		
Good (<7.0%)	192	44
Moderate (7.0-8.0%)	150	34
Poor (>8.0%)	98	22
FBS Control (n=440)		
Good (80-130 mg/dL)	216	49
Poor (>130 mg/dL)	224	51

Chi-square test of independence was performed to analyze the association between the variables and glycemic control. The results are depicted below in Table 2 and 3.

Based on HbA1c levels, both males (45%,) and females (43%,) had similar percentages of good glycemic control as well as, similar trends of poor glycemic control were observed across both the genders (Male:21%,; Female:23%,). A similar pattern was observed for glycemic control in relation to FBS levels for both genders where 49% males and 49% females achieved optimal glycemic control. The remaining 51% for both genders showed poor FBS control. Looking into the age distribution of the study population in relation to HbA1c control, it was observed that 47% of older adults had good glycemic control, while 21% had poor glycemic control. Forty four percent of middle-aged adults had good glycemic control, with 20% of the same age category having uncontrolled HbA1c levels. In young adults 40% of participants had good glycemic control based on their HbA1c levels and 39% were found to have poor glycemic control. When assessing glycemic control based on fasting blood sugar levels, the majority of young adults had poor glycemic control (61%,). Meanwhile, poor FBS control was observed in both middle-aged (49%) and older adults (46%). Poor HbA1c control was seen in 26% of obese patients, which was the same percentage (26%) observed in patients who had a normal BMI. Only 18% of overweight patients had poor glycemic control with regards to HbA1c levels. When assessing fasting blood sugar (FBS) control, poor control was seen in (56%,) participants with a normal BMI. Nearly the same percentages of patients who were both overweight and obese had uncontrolled FBS levels (Overweight:50%, Obese:49%). Among participants who were always adherent to a diabetic diet, good glycemic control was observed in 49%, while the

majority of those who rarely followed the diet, had poorer glycemic control (31%,). Poor FBS control was prevalent among participants who rarely followed a diabetic diet with 66% showing uncontrolled levels. HbA1c was well controlled in 46% of the participants who "Always" exercised for at least 150 minutes in a week, while 38% of participants who were physically inactive had poor glycemic control. Poor glycemic control based on FBS levels, was observed in 57%, among those who exercised rarely

According to HbA1c levels, many participants with a duration of illness of less than 5 years had good glycemic control (52%,). In contrast, poor glycemic control was more prevalent among those who had been diagnosed with type 2 diabetes for over 10 years (32%,). When glycemic control was assessed based on fasting blood sugar (FBS) levels, majority of participants with a disease duration of 5 to 10 years had good glycemic control (54%,), whereas poor control was more common among those with a duration of illness greater than 10 years (58%,). When assessed through HbA1C levels, surprisingly, a significant proportion of participants diagnosed with hypertension had good glycemic control (43%,), whereas 24% of those without a hypertension diagnosis exhibited poor glycemic control. A similar pattern was observed among participants diagnosed with dyslipidemia, where 43%) demonstrated good glycemic control. Among those not diagnosed with dyslipidemia, 31% had poor glycemic control. When glycemic control was assessed using FBS levels, 53% of participants with hypertension had good glycemic control, while the majority of those without hypertension (50.45%,) had poor glycemic control. Among participants diagnosed with dyslipidemia, the distribution was equal with 50%, showing good glycemic control and 50% showing poor control

According to glycemic control status measured by HbA1c level, the majority of participants on hypoglycemic monotherapy (66%, were found to have good glycemic control. This is similar to what was observed among participants on Multiple Oral Hypoglycemic Agents, where 45% demonstrated good glycemic control. In contrast, among those receiving a combination of oral hypoglycemic agents along with insulin, the majority (60%, had poor glycemic control. When assessed using FBS levels, a majority of participants on hypoglycemic monotherapy (60%,) also showed good glycemic control. Whereas, among participants on multiple oral hypoglycemic agents, the majority (51%, had poor glycemic control. This pattern was even more pronounced in participants using both oral hypoglycemic agents along with insulin, with 66% exhibiting poor control. Among participants who reported always being compliant with their medication, the majority (46%, had good glycemic control according to HbA1c levels. In contrast, among participants who reported being 'sometimes compliant' with their medication as well as those who were 'rarely or never compliant, the majority exhibited poor FBS control (Sometimes compliant:73%, Rarely/Never:78%,)

Based on the above results, a significant association was found between mean HbA1c control and duration of illness [X^2= 4.276, p=0.004], type of treatment [X^2 =77.894, p <0.001] and compliance to treatment [X^2 =22.934, p <0.001]. For mean FBS control, a significant association was found for the variables compliance to diet [X^2 =13.565, p=0.001], exercise [X^2 =8.395, p=0.015], type of treatment [X^2 =9.485, p=0.009] and compliance to treatment [X^2 =16.120, p <0.001].

No significant association was found between mean HbA1c and age [X^2=4.276, p=0.370], gender [X^2=0.325, p=0.850], BMI [X^2=5.502, p=0.240], compliance to diet [X^2=4.211, p=0.378], exercise [X^2=4.219, p=0.377], hypertension [X^2=0.903, p=0.637] and dyslipidemia [X^2=2.972, p=0.226]. Furthermore, no significant association was found between mean FBS control and age [X^2=5.115, p=0.078], gender [X^2=0.009, p=0.923], BMI [X^2=1.466, p=0.480], duration of illness [X^2=5.316, p=0.070], hypertension [X^2=2.412, p=0.120] and dyslipidemia [X^2=0.518, p=0.472].

Table 2. Pearson's chi-squared test results of studied variables in relation to HbA1c Control

Characteristics of Participants	*HbA1c (%)*			X^2	*p-value*
	Good (< 7.0)	*Moderate (7.0-8.0)*	*Poor (> 8.0)*		
Age (years)					
Young Adults (18-44 years)	40% (39)	30% (28)	30% (28)		
Middle Aged Adults (45-59 years)	44% (114)	36% (95)	20% (52)	4.276	0.370
Older Adults (60-65 years)	47% (39)	32% (27)	21% (18)		
Gender					
Male	45% (75)	34% (56)	21% (35)	0.325	0.850
Female	43% (117)	34% (94)	63% (63)		
BMI (Kg/m^2)					
Normal	39% (37)	35% (34)	26% (25)		
Overweight	47% (93)	36% (72)	18% (35)	5.502	0.240
Obese	43% (62)	31% (44)	26% (38)		
Compliance to Diet					
Always	49% (46)	27% (25)	24% (23)		
Sometimes	40% (54)	35% (48)	25% (34)	4.211	0.378
Rarely/Never	35% (25)	34% (24)	31% (22)		
Exercise (30 mins x 5 times / week)					
Always	46% (78)	33% (55)	21% (35)		
Sometimes	48% (50)	28% (30)	24% (25)	4.219	0.377
Rarely/Never	38% (64)	39% (65)	23% (38)		
Duration of Illness					
< 5 Years	52% (76)	32% (46)	16% (23)		
5 - 10 Years	45% (61)	36% (49)	19% (25)	15.533	0.004*
> 10 Years	34% (55)	34% (55)	32% (50)		
Hypertension					
Yes	43% (101)	36% (84)	21% (49)	0.903	0.637
No	44% (91)	32% (66)	24% (49)		
Dyslipidemia					
Yes	43% (174)	35% (141)	22% (86)	2.972	0.226
No	46% (18)	23% (9)	31% (12)		
Type of Treatment					

Hypoglycemic Monotherapy (Oral/ Insulin)	66% (54)	23% (19)	11% (9)		
Multiple Oral Hypoglycemic Agents	45% (133)	38% (111)	17% (52)	77.894	**<0.001***
Oral Hypoglycemic Agents with Insulin	8% (5)	32% (20)	60% (37)		
Compliance to treatment					
Always	46% (173)	35% (132)	19% (70)		
Sometimes	30% (17)	30% (17)	40% (22)	22.934	**<0.001***
Rarely/Never	22% (2)	11% (1)	67% (6)		

*** Statistically significant at p-value <0.05**

Table 3. Pearson's chi-squared test results of studied variables in relation to FBS Control

Characteristics of Participants	*FBS (mg/dL)*			
	80-130	*>130*	*X^2*	*p-value*
Age (years)				
Young Adults (18-44 years)	39% (37)	61% (58)		
Middle Aged Adults (45-59 years)	51% (134)	49% (127)	5.115	0.078
Older Adults (60-65 years)	54% (45)	46% (39)		
Gender				
Male	49% (81)	51% (85)	0.009	0.923
Female	49% (135)	51% (139)		
BMI (Kg/m²)				
Normal	44% (42)	56% (54)		
Overweight	50% (100)	50% (100)	1.466	0.480
Obese	51% (74)	49% (70)		
Compliance to Diet				
Always	62% (58)	38% (36)		
Sometimes	44% (60)	56% (76)	13.565	**0.001***
Rarely/Never	34% (24)	66% (47)		
Exercise (30 mins x 5 times / week)				
Always	58% (97)	42% (71)		
Sometimes	46% (48)	54% (57)	8.395	**0.015***
Rarely/Never	43% (71)	57% (96)		
Duration of Illness				
< 5 Years	52% (76)	48% (69)		
5 - 10 Years	54% (73)	46% (62)	5.316	0.070
> 10 Years	42% (67)	58% (93)		
Hypertension				
Yes	53% (123)	47% (111)	2.412	0.120
No	45% (93)	55% (113)		
Dyslipidemia				
Yes	50% (199)	50% (202)	0.518	0.472
No	44% (17)	56% (22)		

Type of Treatment				
Hypoglycemic Monotherapy (Oral/Insulin)	60% (49)	40% (33)		
Multiple Oral Hypoglycemic Agents	49% (146)	51% (150)	9.485	**0.009***
Oral Hypoglycemic Agents with Insulin	34% (21)	66% (41)		
Compliance to treatment				
Always	53% (199)	47% (176)		
Sometimes	27% (15)	73% (41)	16.120	**<0.001***
Rarely/Never	22% (2)	78% (7)		

*** Statistically significant at p-value <0.05**

Tables 4 and 5 shows the results of the univariate analysis of studied variables and glycemic control. The results showed that the people having diabetes for more than 10 years had a higher possibility of having poor HbA1c control [OR=1.99, p =0.003, CI:1.26-3.15] compared to those with diabetes for less than 5 years. Other significant factors in association with HbA1c control were the type of treatment [OR=23.22, p <0.001, CI:8.34-64.63] and the compliance to treatment [OR=1.96, p=0.017, CI:1.13-3.41]. Participants who used a combination of oral hypoglycemic agents and insulin were 23 times more likely to have poor HbA1c control while, those on multiple oral hypoglycemic agents were 2 times more likely to have poor HbA1c control compared with those on hypoglycemic monotherapy.

Table 4. Binary logistic regression to assess the association between studied variables on HbA1c control

Characteristics of Participants	*HbA1c (>7.0%)*		
	OR	*95% CI*	*p-value*
Patient-related factors			
Age			
Young adults (18-44 years)	Ref.		
Middled-aged adults (45-59 years)	0.84	0.52-1.36	0.485
Older adults (60-65 years)	0.80	0.44-1.45	0.469
Gender			
Female	Ref.		
Male	0.92	0.63-1.36	0.684
BMI (Kg/m^2)			
Normal	Ref.		
Overweight	0.72	0.44-1.19	0.201
Obese	0.84	0.50-1.42	0.522
Compliance to Diet			
Always	Ref.		
Sometimes	1.46	0.86-2.47	0.166
Rarely/Never	1.76	0.94-3.32	0.079
Exercise (30 mins x 5 times/week)			

Always	Ref.		
Sometimes	0.94	0.58-1.53	0.803
Rarely/Never	1.36	0.88-2.10	0.166
Disease-related factors			
Duration of Illness			
< 5 years	Ref.		
5-10 years	1.37	0.86-2.20	0.186
> 10 years	1.99	1.26-3.15	**0.003***
Hypertension			
No	Ref..		
Yes	0.97	0.67-1.42	0.883
Dyslipidemia			
No	Ref..		
Yes	1.07	0.56-2.01	0.832
Treatment-related factors			
Type of Treatment			
Hypoglycemic monotherapy	Ref..		
Multiple oral hypoglycemic agents	1.96	1.13-3.41	**0.017***
Oral hypoglycemic agents with insulin	23.22	8.34-64.63	**<0.001***
Compliance to Treatment			
Always	Ref..		
Sometimes	2.05	1.12-3.75	**0.020***
Rarely/Never	3.13	0.64-15.26	0.158

*** Statistically significant at p-value <0.05**

Based on mean FBS levels, the risk of poor glycemic control was higher among middle-aged adults [*OR*=0.58, *p*=0.025, CI:0.36-0.94]. It was also found that people who were rarely compliant with diabetic diet had an increased likelihood of having poor glycemic control *[OR*=3.16, *p* <0.001, CI:1.66-6.01] while those who were sometimes compliant also had twice the possibility of having poor glycemic control [*OR*=2.04, *p*=0.009, CI:1.19-3.49]. Participants who rarely or never exercised were also found to have poor glycemic control compared to those who exercised regularly [*OR*=1.85, *p*=0.006, CI:1.20-2.85]. In addition, the type of treatment and compliance to treatment were found to be statistically significant with having a poor glycemic control based on mean FBS levels. While participants who were on a combination of oral hypoglycemic agents with insulin were 3 times more likely to have poor glycemic control [*OR*=2.90, *p*=0.002, CI:1.46-5.76], those who were sometimes compliant with the treatment had a higher probability of having poor glycemic control [*OR*=3.03, *p* <0.001, CI:1.62-5.65]

Table 5. Binary logistic regression to assess the association between studied variables on FBS Control

Characteristics of Participants	*FBS (>130 mg/dL)*		
	OR	*95% CI*	*p-value*
Patient-related factors			

Age			
Young adults (18-44 years)	Ref..		
Middled-aged adults (45-59 years)	0.58	0.36-0.94	**0.025***
Older adults (60-65 years)	0.56	0.31-1.01	0.053
Gender			
Female	Ref..		
Male	1.07	0.73-1.57	0.733
BMI (Kg/m^2)			
Normal	Ref..		
Overweight	0.76	0.47-1.24	0.274
Obese	0.70	0.42-1.19	0.188
Compliance to Diet			
Always	Ref..		
Sometimes	2.04	1.19-3.49	**0.009***
Rarely/Never	3.16	1.66-6.01	**<0.001***
Exercise (30 mins x 5 times/week)			
Always	Ref..		
Sometimes	1.58	0.97-2.59	0.066
Rarely/Never	1.85	1.20-2.85	**0.006***
Disease-related factors			
Duration of Illness			
< 5 years	Ref..		
5-10 years	0.96	0.60-1.54	0.878
> 10 years	1.57	1.00-2.47	0.051
Hypertension			
No	Ref..		
Yes	0.71	0.49-1.04	0.079
Dyslipidemia			
No	Ref..		
Yes	0.80	0.41-1.55	0.510
Treatment-related factors			
Type of Treatment			
Hypoglycemic monotherapy	Ref..		
Multiple oral hypoglycemic agents	1.36	0.80-2.33	0.257
Oral hypoglycemic agents with insulin	2.90	1.46-5.76	**0.002***
Compliance to Treatment			

Always	Ref..		
Sometimes	3.03	1.62-5.65	**<0.001***
Rarely/Never	3.87	0.79-18.89	0.094

*** Statistically significant at p-value <0.05**

Discussion

This study was carried out to identify the status of glycemic control and to analyze the factors associated with glycemic control among outpatients with type 2 diabetes mellitus presenting to one of the largest tertiary hospitals (IGMH) in Male', the capital of Maldives. In this study, glycemic control was assessed based on mean HbA1c level as well as mean FBS level using cut-off values from the American Diabetes Association (ADA, 2023). Poor HbA1c control was observed in 22% of the participants, with 44% having good HbA1c control and 34% having moderate control. This finding is inconsistent with the findings of other recent studies which showed that the majority of the study participants had poor glycemic control (Salah & Abd-Elraouf., 2020; Rakhis et al., 2022; Al Qarem et al., 2022). This variation in the prevalence of poor glycemic control in the current study might be due to the difference in the cut-off values used in these studies. Additionally, 51% of the participants had poor FBS control, while nearly half (49%) of the participants had good FBS control. Similar findings were reported in a study conducted in Southwest Ethiopia (Yigazu et al., 2017).

The patient-related factors that were assessed in this study included age, gender, BMI, compliance to diet and exercise. In our study, there was no statistical significance between gender and glycemic control. This finding was compatible with another study conducted in South Africa which also showed that gender was not associated with poor glycemic control (Traoré et al., 2021). However, another similar study conducted by Sakin and Alay (2021) showed that females tend to have poor glycemic control compared to males, whereas another study conducted in Jordan reported that the male gender was significantly associated with poor glycemic control (Al Qarem et al., 2022). There was a significant increase in the risk of having poor glycemic control in individuals aged 45-59 years [OR=0.58, p=0.025, CI:0.36-0.96] compared to younger adults aged between 18-44 years. This is consistent with a similar study done in Saudi Arabia, which showed that participants aged between 45-60 had poor glycemic control (Ghabban et al., 2020). Our study showed that there was no association between BMI and glycemic control. This was in line with other similar studies by Chetoui et al. (2019) and Anari et al. (2016) who reported that being overweight or obese was not associated with poor glycemic control. They reported that central adiposity or waist-to-hip ratio, is a stronger indicator of glycemic control in comparison to adiposity or BMI. However, some authors also reported that obesity is one of the major risk factors associated with poor glycemic control (Almalki et al., 2021; Salah & Abd-Elraouf., 2020). Our findings show that being compliant to a diabetic diet is also significant. People who were rarely compliant to the diet were found to have 3 times higher risk of having poor glycemic control compared to those who were always compliant. According to a study by Martínez et al. (2020), adherence to a healthy diet significantly decreased the likelihood of having poor glycemic control. A study conducted in Egypt revealed that participants who rarely exercised were

6 times more likely to have poor glycemic control (Salah & Abd-Elraouf., 2020). A similar finding was found in the present study which showed that people who rarely exercised were 2 times more likely to have poor glycemic control [ORz=1.85, p=0.006, CI:1.20-2.85].

Duration of illness was found to be significant in this study, where participants who had a duration of type 2 diabetes for more than 10 years were 2 times more likely to have glycemic levels above the optimal level compared to those who had the disease for less than 5 years. This finding was similar in many other studies which also showed that longer duration of diabetes was associated with poor glycemic control (Pamungkas, R et al., 2017; Li, J et al., 2018; Chetoui et al., 2020; Oluma, A et al., 2021). Our study did not reveal any significant association between participants who had underlying metabolic diseases such as hypertension and dyslipidemia with glycemic control. On the contrary, other recent studies conducted in South China and Baghdad reported that participants who had diabetes along with hyperlipidemia did not achieve the target glycemic control (Al-Bahrani & Yassin 2022; Zhai et al., 2023). Another study done by Yimam et al. (2020), highlighted that the prevalence of having poor glycemic control was high in participants with hypertension.

Our study also showed that the type of treatment and compliance to treatment were highly associated with glycemic control. Participants who were on a combination of oral hypoglycemic agents and insulin were highly likely to have poor glycemic control [OR=23.22, p<0.001, 95% CI:8.34-64.63], while those on multiple oral hypoglycemic agents were twice as likely to have poor HbA1c control when compared to those on hypoglycemic monotherapy. A similar association was found between FBS control and the type of treatment in which participants who were on a combination of insulin and oral hypoglycemic agents were 3 times more likely to have poor glycemic control. This result is concurrent with a study conducted in Jakarta, Indonesia, which demonstrated that patients who were on monotherapy had good glycemic control while the use of combined antidiabetics was significantly associated with poor glycemic control (Maifitrianti et al., 2020). Similar studies reported by many other authors were also in agreement with the findings of this study (Chetoui et al., 2020; Ghabban et al., 2020; Nigusse et al., 2021; Traoré et al., 2021). According to Maifitrianti et al. (2020), patients who are on combination therapy have a higher risk of having poor glycemic control due to the fact that the disease is likely to have progressed and thus is unlikely to be controlled using monotherapy. This could also be due to patients facing difficulties in taking more than one drug along with injectables, thereby affecting adherence to medication, thus leading to uncontrolled HbA1c and FBS levels. Our findings also show that compliance to treatment was highly significant with glycemic control. Many recent literature supports that patients who were strictly adherent to the medications achieved optimal levels of glycemic control than those who were not compliant (Mirahmadizadeh et al., 2020; Traoré et al., 2021; Al Qarem et al., 2022). In comparison to these findings, our results show that participants who were sometimes compliant to their medications were thrice more likely to have poor FBS control [OR=3.03, p<0.001, 95% CI:1.62-5.65], and twice as likely to have poor glycemic control [OR=2.05, p=0.020, 95% CI:1.12-3.75], compared to those who were always compliant. This is supported by Mirahmadizadeh et al. (2020), who found that adherence to the medication and glycemic control

is influenced by multiple factors such as socioeconomic status, attitudes and motivation of the patients.

Limitation

This study was restricted to using data exclusively from Indira Gandhi Memorial Hospital, and therefore, the data would not represent the general population of the country. However, as data was collected from the National Diabetes Center within IGMH, this ensured that a substantial number of patients with T2DM were included in the study, ensuring a relevant sample for analysis. This study employed a retrospective study design, with part of the data collected through a questionnaire via phone call interviews. This approach subjects the data to a possibility of non-response bias as well as potential recall bias, as the information provided by the participants could not be independently verified by the researchers.

To ensure consistency of the interviews and minimize potential interviewer bias, all the interviewers adhered to a structured-questionnaire along with an interviewer guide. However, this study did not account for other confounding factors such as acute stress reactions, psychosocial factors and socioeconomic factors which may affect the glycemic control. Nevertheless, despite these limitations, this research prioritizes the most significant and measurable factors identified through the literature review.

Conclusion

This study identifies the status of glycemic control and the factors affecting glycemic control in patients with T2DM presenting to Indira Gandhi Memorial Hospital, (IGMH) Male'. Based on the results of this study, the factors associated with glycemic control were found to be age, compliance to diet, exercise, duration of illness, the type of treatment and compliance to treatment. Understanding these factors can assist healthcare professionals in developing targeted policies and interventions to optimize the glycemic levels and minimize the burden of the disease within the community. The findings of this study also shed light on the importance of patient education in developing self-management skills in order to effectively manage chronic illnesses like diabetes mellitus. Therefore, empowering and motivating patients to take an active role in the management of the disease can significantly improve adherence to treatment, and thus improve glycemic control. This, in turn, can reduce the risk of disease-related complications and lessen the overall burden of the disease on both the individuals as well as the community.

Conflict of Interest

The authors declare no conflicts of interest.

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