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GLYCEMIC STATUS AND ITS ASSOCIATED RISK FACTORS AMONG HOSPITALIZED INDONESIAN HAJJ PILGRIMS WITH TYPE 2 DIABETES MELLITUS IN SAUDI ARABIA

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ABSTRACT

Indonesian Hajj pilgrims, especially elderly persons, often have type 2 diabetes (T2DM). Physical exertion and environmental stress during the journey may worsen glycemic instability and metabolic issues. This study examined random blood glucose (RBG) levels and their associations with age, gender, and comorbidities in 2023 hospitalized Indonesian Hajj pilgrims with T2DM in Saudi Arabia. Using Integrated Hajj Health Information System secondary data, a descriptive-analytic cross-sectional approach was used. The study comprised 292 hospitalized Indonesian Hajj pilgrims with T2DM (ICD-10 E11) and RBG findings. A significance level of $p \leq 0.05$ was utilized for chi-square analysis. The majority of participants (75.3%) were aged ≥ 60 , male (54.8%), and had fewer than two comorbidities (57.2% Uncontrolled RBG levels (≥ 200 mg/dL) were observed in 58.9% of subjects. Age was nearly linked with glycemic control ($p=0.050$), while gender and comorbidities were not. These data suggest that older Hajj pilgrims need targeted pre-departure screening and improved diabetes control to avoid problems.

Keywords: Type 2 diabetes mellitus; Random blood glucose; Hajj pilgrims; Risk factors.

АБСТРАКТ

У индонезийских паломников, совершающих хадж, особенно у пожилых людей, часто встречается сахарный диабет 2 типа (СД2). Физические нагрузки и стрессовые факторы окружающей среды во время путешествия могут усугубить нестабильность гликемии и проблемы с обменом веществ. В данном исследовании были изучены показатели уровня глюкозы в крови при случайном измерении (RBG) и их взаимосвязь с возрастом, полом и сопутствующими заболеваниями у 2023 госпитализированных индонезийских паломников с СД2 в Саудовской Аравии. Используя вторичные данные Интегрированной системы медицинской информации о хадже, был применен описательно-аналитический перекрестный подход. Исследование охватило 292 госпитализированных индонезийских паломников, совершающих хадж, с СД2 (МКБ-10 E11) и результатами РГК. Для анализа по критерию хи-квадрат использовался уровень значимости $p \leq 0,05$. Большинство участников (75,3%) были в возрасте ≥ 60 лет, мужского пола (54,8%) и имели менее двух сопутствующих заболеваний (57,2%). Неконтролируемые уровни глюкозы в крови натощак (≥ 200 мг/дл) наблюдались у 58,9% испытуемых. Возраст был слабо связан с контролем гликемии ($p=0,050$), в то время как пол и сопутствующие заболевания — нет. Эти данные свидетельствуют о том, что пожилые паломники, совершающие хадж, нуждаются в целенаправленном скрининге перед отъездом и улучшении контроля диабета для предотвращения проблем.

Ключевые слова: реконструкция передней крестообразной связки; аутотрансплантат длинной малоберцовой мышцы; аутотрансплантат подколенной мышцы; аутотрансплантат четырехглавой мышцы; заболеваемость в месте донорства

INTRODUCTION

Diabetes mellitus (DM) is a chronic metabolic disorder characterized by elevated blood glucose levels resulting from defects in insulin secretion, insulin action, or both. This condition is particularly prevalent among older adults, who are more vulnerable to metabolic dysregulation and diabetes-related complications due to age-related physiological decline. Based on its etiology, DM is classified into four main types: type 1 diabetes, type 2 diabetes, gestational diabetes, and other specific types of diabetes.¹

Globally, diabetes has become one of the most significant public health challenges, with its prevalence continuing to rise in both developed and developing countries.² The majority of type 2 diabetes mellitus (T2DM) cases are strongly associated with modifiable risk factors, particularly unhealthy lifestyle behaviors such as physical inactivity, high-calorie dietary patterns, and obesity.³

According to the International Diabetes Federation (IDF), an estimated 537 million adults worldwide were living with diabetes in 2021, and this number is expected to increase further in the coming years. Individuals with T2DM face a heightened risk of both acute and chronic complications, especially when glycemic control is suboptimal, leading to increased morbidity and mortality.⁴ Data from the *IDF Diabetes Atlas* (2021) show that Indonesia ranks fifth globally among countries with the highest number of adults (aged 20–79 years) with diabetes, with approximately 19.5 million cases.⁵ This corresponds to a national prevalence of around 10.6%, making Indonesia the only Southeast Asian country among the global top ten and underscoring its significant contribution to the regional diabetes burden.⁶

The Hajj pilgrimage is one of the five pillars of Islam and an obligatory act of worship for Muslims who are physically and financially capable. Each year, millions of pilgrims from around the world travel to the Kingdom of Saudi Arabia to perform the pilgrimage. Indonesia consistently ranks among the

countries with the largest Hajj quotas. Importantly, a substantial proportion of Indonesian Hajj pilgrims are older adults, making this population particularly vulnerable to chronic disease complications, including T2DM.^{7,8}

Given the large number of Indonesian pilgrims participating each year, health monitoring has become a critical component of Hajj preparation and implementation. The Hajj pilgrimage involves intense physical activity, exposure to extreme environmental conditions, and dietary changes that may exacerbate pre-existing chronic conditions such as diabetes mellitus. Previous reports from the Indonesian Ministry of Health have indicated that diabetes is among the leading causes of hospitalization and medical complications during Hajj, particularly among elderly pilgrims.⁹ Therefore, understanding glycemic control and its associated risk factors among hospitalized Indonesian pilgrims with type 2 diabetes is essential for developing effective pre-departure screening, clinical management, and health policy interventions to reduce morbidity and improve the safety of Hajj pilgrims.

Previous studies have reported that hyperglycemia during the Hajj pilgrimage is associated with an increased risk of acute complications, including dehydration, diabetic ketoacidosis (DKA), and hyperosmolar hyperglycemic state (HHS).¹⁰ Approximately 20% of Hajj pilgrims with underlying comorbidities who traveled to Makkah were identified as having diabetes mellitus, with documented cases of diabetic ketoacidosis, nonketotic hyperosmolar coma, fatigue, and loss of consciousness due to hypoglycemia.¹¹

However, despite these findings, limited evidence specifically focuses on hospitalized Indonesian Hajj pilgrims with T2DM, who represent a high-risk subgroup with more severe clinical conditions. Recent data reflecting the post-pandemic Hajj context, particularly from the 2023 pilgrimage season, are still scarce, and few studies have simultaneously examined the association

between random blood glucose (RBG) levels and key demographic and clinical factors such as age, gender, and comorbidities in this specific population. Addressing these gaps is essential to better understand glycemic control patterns and to inform targeted interventions for high-risk groups, especially elderly pilgrims.

Monitoring random blood glucose (RBG) levels among Hajj pilgrims with T2DM is essential to prevent the onset of acute and chronic complications during the pilgrimage. Furthermore, identifying risk factors that influence glucose levels, such as age, gender, and the presence of comorbidities, can assist healthcare professionals in planning more targeted interventions throughout the Hajj period. Therefore, this study aims to evaluate the random blood glucose (RBG) levels and identify their association with selected risk factors, namely age, gender, and number of comorbidities, among hospitalized Indonesian Hajj pilgrims with type 2 diabetes mellitus (T2DM) in Saudi Arabia during the 2023 Hajj season.

MATERIAL AND METHODS

A cross-sectional design was used to evaluate random blood glucose (RBG) levels and their association with demographic and clinical factors at a single time during the 2023 Hajj season. This approach is for assessing prevalence and identifying potential associations at a single point in time-bound populations such as hospitalized Hajj pilgrims.

This study utilizes secondary data obtained from the *Sistem Komputerisasi Haji Terpadu Bidang Kesehatan (Siskohatkes)* database, which was accessed with formal authorization from the relevant health authority. The study population included Indonesian pilgrims diagnosed with type 2 diabetes mellitus (ICD-10 code E11) who were hospitalized at the Indonesian Hajj Health Clinics (KKHI) in Makkah, Madinah, or at Saudi Arabian hospitals during the 2023 Hajj season. Only records with complete laboratory data on

random blood glucose levels were included, while incomplete data were excluded.

Relevant variables, including age, gender, number of comorbidities, random blood glucose (RBG) levels, and discharge outcomes, were extracted from predefined fields within the Siskohatkes database based on the study inclusion criteria. All variables were subsequently coded and categorized for analysis. Data quality assurance procedures included verification of diagnostic codes, removal of incomplete records, and consistency checks to ensure the reliability and validity of the dataset before analysis.

The sample size was calculated using an analytical formula for unpaired categorical data. Data collection was conducted between July and October 2024. Bivariate analysis was performed using the Chi-square test with a significance level of $p \leq 0.05$. The Kolmogorov-Smirnov test was used to assess data normality ($p > 0.05$ for normal distribution). Statistical analyses were carried out using SPSS version 29 and Microsoft Excel. Ethical clearance was obtained from the Research Ethics Committee of the Faculty of Medicine, Syarif Hidayatullah State Islamic University Jakarta (Approval No. B-016/F12/KEPK/TL.00/EE-07/2024).

RESULT

During the Hajj season of 2023, a total of 627 Indonesian pilgrims who had been diagnosed with type 2 diabetes mellitus were admitted to hospitals in Saudi Arabia, as well as at the Indonesian Hajj Health Clinics (KKHI) in Makkah and Madinah. There were 335 cases that were not included because their medical records were inadequate; nonetheless, 292 patients were able to meet the inclusion criteria and were studied.

Characteristics of Study Participants

There were a total of 220 participants who were aged 60 years or older, which constitutes 75.3% of the total. On the other hand, 72 individuals, which accounts for 24.7% of the total, were younger than 60 years. When compared to female pilgrims ($n=132$; 45.2%),

male pilgrims made up a somewhat higher proportion (n=160; 54.8%) overall. As opposed to 42.8% (n=125) of the respondents, who reported with two or more comorbid diseases, more than half of the respondents (57.2%) had fewer than two comorbidities presenting themselves. When it comes to the consequences of discharge, the majority of patients (81.8%; n=239) were discharged in stable condition, 12.7% (n=37) were referred to other healthcare facilities, 3.4% (n=10) passed away, and 1.0% of patients either left against the recommendation of their physicians or had discharge information that was inadequate. Furthermore, it is worth noting that 58.9% of the pilgrims, specifically 172 individuals, had uncontrolled random blood glucose levels (above 200 mg/dL), while 41.1% of the pilgrims, specifically 120 individuals, maintained regulated levels (below 200 mg/dL) as indicated in Table 1.

Table 2 contains a listing of the patients who participated in the trial along with their concurrent diagnoses. The most common comorbidities were endocrine and metabolic disorders, which were present in 276 (33.7%) of the patients at the time of the study. After cardiovascular disorders, which accounted for 15.6% of all cases, respiratory diseases (J00–J99) were the second most prevalent, accounting for 16.9% of all cases. This was followed by cardiovascular disorders being the second most prevalent. Among the other low-frequency comorbidities, neurological system problems (6.1%), digestive system problems (5.6%), skin problems (4.8%), and oral cavity problems (4.4%) were among the most common complications. Less than three percent of the entire sample quantity was comprised of diagnostics that were related to the renal and urinary systems, hematologic abnormalities, musculoskeletal disorders, and systemic infections. These diagnostics were relatively infrequent.

Table 1. Demographic and Clinical Characteristics of Hospitalized Hajj Pilgrims with Type 2 Diabetes Mellitus (n = 292)

Variable	n=292	%
Age		
≥ 60 years	220	75.3
< 60 years	72	24.7
Sex		
Male	160	54.8
Female	132	45.2
Number of comorbidities		
< 2 comorbidities	167	57.2
≥ 2 comorbidities	125	42.8
Discharge outcome		
Death	10	3.4
Referred	37	12.7
DAMA**	3	1.0
Recovered	239	81.8
No data available	3	1.0
Random blood glucose status*		
Controlled	120	41.1
Uncontrolled	172	58.9

*Controlled RBG = <200 mg/dL; Uncontrolled RBG = ≥200 mg/dL.

**DAMA = Discharge against medical advice

The distribution of comorbid diagnoses among the study participants is summarized in Table 2. Endocrine and metabolic disorders were the most prevalent comorbid conditions, observed in 276 patients (33.7%). Diseases of the respiratory system (J00–J99) were the second most common, accounting for 16.9% of cases, followed by cardiovascular system disorders (I00–I99) at 15.6%. Other comorbidities were identified at lower frequencies, including disorders of the nervous system (6.1%), digestive system (5.6%), skin (4.8%), and oral cavity (4.4%). Less frequent diagnoses involved the renal and urinary systems, hematologic disorders, musculoskeletal conditions, and systemic infections, each representing less than 3% of the total sample.

Endocrine and metabolic disorders included non-insulin-dependent diabetes mellitus with complications (24.9%), drug-induced hypoglycemia (2.4%), unspecified diabetes mellitus with complications (1.4%), hypothyroidism (1.0%), and electrolyte imbalances such as hypo-osmolality and hyponatremia (0.7%). Other diagnoses, including hyperglycemia, disorders of purine and pyrimidine metabolism, and hyperlipidemia, were each identified in less than 0.5% of patients.

Table 2. Distribution of Comorbid Diagnoses Based on ICD-10 Classification (n=292)

Diagnosis Category	ICD-10 Code	n (%)
Endocrine dan metabolic System disorders	E00-E90	276 (33.7)
Respiratory system disorders	J00-J99	138 (16.9)
Cardiovascular system disorders	I00-I99	128 (15.6%)
Nervous system disorders	G00-G99	50 (6.1)
Digestive system disorders	K00-K95	46 (5.6)
Skin disorders	L00-L99	39 (4.8)
General symptoms and signs		39 (4.8)
Oral disorders	K00-K14	36 (4.4)
Renal and urinary tract disorders	N00-N99	22 (2.7)
Hematologic system disorders	D50-D89	17 (2.1)
Musculoskeletal system disorders	M00-M99	10 (1.2)
Systemic infections	A40-A41, R65	9 (1.1)
Cardiorespiratory system disorders	J00-J99	5 (0.6)
Eye disorders	H00-H59	3 (0.4)

Random Blood Glucose Levels

The mean random blood glucose (RBG) level among hospitalized Hajj pilgrims with type 2 diabetes mellitus was 266 mg/dL. Further stratified analyses revealed that glycemic status did not significantly differ between male and female patients ($p=0.676$) or between those with fewer than two comorbidities and those with two or more ($p=0.352$). However, age demonstrated a

borderline statistical association with glycemic status ($p=0.050$), suggesting that older adults (≥ 60 years) were more likely to exhibit uncontrolled glucose levels compared to their younger counterparts (<60 years). These findings may imply an age-related decline in metabolic regulation and glycemic stability within this population (Table 3).

Table 3. Random Blood Glucose Base on Participants Characteristics (n=292)

Variable	Controlled n (%)	Uncontrolled n (%)	Total n (%)	<i>p-value</i>
Sex				
Male	68 (23.3)	92 (31.5)	160 (54.8)	0.676
Female	52 (17.8)	80 (27.4)	132 (45.2)	
Number of comorbidities				
< 2 comorbidities	73 (25.0)	94 (32.2)	167 (57.2)	0.352
≥ 2 comorbidities	47 (16.1)	78 (26.7)	125 (42.8)	
Age (years)				
< 60	22 (7.5)	50 (17.1)	72 (24.7)	0.050
≥ 60	98 (33.6)	122 (41.8)	220 (75.3)	

Hospital Discharge Status

As shown in Table 4, the majority of hospitalized pilgrims were discharged in stable condition (81.8%), followed by those referred to higher-level facilities (12.7%) and patients who died during treatment (3.4%). Uncontrolled glycemic status was more prevalent among patients who experienced

Table 4. Discharge Status of Hospitalized Participants base on Glycemic Control (n=292)

Discharge Status	Controlled n (%)	Uncontrolled n (%)	Total n(%)
Death	2 (0.7)	8 (2.7)	10 (3.4)
Referred	14 (4.8)	23 (7.9)	37 (12.7)
Discharged Against Medical Advice	2 (0.7)	1 (0.3)	3 (1.0)
Recovered	101 (34.6)	138 (47.3)	239 (81.8)
No data available	1 (0.3)	2 (0.7)	3 (1.0)

DISCUSSION

The findings of this study indicate that the majority of Indonesian pilgrims with type 2 diabetes mellitus (T2DM) who were hospitalized belonged to the older age group (≥ 60 years) and exhibited poor glycemic regulation. This aligns with data from the Indonesian Ministry of Health (2018), which reported that 68.77% of hospitalized pilgrims in Saudi Arabia were classified as high-risk (*risti*), primarily due to advanced age and the presence of comorbid conditions.⁹ Similarly, Nanayakkara et al. found that individuals aged ≥ 60 years with T2DM had a higher prevalence and greater risk of complications compared to younger counterparts. These findings suggest that aging-related declines in insulin sensitivity and compensatory physiological mechanisms may contribute to poor metabolic control, which is further exacerbated by the physical and environmental stressors encountered during the Hajj, including extreme temperatures, increased physical

unfavorable discharge outcomes, including death (2.7%) and referral (7.9%), compared with those with controlled glucose levels (0.7% and 4.8%, respectively). These results indicate that inadequate glycemic control may contribute to poorer hospitalization outcomes among patients with type 2 diabetes.

exertion, and dietary changes. Collectively, these factors may underlie the high rate of hospitalization and poor glycemic outcomes observed among elderly diabetic pilgrims.¹²

The gender distribution among Indonesian pilgrims in this study was relatively balanced, consistent with national data from Statistics Indonesia, which reported that 58.0% of pilgrims were male and 52.0% were female.¹³ In contrast, Yezli et al. observed a predominance of male pilgrims, with a male-to-female ratio of 2.6:1 among 1,164 participants from various countries.¹⁴ Regarding comorbidity, most pilgrims in this study had fewer than two comorbid conditions, consistent with the findings of Nugroho et al., who observed that pilgrims with fewer than three comorbidities outnumbered those with three or more.¹⁵ Likewise, Nowakowska et al. demonstrated that comorbidities are highly prevalent among individuals with T2DM.¹⁶ The presence of multiple chronic conditions among pilgrims with T2DM requires careful management, as the physically demanding activities, exposure to extreme temperatures, and high crowd density can exacerbate pre-existing diseases and increase the risk of acute health complications.

The present study revealed that the majority of hospital admissions among Indonesian Hajj pilgrims with type 2 diabetes mellitus were primarily due to endocrine and metabolic disorders. This finding differs from the 2022 report by the Indonesian Ministry of Health, which identified congestive heart failure, pneumonia, and hypertension as the leading causes of hospitalization, as well as from Saudi hospital data, where chronic

obstructive pulmonary disease (COPD) and acute myocardial infarction were more prevalent.¹⁷ Several factors may account for these discrepancies. The Indonesian pilgrim population has a high prevalence of type 2 diabetes and metabolic conditions, consistent with prior studies identifying metabolic syndrome, including hyperglycemia, hypertension, and obesity, as major contributors to morbidity among Indonesian pilgrims.¹⁸ The predominance of older age groups (≥ 60 years) with greater susceptibility to diabetes and its complications, and the physiological stressors of pilgrimage, such as increased physical exertion, altered diet, and environmental conditions that may impair glycemic control.^{12,10}

Consistent with these findings, previous research has reported that diabetes-related complications, such as hyperglycemia and hypoglycemia, frequently occur among Hajj pilgrims, with respective prevalences of 36.4% and 27.0% in specific groups.¹⁹ Moreover, other studies have indicated that while cardiovascular and respiratory diseases remain prevalent among the general pilgrim population, individuals with diabetes, overweight, or obesity exhibit a higher risk of hospitalization.²⁰ The predominance of metabolic disorders among Indonesian pilgrims likely reflects the demographic and epidemiological characteristics of this population, emphasizing the need for targeted pre-departure screening and metabolic control strategies.

A tendency toward suboptimal glycemic regulation among most hospitalized Hajj pilgrims with type 2 diabetes mellitus was observed in this study. Aligns with previous observational and randomized controlled trials, indicating that improved glycemic control is associated with reduced hospital complications.²¹ Poor glycemic control alongside comorbid conditions highlights the critical need for thorough pre-departure health screening. Prior studies have emphasized that optimal management of chronic diseases before pilgrimage can

significantly lower the risk of medical complications during Hajj.

This study found no significant association between sex and glycemic control based on random blood glucose levels ($p=0.676$). Similar findings were reported by Choe et al., who observed no sex-related differences in HbA1c levels among 2,253 patients with type 2 diabetes mellitus, although fewer women reached target HbA1c compared with men.²² These findings suggest that sex is unlikely to be a primary determinant of glycemic regulation, emphasizing the potential influence of other factors such as treatment adherence, disease duration, and lifestyle behaviors.²³

Comorbidity number did not significantly affect glycemic status ($p=0.352$). McCoy et al. found that patients with many comorbidities had tighter glycemic control, as shown by lower HbA1c values, likely due to more rigorous clinical treatment.²⁴ Patients with several comorbidities may receive more frequent blood glucose testing, stricter treatment changes, and extensive inpatient care. These patients may get more intensive and customized treatment regimens, including as insulin titration and continuous clinical monitoring, during hospitalization, improving short-term glycemic control despite poor baseline metabolic status.

In contrast, Urina-Jassir et al. demonstrated that specific comorbidities such as chronic kidney disease and obesity were significantly associated with poor glycemic control, whereas hypertension showed no such relationship.²⁵ These discrepancies may be explained by variations in comorbidity types, disease severity, healthcare access, treatment adherence, and lifestyle factors, all of which may modulate the complex interplay between metabolic regulation and clinical outcomes in diabetes management.

Uncontrolled glycemic status was more prevalent among participants aged ≥ 60 years (41.8%) compared with those aged < 60 years (17.1%), with a statistically significant association observed between age and random blood glucose levels ($p=0.050$). This

finding is consistent with Qassim et al., who reported a significant association between age and glycemic control ($p < 0.05$), where older adults (≥ 60 years) exhibited higher HbA1c levels compared with younger individuals.²⁶ Age-related insulin resistance and alterations in the insulin–glucose response contribute to reduced glucose uptake in muscle cells, ultimately leading to poorer glycemic regulation.²⁷

According to the findings of the study, patients who had their random blood glucose (RBG) levels under control had significantly reduced rates of referral and mortality as compared to patients whose RBG levels were not under control.

It is interesting to note that a significant number of patients who had RBG levels that were not under control were nonetheless discharged in stable condition, which may seem contradictory. It is possible that these findings are the result of the fact that the measurement of RBG reflects a single-point glucose level, which may not effectively represent the management of glycemic control during the duration of hospitalization. Patients may have presented with transitory hyperglycemia as a result of acute stress, infection, or physiological strain connected with the Hajj trip. This condition might have been adequately controlled during the patients' stay in the hospital. Patients who are hospitalized frequently undergo intense treatment that is continuously monitored. This treatment typically includes rapid insulin adjustment and supportive care, which enables the stabilization of acute metabolic disturbances even when the initial glucose levels are elevated. As a consequence of this, the status of discharge maybe reflects clinical improvement during a brief period of time rather than prolonged glucose control.

A greater percentage of patients discharged in satisfactory condition was noted among those with uncontrolled RBG (47.3%) compared to the controlled group (34.6%), indicating that glycemic status alone may not entirely dictate clinical outcomes. Additional factors, including comorbidities, length of

hospitalization, and treatment efficacy, undoubtedly contribute significantly.

However, due to the characteristics of this secondary dataset, clinical discharge criteria, RBG measurement date, and primary hospitalization reason were missing. Thus, elevated RBG values may have been due to transitory hyperglycemia at admission rather than poor glycemic management during the stay. Patients with high glucose levels may have been admitted for acute conditions that might be handled and discharged in stable condition.

Furthermore, the designation of "discharged in good condition" in the database most likely represents overall clinical stability rather than stringent glycemic normalization, which may contribute to explain the gap that was discovered. The limitations of relying simply on single-point RBG measurements in the evaluation of metabolic regulation in hospitalized patients are brought to light by these findings.

These findings emphasize the necessity for a comprehensive metabolic and clinical examination to better understand the relationship between glucose control and treatment outcomes in type 2 diabetes patients during Hajj. Previous research indicates that higher glucose variability at hospital discharge significantly raises 30-day readmission risk (RR 1.08, 95% CI 1.05–1.10; $p < 0.0001$).²⁸

This research has a number of shortcomings that need to be taken into consideration. This study focuses on age, gender, and comorbidities, but it does not take into consideration potential confounding factors. These factors include food pattern, physical activity, medication use, and environmental or cultural influences during the Hajj period, all of which have the potential to impair glycemic control. The ability to conduct a full evaluation of glycemic management over time is hindered by the use of random blood glucose as a single-point measurement. Transient hyperglycemia and persistent poor metabolic control are difficult to differentiate from one another because

longitudinal markers, such as fasting blood glucose or HbA1c, are not available.

In the future, research should add more comprehensive metabolic and behavioral indicators to improve interpretative accuracy. This would allow for a more accurate and comprehensive understanding of glucose management and its clinical consequences among Hajj pilgrims who have type 2 diabetes.

CONCLUSION

This study demonstrated that most pilgrims with type 2 diabetes exhibited suboptimal glycemic control. No significant associations were found between sex or number of comorbidities and glycemic status; advancing age was associated with poorer glucose regulation.

These findings highlight the need for targeted pre-departure screening and comprehensive diabetes education, particularly among elderly pilgrims, to enhance metabolic stability

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