

Assessment of Glycemic Control Among Prospective Hajj Pilgrims with Type 2 Diabetes Mellitus in Tangerang City, Indonesia

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Abstract

Background. Diabetes Mellitus Type 2 (T2DM) is a significant health concern for Hajj pilgrims, with glycaemic control crucial for their well-being during the pilgrimage. Physical health is key to determining *istithaah*, including HbA1c and fasting blood glucose tests for prospective Hajj pilgrims with type 2 diabetes mellitus.

Objective. This study describes HbA1c and fasting blood glucose levels as indicators of glycaemic control among Indonesian prospective Hajj pilgrims diagnosed with T2DM based on laboratory results from medical check-ups for the 2024 departure in Tangerang City, and assesses their association with demographic factors.

Methodology. A cross-sectional study analyzed HbA1c from 125 pre-departure medical check-ups of 75 female and 50 male prospective Hajj pilgrims. Data were collected from medical records at a public hospital in Tangerang City and from the Hajj Integrated Computer Health System (SISKOHATKES) application in 2024. Statistical analysis was performed using the Chi-square test or Fisher's exact test, as appropriate.

Results. This study showed that most subjects were female, with the most common age group being 18–59 years (adult). The most prevalent health eligibility (*istithaah*) status was eligible with assistance. More than 50% of Hajj pilgrims with T2DM had comorbid conditions such as hypertension, cardiomegaly, and hyperlipidaemia. The mean HbA1c level was $9.82 \pm 2.2\%$, with most participants exhibiting uncontrolled glycaemic status (HbA1c $>7.5\%$). Similarly, the mean fasting blood glucose level was 197.0 ± 67.8 mg/dL, with the majority also falling within the uncontrolled range (fasting blood glucose >126 mg/dL). There was no significant correlation between HbA1c levels and age or sex.

Conclusion. The majority of prospective Hajj pilgrims with T2DM are uncontrolled in terms of glycaemic status. These findings require comprehensive assessment and management strategies before, during, and after the Hajj pilgrimage to minimize risk and prevent complications.

Key words: type 2 diabetes mellitus, prospective Hajj pilgrims, HbA1c levels, *istithaah*

INTRODUCTION

Hajj is the fifth pillar of Islam, consisting of activities that predominantly involve physical exertion and require optimal physical fitness and health. In its implementation, prospective Hajj pilgrims must fulfill various requirements, including physical health and mental and spiritual readiness, to determine their eligibility for health (*Istithaah*).^{1,2}

Millions of Muslims from more than 183 countries annually perform the Hajj pilgrimage in the Kingdom of Saudi Arabia during the lunar month of Dhu al-Hijjah.

Approximately 1.8 million Muslims participated in the Hajj pilgrimage in 2024.¹ However, most pilgrims are generally middle-aged or older when they can afford the journey. A large percentage of Hajj pilgrims are elderly and may have chronic health conditions.³ Data from the Hajj Health Centre indicates that the morbidity and mortality rates among Indonesian Hajj pilgrims in Saudi Arabia remained high between 2017 and 2023. Each year, more than 4,000 pilgrims required hospitalization in Indonesian Hajj Health Clinics (KKHI) and Saudi Arabian hospitals (RSAS) over the past five years.²

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T2DM is a metabolic disease that significantly impacts the quality of life of those affected. This condition is characterized by impaired glucose metabolism, which can lead to various serious complications, both acute and chronic.⁴ The prevalence of diabetes mellitus in Indonesia in 2023 was 11.7%.⁵ T2DM is one of the three most prevalent health problems among Hajj pilgrims. A total of 5.77% and 12.65% of Hajj pilgrims in Nusa Tenggara Barat and Banda Aceh, respectively, suffer from T2DM.⁶ In Tangerang City, the number of prospective Hajj pilgrims diagnosed with type 2 diabetes mellitus tends to increase each year.

The significant lifestyle changes experienced by diabetic patients during Hajj, including variations in geography, climate, diet, and physical activity, pose a considerable challenge. Moreover, diabetes has increasingly been recognized as a leading contributor to illness and death during the pilgrimage. Many of them also struggle with diabetes-related complications, including eye disorders, coronary artery disease, and diabetic foot problems.^{7,8} Poorly managed diabetes mellitus and persistent hyperglycaemia play a crucial role in worsening vascular disease outcomes. Chronic elevation of blood glucose levels and prolonged disease duration are primary risk factors for the progression of microangiopathic complications.⁹

As the country with the largest Muslim population, Indonesia has the world's largest Hajj quota. In 2024, Indonesia's Hajj quota is 241,000 pilgrims. The health examination of prospective Hajj pilgrims is conducted to ensure their well-being (*istitaah*). This examination consists of three stages conducted by the district/city Hajj health team, including medical check-ups, cognitive assessments, mental health evaluations, and assessments of their ability to perform daily activities independently.¹⁰ Based on the health examination results, the Hajj health (*istitaah*) status is categorized as follows: eligible, eligible with assistance, temporarily not eligible, and not eligible.

HbA1c is a form of haemoglobin A that undergoes glycation at the N-terminal of its beta-globin chain valine.¹¹ HbA1c is an essential parameter as the standard of care for diagnosing, evaluating, and monitoring diabetes mellitus, particularly type 2 diabetes. For diagnostic use, HbA1c testing should be conducted in a National Glycohemoglobin Standardization Program (NGSP)-certified laboratory to ensure accurate, standardized results. HbA1c is a crucial measure of long-term glucose control, reflecting the overall glycaemic profile from the previous two to three months.¹² Prospective Hajj pilgrims with uncontrolled T2DM with an HbA1c level >8% will receive treatment for one month, followed by reassessment. If the HbA1c level remains >8%, their departure for the current year will be postponed, or further action will be taken in accordance with applicable regulations.¹⁰ It is essential to ensure that prospective Hajj pilgrims are in optimal health before departure. This study aimed to describe glycaemic control (HbA1c and fasting blood glucose levels) among prospective Hajj pilgrims in Tangerang City in 2024 with T2DM and to assess its

association with demographic factors, including age and sex. The results can inform the development of more focused health policies to reduce diabetes risk and manage diabetes among Hajj pilgrims.

METHODOLOGY

This study employed a quantitative, cross-sectional design using secondary data obtained from the medical records of prospective Hajj pilgrims diagnosed with T2DM in Tangerang City, Indonesia. The data were collected from a government-owned public hospital and were recorded through the Hajj Integrated Computer Health System (SISKOHATKES) during the 2024 Hajj health screening period. The minimum sample size was calculated using the single population proportion formula ($n = Z^2PQ/d^2$), assuming a 95% confidence level ($Z=1.96$), an expected proportion of 50%, and a margin of error of 10%, yielding a minimum sample size of 96 participants. Subsequently, total enumeration was applied, and all prospective Hajj pilgrims with T2DM who met the inclusion and exclusion criteria during the study period were enrolled, yielding a final sample of 125 participants. Eligible subjects who were officially registered as 2024 Hajj pilgrims in Tangerang City had a confirmed diagnosis of T2DM based on medical records and had completed laboratory testing for HbA1c as part of the pre-Hajj medical screening. Individuals with incomplete medical records or those diagnosed with other forms of diabetes, such as type 1 or gestational diabetes, were excluded from the study.

The primary outcome of interest in this study was glycaemic control, as measured by HbA1c levels. HbA1c was categorized into two groups: controlled ($\leq 7.5\%$) and uncontrolled ($> 7.5\%$). This threshold represents a more stringent target than the standard eligibility criterion of <8% recommended by the Indonesian Ministry of Health, and was chosen to provide a more sensitive assessment of glycaemic status in the context of the physically demanding Hajj pilgrimage. Independent variables included demographic characteristics (age: adult, pre-elderly, or elderly; sex: male or female), as well as clinical factors (health eligibility status [*istitaah*] and comorbidities). The Hajj health team classified health eligibility status as eligible, eligible with assistance, temporarily not eligible, and not eligible based on the results of the medical examinations. Comorbidities were recorded based on ICD-10 diagnoses in the medical records and included conditions such as hypertension, cardiomegaly, hypercholesterolemia, and hyperlipidaemia.

Data analysis was conducted using SPSS version 27, with descriptive statistics used to summarize patient characteristics. The distribution of continuous variables, including HbA1c and fasting blood glucose levels, was assessed using the Kolmogorov-Smirnov test. A p -value <0.05 was considered indicative of non-normal distribution; variables are reported as median (interquartile range [IQR]) and range. The association between HbA1c levels

and sex was analyzed using Fisher's exact test due to small expected cell counts, and the association between HbA1c levels and age groups was assessed using the Chi-square test. A p -value of less than 0.05 is considered statistically significant. Ethical approval for this study was granted by the Ethics Committee of the Faculty of Medicine, UIN Syarif Hidayatullah Jakarta (Approval Number: B-018/F12/KEPK/TL.00/EE-08/2024).

RESULTS

The characteristics of the study subjects are presented in Table 1. A total of 75 subjects (60.0%) were female, while 50 subjects (40.0%) were male. Based on age classification, most subjects were categorized as pre-elderly (53.7%), while seven subjects (6.3%) were classified as adults. The mean age in this study was 57.71 ± 8.14 years, ranging from 38 to 83 years. Regarding the health assessment (*istitaah*), only one subject (0.8%) met the eligibility criteria for Hajj without assistance, whereas 124 subjects (99.2%) were deemed eligible with assistance.

Analysis of comorbidities among 125 samples based on the International Classification of Diseases (ICD) by the World Health Organisation (WHO) is shown in Table 2. The most common comorbid condition with diabetes mellitus was unspecified hyperlipidaemia, observed in 42 subjects (33.6%). This was followed by essential (primary) hypertension, which was present in 28 subjects (22.4%), and cardiomegaly in 12 subjects (9.6%). Additionally, isolated hypercholesterolemia was identified in 11 subjects (8.8%), while isolated diabetes mellitus was recorded in 32 subjects (25.6%).

The distribution of HbA1c and fasting blood glucose levels among pilgrims diagnosed with type 2 diabetes mellitus shows that the majority of respondents have suboptimal glycaemic control.

Of 125 subjects, 96 (76.8%) had HbA1c levels $>7.5\%$ and 113 (90.4%) had fasting blood glucose levels ≥ 126 mg/dL, indicating poor glycaemic control by both markers (Table 3). Only 29 respondents (23.2%) had controlled HbA1c levels ($\leq 7.5\%$), and 12 (9.6%) had controlled fasting blood glucose (<126 mg/dL). These findings demonstrate a consistent pattern of suboptimal glycaemic control across both short-term and long-term indicators, emphasizing the need for intensified intervention strategies to improve metabolic outcomes in this population.

Based on Table 4, HbA1c levels $\leq 7.5\%$ and $> 7.5\%$ were more prevalent among female prospective Hajj pilgrims than males. However, it was not statistically significant ($p = 0.832$).

The proportion of prospective Hajj pilgrims with HbA1c levels $>7.5\%$ was higher across all age groups. The distribution of HbA1c levels ($\leq 7.5\%$ and $>7.5\%$) did not show a statistically significant ($p = 0.457$) association with

Table 1. Characteristics of Study Participants (N = 125)

Characteristic	Description	n (%) / Median (IQR; min-max)
Sex	Male	50 (40.0)
	Female	75 (60.0)
Age (years)	Adult (18-59)	74 (59.2)
	Pre-elderly (60-64)	26 (20.8)
	Elderly (>65)	25 (20.0)
HbA1c (%)		9.4 (3.9; 6.0-15.0)
Fasting blood glucose (mg/dL)		176 (105; 100-395)
Health eligibility (istitaah)	Eligible	1 (0.8)
	Eligible with assistance	124 (99.2)
	Temporarily not eligible	0 (0.0)
	Not eligible	0 (0.0)

Table 2. Comorbidities (N = 125)

Comorbidities	n (%) (N = 125)
Isolated DM	32 (25.6)
Essential (primary) hypertension	28 (22.4)
Cardiomegaly	12 (9.6)
Isolated hypercholesterolemia	11 (8.8)
Hyperlipidaemia, unspecified	42 (33.6)

Table 3. HbA1c and fasting blood glucose status of the study subjects (N = 125)

Variable	Category	n (%)
HbA1c (%)	≤ 7.5 (Controlled)	29 (23.2)
	> 7.5 (Uncontrolled)	96 (76.8)
Fasting blood glucose (mg/dL)	<126	12 (9.6)
	≥ 126	113 (90.4)

Table 4. Association between demographic factors and HbA1c level (N = 125)

Variable	Category	HbA1c ≤ 7.5 n(%) (n = 29)	HbA1c > 7.5 n(%) (n = 96)	p-value*
Sex	Female	18 (62.1)	57 (59.4)	0.832
	Male	11 (37.9)	39 (40.6)	
Age Group	Adult	17 (58.6)	57 (59.4)	0.457
	Pre-elderly	8 (27.6)	18 (18.8)	
	Elderly	4 (13.8)	21 (21.9)	

*Fisher's exact test for sex variable; Chi-square test for age group

age groups (Table 4), indicating that age group did not significantly influence HbA1c levels in this study.

DISCUSSION

More than 50% of the study subjects were adults (19–59 years old), with a mean age of 57.71 ± 8.15 years. According to Sari's study, data from the public health office indicate that most prospective Hajj pilgrims from Semarang City in 2024 belong to the 51–60 age group.¹³ This is similar to Yousuf's study, which reported an average age of 55.41 ± 10.6 years for Hajj pilgrims with diabetes mellitus.¹⁴ The oldest study subject was 83 years old, which is not significantly different from Sari's study, which recorded the oldest participant at

88 years old. The proportion of elderly Hajj pilgrims in Sari's study was 34% of the pilgrims from Semarang City, which is relatively similar to this study, where the proportion of elderly participants was 20%. Elderly Hajj pilgrims require strict monitoring from Hajj officers, particularly in the health sector. Age is a key determinant of an individual's health, as ageing is associated with various health issues. Elderly Hajj pilgrims experience changes in physical condition, immune system, anatomy, and organ function. These ageing-related changes make them more vulnerable to disease than younger individuals. Therefore, special attention must be given to elderly Hajj pilgrims, both by themselves and by the Hajj health team, through regular health monitoring, routine medication, physical exercise, and a well-balanced diet.¹³

With a predicted global diabetes prevalence of 8.8% and approximately 2.5 million adult Muslims performing Hajj, it is estimated that more than 220,000 Hajj pilgrims each year have diabetes. Healthcare providers must be aware of the potential risks that may arise during Hajj. A prospective observational study revealed that 26% of patients admitted to Makkah Hospital were newly diagnosed with diabetes and were previously unaware of their condition. In comparison, 74% had a prior diagnosis of diabetes.¹⁵

The Indonesian Ministry of Health has determined that Hajj pilgrims with controlled T2DM managed with medication are eligible for assistance. This means they can perform Hajj while receiving continuous medical supervision and management throughout their Hajj journey. The distribution system for medicines among Indonesian Hajj pilgrims has been optimized through the Sobathaji application, which facilitates medication management and distribution for each group. Diabetes medications, such as insulin and oral antihyperglycemic agents, are provided by the Indonesian Hajj Health Clinic (KKHI) and efficiently distributed through accommodation sectors. Additionally, pilgrims receive pre-departure medication supplies and undergo regular medical monitoring during the pilgrimage.¹⁶

Our finding that 76.8% of prospective Hajj pilgrims with type 2 diabetes mellitus had uncontrolled HbA1c levels (>7.5%) aligns with evidence from other Hajj contexts, reinforcing the persistent challenge of glycaemic management in this setting. In this study, glycemic control was defined using an HbA1c cut-off of 7.5%, which is more stringent than the <8% threshold recommended by the Indonesian Ministry of Health for Hajj eligibility. The use of a lower cut-off was intended to provide a more sensitive assessment of glycemic status in prospective Hajj pilgrims, given the substantial physical exertion, heat exposure, and potential disruption in medication adherence during the pilgrimage. A previous study conducted among Indonesian Hajj pilgrims reported a high prevalence of glycaemic abnormalities. For instance, a study based on SISKOHATKES data in DKI Jakarta found that 29.4% of women of reproductive age had prediabetes, indicating a considerable burden of metabolic dysregulation in this

population. In a prospective observational study conducted in Saudi Arabia, Khogeer et al., reported that 70.8% of pilgrims with diabetes experienced acute hyper-glycaemia, with significant proportions also suffering from foot injuries (28.8%) and hypoglycaemia (14.9%) during the pilgrimage.¹⁷ These high complication rates underscore the clinical consequences of inadequate glycaemic control during Hajj.

Moreover, established guidelines from Ibrahim et al. (2018) emphasize that structured pre-Hajj risk stratification, insulin and medication adjustment, foot-wear counseling, and education can significantly mitigate acute risks such as hypoglycaemia, infections, and cardiovascular strain.¹⁵ This suggests a gap in the execution of such preparatory programs in our study population, where unregulated HbA1c levels and comorbidities like hypertension and hyperlipidaemia may heighten complication risks during the pilgrimage. Integrating these recommended interventions into Indonesia's Hajj health framework—especially via KKHI clinics and community health services—could substantially enhance metabolic readiness and safety for pilgrims with diabetes.

It is necessary to detect and manage comorbidities in prospective Hajj pilgrims. Khogeer et al.'s study involved 281 pilgrims with T2DM, of whom 199 (70.8%) experienced foot injuries, 77 (27.4%) had hyperglycaemia, and 37 (13.2%) suffered from hypoglycaemia, with some individuals exhibiting more than one complication. Redness (28.8%) and blisters (20.6%) were the most common symptoms among those with foot injuries. Fatigue (14.9%) and headache (12.5%) were the most frequently reported symptoms of hypoglycaemia. Additionally, pilgrims with T2DM experienced a significantly higher rate of acute complications compared to those with type 1 DM (81.8% versus 18.2%, $p = 0.33$).¹⁷

The physically demanding activities and extreme weather during the Hajj pilgrimage can worsen conditions like hyperlipidaemias and hypercholesterolemia. These increase the risk of atherosclerosis and coronary artery disease, which are further aggravated by physical exertion during the pilgrimage.¹⁸⁻²⁰

Similarly, uncontrolled hypertension and cardiomegaly can lead to stroke or heart failure. Among prospective Hajj pilgrims with T2DM, 22.4% have primary hypertension, 9.6% have cardiomegaly, and 8.8% have hypercholesterolemia.

Hypertension is recognized as a significant risk factor for cardiovascular disease and is often linked to T2DM. High blood pressure was identified in 70.5% of the patients, and systolic blood pressure showed a positive relationship with age.²¹ Systematic reviews and meta-analyses were conducted to determine the prevalence of diabetes and hypertension among Hajj pilgrims. A total of 26 studies, carried out between 1993 and 2018 with 285,467 participants, revealed that the prevalence of hypertension and diabetes

in all included studies was 12.2% and 5%, respectively.²² Hypertension is a significant factor in the number of hospitalized pilgrims during the Hajj.⁸ Hypertension, alongside diabetes, serves as an essential risk factor for cardiovascular disease (CVD), which is the leading cause of death among pilgrims.²³ Hypertension contributed to 3% of ICU admissions as a primary cause and was present as a comorbidity in 26.4% of cases. Over 10% of patients died, with 60% of these deaths attributed to CVD.²⁴

In 2002, CVD was identified as the leading cause of death among Hajj pilgrims, accounting for 45.8% of fatalities, while hypertension was responsible for 2.7% of the total deaths.²⁵ An analysis of data from the Indian medical mission over three consecutive Hajj seasons (2014–2016) identified diabetes and hypertension as the most prevalent pre-existing conditions among pilgrims, with CVD accounting for over 70% of deaths.²⁶ Likewise, among approximately 1.7 million Indonesian pilgrims who participated in Hajj between 2004 and 2011, hypertension and diabetes were frequently observed, and CVD was responsible for 45–66% of fatalities.²⁷ Collaborative efforts between the pilgrims' home countries and the Kingdom of Saudi Arabia must be promptly implemented to reduce incidence rates by conducting effective medical screening to identify and eliminate risk factors for cardiovascular diseases, mainly poorly controlled conditions.²⁷

Epidemiological studies have shown that insulin resistance and diabetes are not only metabolic disorders but also key factors that increase the risk of hypertension, vascular stiffness, and cardiovascular disease. On the other hand, excessive arterial stiffness and impaired vasorelaxation further exacerbate insulin resistance and contribute to the progression of diabetes. The molecular mechanisms linking diabetes to hypertension include overactivation of the renin-angiotensin-aldosterone system, heightened sympathetic nervous system activity, mitochondrial dysfunction, excessive oxidative stress, and systemic inflammation. Recent studies have identified additional mechanisms underlying the heightened risk of hypertension in diabetes, such as increased activation of epithelial sodium channels, changes in extracellular vesicles and their microRNAs, disruptions in gut microbiota, and elevated activity of renal sodium-glucose cotransporters, all of which contribute to hypertension in the context of diabetes. This review also explores the impact of socioeconomic factors, current blood pressure targets, and treatment strategies recommended for managing hypertension in diabetic patients.²⁸

In 2011, the WHO recommended HbA1c as a diagnostic tool for diabetes, specifically for identifying type 2 diabetes, in its clinical practice guidelines.²⁹ Reference range HbA1c levels are <5.7%. Prediabetes is diagnosed when HbA1c levels are between 5.7% and 6.4%, while diabetes is diagnosed when HbA1c levels are $\geq 6.5\%$.³⁰ In this study, of 125 respondents, 96 (76.8%) study subjects had HbA1c levels greater than 7.5%. This indicates that the respondent's blood glucose levels were uncontrolled. Hajj pilgrims with uncontrolled

diabetes mellitus are at high risk of experiencing acute and chronic complications during Hajj.

Before embarking on the Hajj pilgrimage, patients should undergo a comprehensive clinical assessment, including a detailed foot examination, an evaluation of renal function, and cardiovascular health. This medical assessment should ideally be conducted at least 2–3 months before departure. Blood glucose levels, both fasting and postprandial, and HbA1c levels must be closely monitored. Identifying patients with existing microvascular or macrovascular complications and other comorbid conditions is crucial. A cardiac evaluation with an electrocardiogram should be performed for those with cardiovascular risk factors; if significant risks are detected, the patient should be advised against participating in the Hajj. Additionally, a two-dimensional echocardiogram and a stress test should be conducted if coronary artery disease is suspected. Patients with HbA1c levels around 7% are considered at low risk and may be approved for the Hajj journey.³¹

Patients with diabetes mellitus are encouraged to eat regularly and should be reminded to avoid sugary drinks unless necessary to manage hypoglycaemia. If pilgrims with diabetes experience hypoglycaemia, they can eat dates. They should consume complex carbohydrates before performing Tawaf and Sai, and may bring dates if needed. During the Hajj journey, strict glycaemic control is not recommended because hypoglycaemia can be more fatal than hyperglycaemia.³²

Although no statistically significant association was observed between sex and HbA1c levels ($p = 0.832$), this finding should be interpreted with caution, as the small sample size or unmeasured confounding factors may have influenced the study. This aligns with Adriani et al.'s study, which found no significant correlation between sex and HbA1c levels ($p = 0.143$). The proportion of HbA1c levels $>7.5\%$ is higher in females than in males. In females, especially those who are menopausal, oestrogen levels decrease, leading to unpredictable fluctuations in blood glucose levels and increased fat accumulation.³³ The study by Stedman et al. showed that the median HbA1c levels in women aged ≥ 55 years and 45–55 years were the same as those in men. However, in women under 45 years old, the median HbA1c level was lower than in men of the same age.³⁴

No statistically significant association was observed between HbA1c levels and age group ($p = 0.457$). Roth et al., found that HbA1c levels tend to rise progressively with age, with an estimated increase of 0.074% per decade.³⁶ This elevation in blood glucose and HbA1c levels is attributed to age-related declines in pancreatic β -cell function, reduced insulin receptor activity, decreased insulin sensitivity, loss of muscle mass, and lower glucose utilization.³⁸ The study by Gülsen et al., which involved adult subjects without diabetes mellitus, found that HbA1c levels were significantly higher in males than in females, particularly

in the 30-49 age group. A significant correlation between HbA1c levels and age was observed in males and females aged 30-49 years ($p < 0.05$), with HbA1c gradually decreasing with age. No significant correlation was observed between HbA1c levels and age ($p > 0.05$).³⁹

Individuals with T2DM require comprehensive management before, during, and after the Hajj pilgrimage to prevent complications. In Indonesia, Hajj pilgrims must fulfill health eligibility requirements before departing for Saudi Arabia. Therefore, Hajj health examinations and guidance must be enhanced to ensure the pilgrims' well-being from their home country to the Kingdom of Saudi Arabia. Pilgrims are declared health-eligible (*istitaah*) after undergoing a series of health interventions to control risk factors and maintain their health status within the eligibility criteria (*istitaah*).

This study focused only on bivariate analysis without adjusting for multiple variables, which may have led to residual confounding. Additionally, the lack of follow-up data prevented the assessment of glycaemic control during and after the Hajj pilgrimage. Furthermore, the cross-sectional design limits the ability to infer causal association between glycaemic control and demographic variables such as age and sex.

These findings highlight the need for strengthened pre-departure screening, risk stratification, and comprehensive diabetes management strategies to improve metabolic readiness among Hajj pilgrims. In addition, a substantial proportion of pilgrims present with cardiometabolic comorbidities, such as hypertension, cardiomegaly, and hyperlipidaemia, which may further increase the risk of complications during the Hajj pilgrimage.

CONCLUSION

Glycemic control among prospective Hajj pilgrims with T2DM in Tangerang City in 2024 remains suboptimal. The absence of statistically significant associations with demographic factors suggests that more complex clinical and behavioral determinants likely influence glycemic status in this population. Strengthening pre-departure screening and individual management strategies may be essential to improve health outcomes during the Hajj pilgrimage.

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Statement of Authorship

All authors certified fulfillment of ICMJE authorship criteria.

CRedit Author Statement

MM: Conceptualization, Methodology, Formal analysis, Investigation, Resources, Data curation, Writing – original draft preparation, Writing – review and editing, Visualization, Supervision, Project administration; **MPH:** Validation; **DT:** Methodology, Writing – review and editing, Supervision; **YTS:** Formal analysis, Validation, Data curation, Writing – review and editing; **AS:** Conceptualization, Writing – review and editing, Supervision.

Data Availability Statement

The datasets generated and analyzed during the current study are not publicly available due to institutional and ethical restrictions. However, data may be obtained from the corresponding author upon reasonable request and with permission from the Tangerang City Health Office and affiliated institutions.

Author Disclosure

The authors declared no conflict of interest.

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