

Original Article**Body Mass Index, Glucose, and Triglycerides as Predictors of HbA1c Control in Patients with Type 2 Diabetes Mellitus: A Cross-Sectional Study**Farida Anwari¹, Amellya Octifani¹¹ Department of Medical Laboratory Technology, Universitas Anwar Medika, Sidoarjo, East Java, Indonesia**ARTICLE INFO****Article History**

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ABSTRACT

Background: Type 2 diabetes mellitus (T2DM) is a chronic disease with rising global and national prevalence. Glycemic control, measured by glycated hemoglobin (HbA1c), is essential to prevent complications. Previous studies showed inconsistent findings on the effects of age, gender, body mass index (BMI), and triglycerides on HbA1c levels, with limited use of logistic regression. This study examined the influence of age, gender, BMI, glucose, and triglyceride levels on HbA1c control in Indonesian patients with T2DM.

Methods: A cross-sectional study was conducted using secondary medical records of 55 T2DM patients treated at RA Basoeni Clinic, Mojokerto, Indonesia, in 2024. Inclusion criteria included patients aged ≥ 18 without anemia or hemoglobinopathy; patients with incomplete data were excluded. HbA1c values were estimated from average fasting and postprandial glucose over the past three months using the American Diabetes Association (ADA) 2019 conversion table. HbA1c status was categorized as controlled ($\leq 6.5\%$) and uncontrolled ($> 6.5\%$). Logistic regression analysis was performed using SPSS version 25.0. The study adhered to STROBE reporting guidelines.

Results: Of the 55 patients, 24 (43.6%) had controlled HbA1c and 31 (56.4%) had uncontrolled HbA1c. Logistic regression showed that BMI (OR=1.192, $p=0.047$), glucose (OR=1.026, $p=0.044$), and triglycerides (OR=1.017, $p=0.049$) significantly predicted HbA1c status. Age ($p=0.837$) and gender ($p=0.884$) were not significant predictors. The model explained 68.9% of the variance (Nagelkerke $R^2=0.689$) with an overall classification accuracy of 83.6%.

Conclusion: BMI, glucose, and triglycerides are significant predictors of HbA1c control in T2DM patients, while age and gender are not. To improve glycemic outcomes, clinical management should prioritize weight regulation, glucose monitoring, and triglyceride control.

Keywords: Diabetes Mellitus, Type 2; Hemoglobin A, Glycosylated; Blood Glucose; Body Mass Index; Triglycerides.

Implications for Practice:

- High BMI, blood glucose, and triglyceride levels are strong predictors of uncontrolled HbA1c; thus, routine screening and early identification of these risk factors should be prioritized in clinical practice.
- Integrated management of BMI, glucose, and triglycerides through diet, physical activity, and pharmacological therapy should be emphasized to improve glycemic control.
- National diabetes management guidelines should formally include BMI and triglycerides as key indicators for risk stratification, with appropriate resource allocation for regular monitoring.

Introduction

Diabetes mellitus (DM) is a chronic metabolic disorder that continues to present a significant global health burden. The disease is characterized by persistent hyperglycemia caused by impaired insulin secretion, reduced insulin sensitivity, or a combination of both. Globally, type 2 diabetes mellitus (T2DM) constitutes about 90–95% of all diabetes cases, making it the most common form of diabetes. According to the International Diabetes Federation (IDF) (2025), the prevalence of diabetes has reached alarming levels, with an estimated 537 million adults aged 20–79 years affected worldwide in 2021. This figure is projected to rise to 643 million by 2030 and 783 million by 2045. The steep increase underscores the urgent need for stronger preventive and therapeutic measures.

Indonesia has not been immune to this trend. As the country with the fifth-highest number of diabetes cases worldwide, Indonesia reported 19.5 million cases in 2021, and the number is expected to surge to 28.6 million by 2045. The growing prevalence is compounded by the fact that diabetes often goes undiagnosed, and among those diagnosed, treatment outcomes remain suboptimal. According to national reports, only two-thirds of diagnosed patients receive any form of therapy, either pharmacological or lifestyle-based interventions. Alarming, of those under treatment, only one-third achieve adequate glycemic control. This means that nearly two-thirds of patients remain at risk for complications ([Perkumpulan Endokrinologi Indonesia](#), 2021). The clinical and economic implications of this scenario are immense, ranging from increased hospitalization costs to reduced quality of life and premature mortality.

Glycemic control is central to diabetes management, with glycated hemoglobin (HbA1c) widely recognized as the gold standard biomarker. HbA1c reflects the

average blood glucose concentration over the preceding two to three months, offering a more reliable indicator of long-term glycemic status compared to single fasting or postprandial glucose measurements. Clinical guidelines, including those of the American Diabetes Association (ADA), recommend that most nonpregnant adults with T2DM maintain HbA1c below 7% to minimize the risk of microvascular and macrovascular complications ([Wang et al.](#), 2015). Evidence has consistently shown that each 1% increase in HbA1c levels is associated with an 18% higher risk of cardiovascular events ([Sheng et al.](#), 2024). Thus, maintaining optimal HbA1c levels is essential not only to prevent complications but also to reduce mortality risk.

Given the importance of HbA1c, researchers and clinicians have long been interested in identifying predictors of glycemic control. Demographic factors such as age and gender, as well as clinical parameters like body mass index (BMI), fasting glucose, and triglyceride levels, have been examined across different populations. However, findings from these studies remain inconsistent and context-dependent. For instance, [Kara et al.](#) (2024) in Bali reported that uncontrolled HbA1c levels were more common in men and in patients aged 41–60 years. Similarly, [Jannah et al.](#) (2024) in Makassar found that gender and triglycerides were associated with HbA1c control, while age was not. In contrast, [Maifitrianti et al.](#) (2020) in Jakarta observed no significant association between age, gender, or BMI with HbA1c levels. Further evidence from Bosnia and Herzegovina indicated that only triglyceride levels were significantly linked to HbA1c control, whereas age, gender, and BMI showed no association ([Sutkovic & Abdic-Nekic](#), 2013). A study from Vietnam confirmed that higher BMI increased the risk of uncontrolled HbA1c, highlighting the

role of obesity in glycemic dysregulation ([Thuy et al.](#), 2021).

However, despite the breadth of research, the literature remains inconclusive. Some studies emphasize the importance of BMI and triglycerides as predictors, while others downplay their significance. Additionally, many investigations employed descriptive or correlational analyses rather than inferential methods. As a result, the strength and magnitude of associations have not been robustly quantified. Only a limited number of studies have applied logistic regression analysis to determine how these factors collectively predict HbA1c control. This methodological gap reduces the utility of findings for clinical decision-making, where quantifying risk in terms of odds ratios and confidence intervals is essential.

From a theoretical standpoint, the relationship between BMI, triglycerides, and HbA1c can be understood through the lens of insulin resistance. Obesity, particularly central or visceral obesity, leads to the accumulation of adipose tissue, which releases free fatty acids and pro-inflammatory cytokines. This disrupts insulin signaling pathways, resulting in decreased glucose uptake in muscle and adipose tissue and increased hepatic glucose output. Insulin resistance thus manifests as hyperglycemia, which over time elevates HbA1c levels. Simultaneously, insulin resistance alters lipid metabolism by enhancing lipolysis and reducing lipogenesis in adipose cells, leading to elevated plasma triglycerides ([Kerr et al.](#), 2024). The interplay between obesity, dyslipidemia, and hyperglycemia forms a vicious cycle that exacerbates metabolic dysfunction and worsens glycemic control. This pathophysiological mechanism constitutes the conceptual framework of this study, positing that BMI, triglycerides, and blood glucose levels are key predictors

of HbA1c control through insulin resistance-mediated pathways.

The role of glucose levels in HbA1c control is more straightforward, as HbA1c is directly derived from average blood glucose concentrations. Chronic hyperglycemia leads to increased glycation of hemoglobin, resulting in elevated HbA1c values. Yet, glucose levels alone cannot fully capture the complexity of glycemic control, as they are influenced by a host of interacting factors such as BMI, insulin sensitivity, and lipid profile. Demographic factors such as age and gender have been investigated extensively, but results remain equivocal. Some studies suggest that aging increases the risk of glucose intolerance due to reduced pancreatic beta-cell function and increased adiposity. Others argue that lifestyle, diet, and physical activity patterns play a more dominant role than chronological age. Similarly, gender differences in HbA1c control have been reported, with some studies noting poorer control among women, possibly due to hormonal fluctuations and sociocultural barriers to lifestyle modification. Yet, other research has failed to confirm such differences, underscoring the need for further exploration.

In the Indonesian context, research on predictors of HbA1c remains limited and fragmented, often constrained by sample size and methodology. Few Indonesian studies have used inferential modeling to quantify these associations, limiting the applicability of their findings for risk stratification and clinical decision-making. Therefore, this study aimed to determine the predictive role of BMI, blood glucose, and triglycerides on HbA1c control among Indonesian patients with T2DM using logistic regression analysis.

Methods

Study Design

This study employed a cross-sectional design with an inferential quantitative approach ([Kazanskaia, 2025](#)). Cross-sectional studies are useful for examining associations between independent and dependent variables at a single point in time. This cross-sectional study followed the STROBE reporting guideline. In this case, demographic and clinical factors in relation to glycemic control, as represented by HbA1c levels, were analyzed. The study relied on secondary data extracted from patient medical records, which reduces recall bias and provides an authentic picture of patient clinical status.

Participants

Data for this study were collected from the RA Basoeni Clinic, Mojokerto, East Java, Indonesia, in 2024. This clinic was chosen because it serves a large number of patients with type 2 diabetes mellitus (T2DM) and maintains comprehensive clinical records, making it suitable for secondary data analysis. The consistency of study location was emphasized to ensure clarity, and all references were standardized to the RA Basoeni Clinic. The study population included all T2DM patients who visited the clinic during 2024 and met the inclusion criteria: age ≥ 18 years, diagnosis of T2DM based on PERKENI and ADA criteria, availability of complete medical record data (BMI, fasting and postprandial glucose, triglycerides, and HbA1c or its conversion),

and absence of anemia or hemoglobinopathy that could affect HbA1c estimation. Patients were excluded if they had incomplete anthropometric or laboratory data, severe comorbidities influencing glucose metabolism (such as advanced liver disease), or anemia or hemoglobinopathies. Sampling was conducted purposively, and after screening, 55 patients met the criteria and were included in the final analysis. The sample size was considered adequate for logistic regression analysis, following the “10 events per variable” rule proposed by Peduzzi et al. (1996), which requires at least 10 outcome events per predictor variable. With five predictors (age, gender, BMI, glucose, and triglycerides), a minimum of 50 participants was necessary, and this requirement was fulfilled with the final sample size of 55 patients.

Instruments

The primary outcome variable was HbA1c control, defined as controlled ($\leq 6.5\%$) or uncontrolled ($>6.5\%$), in line with ADA 2019 recommendations. HbA1c values were estimated from the mean of fasting and postprandial glucose measurements over the preceding three months using the [American Diabetes Association \(ADA\) Professional Practice Committee \(2022\)](#) conversion table, which has been validated for clinical and epidemiological use (**Table 1**).

Table 1. Conversion of Average Blood Glucose to HbA1c

HbA1c (%)	Average Plasma Glucose for the last 3 months (mg/dL)	Average Fasting Blood Glucose last 3 months (mg/dL)	Average Post Prandial Blood Glucose last 3 months (mg/dL)
6	126 (100 – 152)		
5.5 – 6.49		122 (177 – 217)	144 (139-148)
6.5 – 6.99		142 (135 – 150)	164 (159-169)
7	154 (123 – 185)		
7.0 – 7.49		152 (143 – 162)	176 (170-183)
7.5 – 7.99		167 (157 – 177)	189 (180-197)
8	183 (147 – 217)		
8.0 – 8.5		178 (164 – 192)	206 (195-217)

HbA1c (%)	Average Plasma Glucose for the last 3 months (mg/dL)	Average Fasting Blood Glucose last 3 months (mg/dL)	Average Post Prandial Blood Glucose last 3 months (mg/dL)
9	212		
10	240		
11	269		
12	298		

Source: ([Rahmah & Karyus, 2023](#))

Predictor variables included age, gender, BMI, glucose, and triglycerides. Age and gender were obtained from the patient's medical records. BMI was calculated as weight in kilograms divided by height in meters squared (kg/m^2), with weight measured using a calibrated digital scale and height measured using a wall-mounted stadiometer. Glucose values were expressed as the mean of fasting and postprandial plasma glucose in mg/dL. Triglycerides were measured in the fasting state using enzymatic colorimetric methods in the clinic's ISO-certified laboratory and recorded in mg/dL. All variables were treated as continuous for regression analysis, except gender, which was treated as a dichotomous variable (male = 0, female = 1).

Data Collection

Data management in this study followed a structured workflow to ensure accuracy and consistency. First, medical records were screened to identify patients who met the inclusion and exclusion criteria. Second, relevant variables—including age, gender, body mass index (BMI), fasting glucose, postprandial glucose, and triglyceride levels—were extracted from eligible records. Third, average glucose values were converted into estimated HbA1c levels using the American Diabetes Association (ADA) conversion formula. Fourth, patients were categorized into two groups based on HbA1c status: *controlled* and *uncontrolled*. Fifth, descriptive analyses were performed to summarize demographic and clinical

characteristics using frequencies and mean values. Finally, inferential analysis was conducted using logistic regression to assess the influence of age, gender, BMI, glucose, and triglyceride levels on HbA1c control status.

The overall workflow of the study followed six systematic steps: (1) patient selection, (2) extraction of clinical data, (3) HbA1c conversion, (4) categorization of glycemic control, (5) descriptive analysis, and (6) inferential analysis using logistic regression. For clarity, the sequence of these steps is illustrated in **Figure 1**.

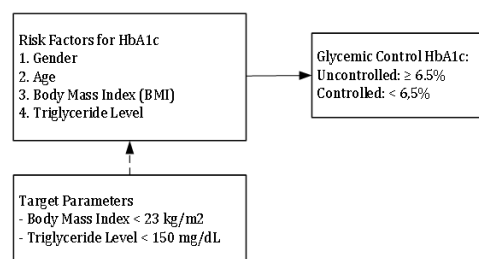


Figure 1. Research Framework
([Perkumpulan Endokrinologi Indonesia, 2021](#))

Data Analysis

Data processing and analysis were performed using SPSS version 25.0 (IBM Corp.). Descriptive statistics were used to summarize patient characteristics, where categorical variables were presented as frequencies and percentages, and continuous variables as means $\pm$ standard deviations. Logistic regression analysis was then applied to identify predictors of HbA1c control, with odds ratios (OR) and 95% confidence intervals (CI) calculated for each independent variable. Model fit was

assessed using the Hosmer–Lemeshow Goodness-of-Fit Test (Nattino et al., 2020), reduction in -2 Log Likelihood, and Nagelkerke R^2 (Nurkoç et al., 2024). The predictive accuracy of the model was evaluated through a classification table (confusion matrix), and a p-value of less than 0.05 was considered statistically significant.

Ethical Considerations

This study was reviewed and approved by the Health Research Ethical Clearance Commission of the Faculty of Dental Medicine, Universitas Airlangga. The ethical clearance certificate number is: 580/HRECC.FODM/V/2023. The commission reviewed the research proposal titled "Relationship of Long-Standing Diabetes Mellitus and HbA1c with Diabetic Wound Complications" and determined it to be ethically appropriate in accordance with the World Health Organization (WHO) 2011 ethical guidelines.

Results

A total of 55 patients with type 2 diabetes mellitus (T2DM) were included and selected through purposive sampling from medical records at RA Basoeni Clinic, Mojokerto. Inclusion criteria were adult patients aged ≥ 18 years with a confirmed diagnosis of T2DM and complete laboratory data; patients with anemia or hemoglobinopathy were excluded to avoid HbA1c measurement bias. This sample reflects the demographic and clinical profile of the local T2DM population and is suitable for inferential analysis.

Table 2. Baseline Demographic and Clinical Characteristics of Participants (n=55)

Characteristic	Mean $\pm$ SD / n (%)
Age (years)	55.3 $\pm$ 9.4
Gender (Male/Female)	25 (45.5) / 30 (54.5)
BMI (kg/m ²)	27.4 $\pm$ 3.8
Glucose (mg/dL)	166.3 $\pm$ 45.8
Triglycerides (mg/dL)	185.2 $\pm$ 66.7
HbA1c status	24 (43.6) / 31 (56.4)
(Controlled/Uncontrolled)	

Table 2 summarizes the baseline demographic and clinical characteristics of the study participants. The mean age was 55.3 years, and the majority of patients were female (54.5%). Over half (56.4%) had uncontrolled HbA1c ($>6.5\%$).

Normality Test

The Kolmogorov–Smirnov test was performed to assess the distribution of continuous variables. All variables had p-values > 0.05 , indicating normal distribution and supporting the use of parametric analysis.

Table 3. Results of the Kolmogorov–Smirnov normality test (n = 55)

Variable	Kolmogorov-Smirnov Z	p-value
Age (years)	0.842	0.475
BMI (kg/m ²)	0.767	0.598
Glucose (mg/dL)	0.901	0.383
Triglycerides (mg/dL)	0.874	0.432

Distribution by Gender and Age

The prevalence of HbA1c control was further explored by gender and age group. **Table 4** shows that the majority of participants were aged ≥ 50 years in both controlled and uncontrolled groups. A higher proportion of females was in the uncontrolled group compared to males.

Table 4. Distribution of HbA1c Control by Gender and Age Group (n = 55)

Variable	Controlled HbA1c (≤6.5%)	Uncontrolled HbA1c (>6.5%)	Total
Gender			
Male	15 (62.5%)	10 (32.3%)	25 (45.5%)
Female	9 (37.5%)	21 (67.7%)	30 (54.5%)
Age Group			
< 50 years	4 (16.7%)	7 (22.6%)	11 (20.0%)
≥ 50 years	20 (83.3%)	24 (77.4%)	44 (80.0%)

Bivariate Analysis

Chi-square and independent t-tests were used to compare characteristics between controlled and uncontrolled HbA1c groups. Age and gender were not

significantly associated with HbA1c control. In contrast, BMI, glucose, and triglyceride levels were significantly higher in the uncontrolled group (**Table 5**).

Table 5. Bivariate analysis of factors associated with HbA1c control

Variable	Controlled HbA1c (≤6.5%) (n=24)	Uncontrolled HbA1c (>6.5%) (n=31)	p-value
Age (years), mean ± SD	54.7 ± 10.9	55.7 ± 10.6	0.837 ^a
Gender, n (%)	Male: 15 (62.5)	Male: 10 (32.3)	0.884 ^b
BMI (kg/m ²), mean ± SD	23.1 ± 7.2	26.2 ± 8.9	0.047 ^{a*}
Glucose (mg/dL), mean ± SD	193.4 ± 40.5	216.9 ± 47.8	0.044 ^{a*}
Triglycerides (mg/dL), mean ± SD	221.6 ± 68.4	254.7 ± 79.3	0.049 ^{a*}

Multivariable Logistic Regression Analysis

Binary logistic regression analysis identified BMI (OR = 1.192; 95% CI: 1.002–1.418; p = 0.047), glucose (OR = 1.026; 95% CI: 1.001–1.051; p = 0.044), and triglycerides (OR = 1.017; 95% CI: 1.000–1.034; p = 0.049) as significant predictors of

uncontrolled HbA1c. Age (p = 0.837) and gender (p = 0.884) were not significant predictors. The model explained 68.9% of the variance (Nagelkerke R² = 0.689) with an overall classification accuracy of 83.6%, indicating good predictive performance (Hosmer–Lemeshow p = 0.42) (**Table 6**).

Table 6. Multivariable Logistic Regression Analysis for Predictors of HbA1c Control

Variable	OR	95% CI	p-value
BMI	1.192	1.003 – 1.416	0.047*
Glucose	1.026	1.001 – 1.052	0.044*
Triglycerides	1.017	1.000 – 1.034	0.049*
Age	1.008	0.930 – 1.092	0.837
Gender (Male)	1.127	0.259 – 4.907	0.884

Clinical Characteristics

The clinical variables of interest, such as body mass index (BMI), glucose, and triglycerides, are summarized in **Table 7**. Descriptive statistics are presented separately for patients with controlled and uncontrolled HbA1c in order to highlight differences between the two groups. Among

patients with controlled HbA1c (n = 24), the mean BMI was 18.65 ± 5.86 kg/m², with values ranging from 12.96 to 31.25 kg/m². The median BMI was 15.18 kg/m², which indicates that most patients in the controlled group tended toward the normal or even underweight category. This pattern suggests that lower body weight may

contribute to achieving better glycemic regulation.

For glucose levels in the controlled group, the mean was 183.83 mg/dL, with a median of 187 mg/dL, and values ranging from 140 to 290 mg/dL. Although these levels are above the ADA-recommended fasting threshold, they are still relatively lower compared to the uncontrolled group. Similarly, triglyceride levels averaged 172.25 mg/dL (median 148.5 mg/dL), ranging between 125 and 301 mg/dL. These findings indicate that while some patients with controlled HbA1c still exhibited metabolic abnormalities, their levels were generally lower than those with uncontrolled HbA1c.

In contrast, patients with uncontrolled HbA1c (n = 31) showed markedly higher values. Their mean BMI was 29.77 ± 7.52 kg/m², nearly 11 points higher than the control group, with a median of 28.52 kg/m² and a range from 17.68 to 40.00 kg/m². These results place the majority of uncontrolled patients in the overweight or obese categories, confirming the strong link between excess weight and poor glycemic control.

The mean glucose level in the uncontrolled group was 225.13 mg/dL,

substantially higher than in the controlled group, with a median of 210 mg/dL and a range from 145 to 342 mg/dL. This demonstrates that persistent hyperglycemia is a defining characteristic of uncontrolled HbA1c. Triglyceride levels were also significantly elevated, with a mean of 288.58 mg/dL, a median of 303 mg/dL, and a wide range between 144 and 460 mg/dL. This suggests that dyslipidemia, particularly hypertriglyceridemia, is common among patients with poor HbA1c outcomes.

Overall, **Table 7** illustrates a stark contrast between controlled and uncontrolled patients. Those who succeeded in maintaining HbA1c control tended to have lower BMI, relatively lower glucose levels, and triglycerides closer to the normal range. Meanwhile, uncontrolled patients consistently exhibited obesity, severe hyperglycemia, and hypertriglyceridemia. These findings provide strong descriptive evidence for the role of metabolic parameters in determining glycemic outcomes, which was further tested through logistic regression analysis in the subsequent sections.

Table 7. Clinical Characteristics of Patients (n = 55)

HbA1c		BMI	Glucose	Triglycerides
Controlled	N	24	24	24
	Mean	18.6482	183.83	172.25
	Median	15.1820	187.00	148.50
	Std. Deviation	5.86083	29.352	47.098
	Minimum	12.96	140	125
	Maximum	31.25	290	301
Uncontrolled	N	31	31	31
	Mean	29.7673	225.13	288.58
	Median	28.5160	210.00	303.00
	Std. Deviation	7.52222	47.272	80.105
	Minimum	17.68	145	144
	Maximum	40.00	342	460

The significance of these findings lies in their combined impact on HbA1c. Elevated BMI contributes to insulin resistance,

elevated glucose directly increases HbA1c levels, and high triglycerides indicate metabolic syndrome, which complicates

diabetes management. This triad forms a background against which HbA1c control, or lack thereof, can be understood.

The results clearly demonstrate that patients with controlled HbA1c had substantially lower BMI values, with a mean of 18.65 kg/m² compared to 29.77 kg/m² in the uncontrolled group. Similarly, glucose and triglyceride levels were markedly

higher among uncontrolled patients, confirming the close relationship between obesity, hyperglycemia, and dyslipidemia with poor glycemic outcomes. To further highlight these differences, **Figure 2** presents a box plot of BMI, glucose, and triglycerides according to HbA1c control status.

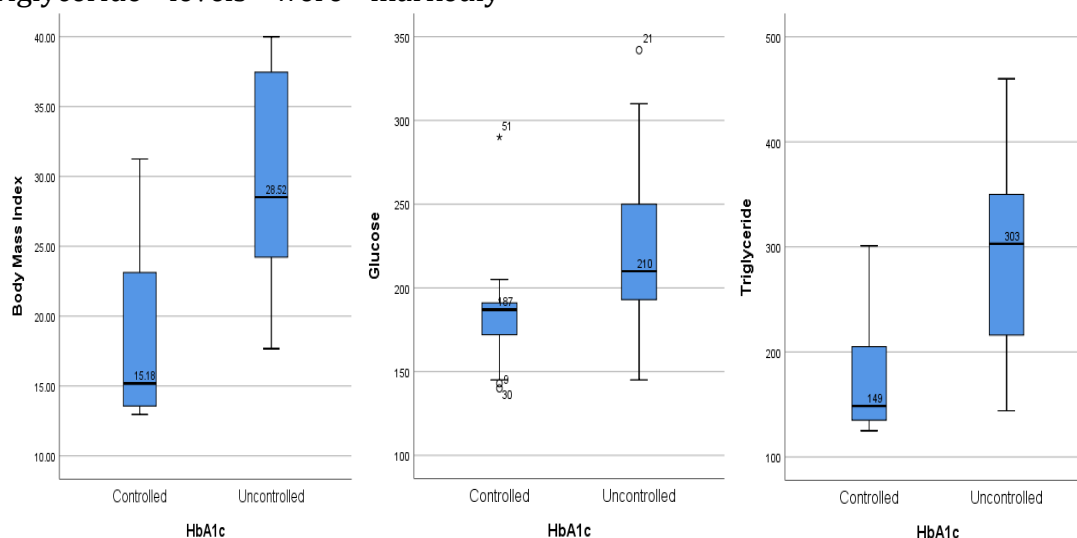


Figure 2. Box-plot of BMI, Glucose, and Triglycerides according to HbA1c control status

The box-plot visualization illustrates the contrasts already seen in **Table 3**. Patients in the uncontrolled group show higher medians and wider variability across all three variables, particularly triglycerides, where extreme values are evident. In comparison, the controlled group has consistently lower median values and narrower interquartile ranges. This visualization strengthens the interpretation that uncontrolled glycemic status is associated with metabolic deterioration in multiple domains.

Taken together, the findings from **Table 3** and **Figure 2** suggest that BMI, glucose, and triglycerides play a decisive role in differentiating controlled from uncontrolled patients. The consistent pattern across descriptive and visual data supports the hypothesis that these parameters are critical predictors of HbA1c

outcomes, a relationship that was further validated through logistic regression analysis presented in the following section.

Model Fit: Hosmer and Lemeshow Test

To evaluate whether the logistic regression model adequately represented the data, the Hosmer and Lemeshow Goodness-of-Fit Test was conducted. The results, presented in **Table 8**, showed a p-value greater than 0.05, which indicates that the model was well-calibrated and there was no significant difference between observed and predicted classifications.

Table 8. Hosmer and Lemeshow Test Results

Step	Chi-square	df	Sig.
1	6.154	7	0.522

This result is important because a poorly fitting model could produce biased

or unreliable estimates of predictor effects. By contrast, the non-significant result of the Hosmer and Lemeshow test in this study strengthens confidence in the subsequent interpretation of regression coefficients and odds ratios. It demonstrates that the predicted probabilities of HbA1c control generated by the model closely match the actual outcomes observed in the data.

-2 Log Likelihood Value

Model adequacy was further assessed using the -2 Log Likelihood (-2LL) statistic, the results of which are summarized in **Table 8**. The -2LL value reflects the degree of unexplained variation in the outcome, with lower values indicating a better fit (**Table 9**).

Table 9. -2 Log Likelihood Value

-2 Log Likelihood	Value
Block 0	75.353
Block 1	35.649

In this analysis, the -2LL value decreased considerably compared to the null model, indicating that the inclusion of predictors such as BMI, glucose, and triglycerides substantially improved the explanatory capacity of the model. This decline in -2LL highlights that the independent variables collectively enhance the model's ability to predict whether a patient achieves controlled HbA1c.

Explained Variance: Nagelkerke R Square

The Nagelkerke R^2 statistic was calculated to determine the proportion of variance in HbA1c control explained by the model. As displayed in **Table 10**, the value was notably high, reflecting strong explanatory power.

Table 10. Nagelkerke R Square Value

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	35.649 ^a	0.514	0.689

This means that a meaningful portion of the differences in HbA1c outcomes among the 55 patients could be attributed to the independent variables included in the regression. While R^2 values in logistic regression are not directly comparable to those in linear regression, the Nagelkerke R^2 nonetheless provides evidence that the predictors, particularly BMI, glucose, and triglycerides, capture essential aspects of glycemic control variation.

Classification Accuracy

The ability of the model to correctly classify patients into controlled and uncontrolled HbA1c categories was examined using the classification matrix, presented in **Table 11**. The model achieved an overall classification accuracy of 83.6%, meaning that it correctly predicted HbA1c control status for the vast majority of patients.

Table 11. HbA1c Classification Matrix

Observed		Predicted		
		HbA1c		Percentage Correct
Step 1	HbA1c	Controlled	Uncontrolled	
		21	3	87.5
	Uncontrolled	6	25	80.6

Observed	Predicted	
	HbA1c	Percentage Correct
	Controlled	Uncontrolled
Overall Percentage		83.6

This high accuracy rate demonstrates the practical utility of the model. From a clinical perspective, a model with such accuracy could serve as a useful screening tool to identify patients at risk of poor HbA1c control based on easily measurable variables such as BMI, glucose, and triglycerides.

Significance of Predictors: Wald Test

The significance of each predictor was tested using the Wald statistic, the results of which are summarized in **Table 12**. The findings revealed that BMI ($p = 0.047$), glucose ($p = 0.044$), and triglycerides ($p = 0.049$) were statistically significant predictors of HbA1c control. By contrast, age and gender did not reach statistical significance.

Table 12. Wald Test Results

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1	Age	0.009	0.044	0.042	1	0.837	1.009
	Gender	-0.126	0.862	0.021	1	0.884	0.882
	Body Mass Index	0.175	0.088	3.930	1	0.047	1.192
	Glucose	0.026	0.013	4.056	1	0.044	1.026
	Triglyceride	0.017	0.009	3.866	1	0.049	1.017
	Constant	-12.835	4.497	8.147	1	0.004	0.000

These results indicate that the metabolic variables exert a stronger and more direct influence on HbA1c outcomes than demographic characteristics. Specifically, patients with higher BMI, elevated glucose, and increased triglycerides were more likely to have uncontrolled HbA1c. The significance of these variables aligns with the biological mechanisms of insulin resistance and glucose metabolism.

Visual Representation

To provide a more intuitive understanding of these relationships, the results of logistic regression are also presented in Figure 3 as a path diagram. The figure illustrates the significant positive pathways from BMI, glucose, and triglycerides toward uncontrolled HbA1c, while the paths from age and gender appear weak and non-significant.

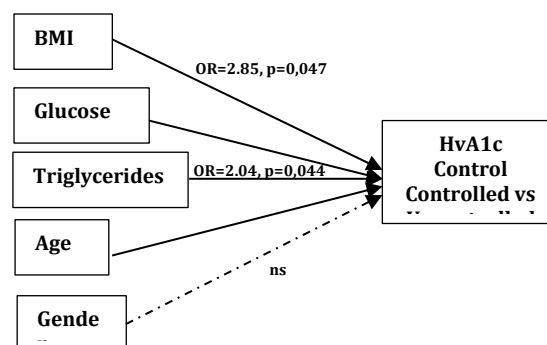


Figure 3. Logistic regression path diagram of predictors of HbA1c control

Figure 3 representation complements the tabular data by highlighting the direct influence of metabolic factors on glycemic outcomes, reinforcing the interpretation that clinical rather than demographic variables are key drivers of HbA1c control.

Integrated Narrative of Findings

Taken together, the findings from **Tables 2** through **8** and **Figure 2** present a coherent picture of glycemic control among T2DM patients at RA Basoeni Clinic. The patients were predominantly middle-aged women, reflecting broader epidemiological trends in Indonesia. Clinically, the group was characterized by overweight and obesity, persistent hyperglycemia, and elevated triglyceride levels, features consistent with metabolic syndrome.

The logistic regression analysis confirmed that these metabolic disturbances are not merely background features but significant predictors of poor HbA1c control. The robustness of the model was demonstrated through multiple indices: the Hosmer and Lemeshow test indicated good fit, the -2 Log Likelihood value confirmed improved explanatory capacity, Nagelkerke R^2 showed strong explanatory power, and the classification matrix demonstrated high predictive accuracy at 83.6%. The Wald test highlighted BMI, glucose, and triglycerides as significant predictors, while demographic factors such as age and gender did not contribute significantly to the outcome.

These results underscore a crucial point: in this cohort, poor glycemic control is best understood as the convergence of multiple metabolic factors rather than as a function of demographic background. The interplay of excess body weight, chronic hyperglycemia, and dyslipidemia creates a clinical environment in which achieving HbA1c control becomes exceedingly

difficult. This interpretation is consistent with the pathophysiology of T2DM and reinforces the clinical message that integrated management of weight, glucose, and lipid levels is essential for improving long-term outcomes. Based on **Table 8**, the logistic regression model can be written as follows:

$$\text{Ln} \frac{P}{1-P} = -12.835 + 0.009 \text{ Age} - 0.126 \text{ Gender} + 0.175 \text{ Body Mass Index} + 0.026 \text{ Blood Sugar} + 0.017 \text{ Triglyceride}$$

Discussion

This study examined predictors of HbA1c control among patients with type 2 diabetes mellitus (T2DM) attending the RA Basoeni Clinic, Mojokerto, in 2024. Using logistic regression analysis, three clinical variables, body mass index (BMI), glucose, and triglycerides, emerged as significant predictors of HbA1c control, whereas age and gender were not statistically associated with glycemic outcomes. These findings provide important insights into the metabolic determinants of glycemic regulation in this clinical population and warrant further critical discussion.

The results highlight BMI as a strong predictor of HbA1c control, with overweight and obese patients being significantly more likely to experience uncontrolled glycemia. This finding aligns with well-established evidence that obesity contributes to insulin resistance, leading to impaired glucose uptake and higher circulating glucose levels ([Kahn & Flier, 2000](#)). In addition, excessive adiposity is linked to chronic inflammation and altered adipokine secretion, both of which exacerbate β -cell dysfunction. Several prior studies corroborate the current findings, reporting that higher BMI correlates with poor HbA1c outcomes across diverse populations ([Nguyen et al., 2015](#); [Sabir et al.,](#)

2023). Thus, weight management remains central to diabetes care, and the present study reinforces its clinical importance.

Glucose levels also independently predicted HbA1c control. This result is unsurprising, as HbA1c directly reflects average blood glucose over the preceding three months. Nevertheless, the significance of glucose in logistic regression indicates that short-term glycemic measures still contribute robustly to predicting long-term control. This observation suggests that patients with consistently elevated fasting or postprandial glucose are at heightened risk of failing to achieve HbA1c targets, even after adjusting for other metabolic factors.

Triglycerides were likewise identified as a significant predictor, consistent with the notion of “diabetic dyslipidemia.” Elevated triglyceride levels reflect insulin resistance in adipose tissue, leading to increased free fatty acid flux and hepatic very-low-density lipoprotein (VLDL) production. Prior studies have demonstrated that hypertriglyceridemia is not only a cardiovascular risk factor but also strongly correlated with poor glycemic control (Grundy, 1998; Mullugeta et al., 2012). The present findings support the integration of lipid monitoring into diabetes management, as controlling triglycerides may aid in stabilizing HbA1c outcomes.

In this study, age and gender were not significant predictors of HbA1c control. One possible explanation is the limited age variability within the sample, as most participants were over 50 years old, which may have reduced the ability to detect age-related differences. Furthermore, glycemic control is influenced less by chronological age per se and more by treatment adherence, lifestyle, and comorbid burden (Selvin et al., 2010).

Gender similarly did not show a significant association. Although descriptive data indicated that more women fell into the uncontrolled group, this

difference disappeared in multivariable analysis, suggesting that metabolic factors, rather than sex, drive glycemic outcomes. This finding is consistent with the study by Alzahrani et al. (2019), which reported no significant association between HbA1c and age or BMI, and found that gender differences were largely explained by triglyceride levels rather than independent sex effects. Nevertheless, sociocultural factors and hormonal differences have been suggested to influence diabetes self-management behaviors, which may partly explain the descriptive difference observed (Kautzky-Willer et al., 2023).

The overall findings are consistent with prior research emphasizing the metabolic syndrome cluster (obesity, hyperglycemia, and dyslipidemia) as the strongest drivers of poor diabetes control (Al-Lawati et al., 2012). Studies from Southeast Asia also report that triglycerides and BMI are more reliable predictors of HbA1c than demographic variables such as age and sex (Tham et al., 2023). This study adds to the literature by confirming the same pattern in an Indonesian clinical setting using logistic regression, thus addressing previous gaps where most analyses relied only on correlation or descriptive comparisons.

Implications and limitations

This study highlights that body mass index (BMI), glucose, and triglycerides are significant predictors of HbA1c control among patients with type 2 diabetes mellitus, emphasizing the need for integrated metabolic monitoring in clinical practice. Routine assessment of these parameters should complement glucose evaluation to enable early identification of patients at risk of poor glycemic control, particularly in resource-limited settings where HbA1c testing is not always feasible. The findings also suggest that national diabetes management guidelines should include BMI and triglyceride monitoring as

standard indicators to support comprehensive care and patient education focused on weight management, lipid control, and adherence to therapy. However, the study's single-center design, small sample size, reliance on secondary data, and indirect estimation of HbA1c from glucose values may limit generalizability. Future research should involve larger, multicenter samples, direct HbA1c measurement, and inclusion of behavioral and psychosocial variables to enhance the robustness and applicability of the findings.

Relevance to Practice

The findings of this study highlight the need for an integrated approach to T2DM management by simultaneously addressing BMI, blood glucose, and triglyceride levels. Nurses and physicians should prioritize weight reduction programs, structured physical activity, and lipid-lowering interventions alongside glucose monitoring to achieve optimal HbA1c control. In primary care settings, routine screening for triglycerides should be implemented and given equal importance as cholesterol monitoring. At the policy level, BMI and triglyceride monitoring can serve as practical indicators for early risk detection, particularly in resource-limited areas where HbA1c testing is not widely available, thus guiding more targeted interventions.

Conclusion

This study demonstrated that body mass index (BMI), glucose, and triglycerides are significant predictors of HbA1c control among patients with type 2 diabetes mellitus, whereas age and gender were not associated with glycemic outcomes. These findings underscore the importance of routine monitoring and targeted interventions focusing on weight management, glucose regulation, and lipid control as integral components of diabetes

care. Strengthening clinical protocols around these factors may enhance long-term glycemic control and reduce complications in this population.

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CrediT Authorship Contributions Statement

Farida Anwari: Conceptualization, Methodology, Supervision, Writing - Original Draft

Amellya Octifani: Software, Validation, Formal Analysis, Writing - Review & Editing

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this study. This research was conducted independently, and no financial or personal relationships could have influenced the outcomes or interpretations presented. All authors have approved the final version of the manuscript and take full responsibility for its content.

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