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Health Risk Behaviors and Associated Factors Among Hajj 2024 Pilgrims: A Multinational Cross-Sectional Study

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Background and Objective: The Hajj, a massive annual pilgrimage to Mecca, attracts over 2 million participants. The physically demanding rituals, extreme heat, and crowding increase the risk of injuries worsen chronic conditions, and facilitate infectious disease transmission. Therefore, this study aims to assess the risk behavior and associated factors among pilgrims during the Hajj season of 2024.

Methods: A cross-sectional study was conducted among pilgrims during the Hajj season from June 25 to July 30, 2024. The data were randomly collected from departures at Jeddah's King Abdulaziz International Airport and analyzed using the Statistical Package for the Social Sciences (SPSS).

Results: Out of the 1183 pilgrims, 47.5% were male (n=562). The mean age was 54.98±13.96. Risky behaviors were common among pilgrims: 26.9% (n = 318) did not use umbrellas in direct sunlight, and 49.6% preferred walking over using transportation. Additionally, 51.7% did not take prescribed medication, and 59.9% did not seek urgent care for severe symptoms. The mean risk-taking behavior score was 3.24±1.05, with 36.6% of pilgrims exhibiting high-risk behavior and 63.4% exhibiting low-risk behavior. Significant associations were found between risk behavior and education ($\chi^2 = 96.502$, $p < 0.001$), nationality ($\chi^2 = 69.681$, $p < 0.001$), and certain health conditions (asthma, hearing and vision impairment, and heart disease). Multiple linear regression identified gender (B=0.218, SE=0.059, CI=0.102 to 0.334, p<0.001), education (B=−0.044, SE=0.019, CI=−0.082 to −0.006, p=0.023), nationality (B=−0.168, SE=0.024, CI=−0.215 to −0.122, p<0.001), presence of vision impairment (B=−3.177, SE=1.429, CI=−5.981 to −0.372, p=0.026), and heart disease (B=2.118, SE=1.013, CI=0.130 to 4.106, p=0.037) as predictors of risky behavior (p<0.001).

Conclusion: Minor risk behaviors among pilgrims can lead to increased morbidity, mortality, and logistical challenges. Guidance promoting healthy practices before and during the pilgrimage is essential to mitigate these risks and reduce adverse outcomes.

Keywords: risk behaviours, physical activity, chronic diseases, direct sunlight

Introduction

With around two million participants each year, the annual Islamic pilgrimage, mostly known as Hajj, is one of the world's most significant mass gathering events.[1–3] During this Islamic gathering, individuals from different countries come to holy cities in Saudi Arabia. Serious public health issues are associated with this massive aggregation of pilgrims from various backgrounds, especially regarding emergency medical assistance.[4–7] The physically demanding nature of the Hajj ceremonies combined with the hot, crowded environment can make people prone to injuries, make pre-existing medical issues worse, and make infectious diseases easier to spread.[2,3]

During rituals in Hajj, the behavior analysis of pilgrims significantly elevates the risk of spreading numerous infectious diseases and other adverse health outcomes.[2] Additionally, the behaviors of pilgrims towards atmospheric situations can predispose them to heat-related illnesses. For example, most of the literature revealed that developing heat

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stroke is more prevalent among pilgrims. This may be explained through various factors, such as the continued need to travel from one place to another. Furthermore, heat stroke (HS) and heat exhaustion (HE) during the Hajj were significantly correlated with age and raised temperatures, which is not surprising considering that the 2024 Hajj took place in the middle of summer, with very high temperatures being recorded.[7] In Saudi Arabia, the temperatures range between lows of 13°C (55 °F) in January and highs of 43 °C (110 °F) starting from June to October.[7]

Large gatherings and the requirement of physical walking or lack of transportation are major contributing factors to physical injuries.[8,9] In addition, previous literature reported that muscular injuries and fractures could be attributed to excessive walking for 5–15 miles to fulfill rituals and the lack of use for available transport services, which have increased the risk of falls, slips, and stampedes among pilgrims.[3–5] Studies have shown that the most common medical issues experienced by pilgrims include heat-related illnesses, respiratory tract infections, and traumatic injuries.[3,7,10] Additionally, the risk of communicable disease outbreaks, such as influenza and meningococcal meningitis, is elevated during the Hajj due to the proximity of participants.[10] In addition, earlier investigations were conducted to monitor behaviors, such as daily water consumption, duration of sleep, adherence to hand hygiene practices, and utilization of protective face masks.[8,11] Those pilgrims who did not participate in an organized camp or did not receive health education guidance before Hajj exhibited significantly higher susceptibility to engaging in unfavorable health-related behaviors during the pilgrimage[3] and were more vulnerable to developing illness.[12]

In collaboration with international health organizations, the Saudi government has implemented extensive healthcare, infrastructure, and emergency response plans to manage these challenges.[10,13,14] One of the critical components of the health infrastructure during Hajj is the deployment of mobile clinics and temporary hospitals equipped with advanced medical facilities.[15] These units are strategically located to rapidly respond to and treat pilgrims.[10] Public health campaigns are also conducted to educate pilgrims on preventive measures, such as personal hygiene and heat management.[15] However, the dynamic and unpredicted nature of the pilgrimage necessitates continuous improvement and adaptation of these services.

Pilgrims engaging in risk-taking may exacerbate their existing health conditions or develop new conditions requiring urgent care. Thus, evaluating the behaviors, attitudes towards avoidance of risk-taking behavior, adaptation practices, and recognition among the Hajj population is crucial for informing appropriate interventions to reduce health impacts of heat-related illnesses and risk-taking behaviors during Hajj and to improve health outcomes.[3,7] Effective urgent care planning and responses are crucial to ensuring the health and safety of Hajj pilgrims. Thus, understanding the unique health challenges and urgent care requirements of pilgrims participating in Hajj can inform more targeted and effective public health interventions to protect the well-being of participants. Especially given the absence of studies addressing behaviors among pilgrims, which have been associated with increased mortality during Hajj seasons.[16] Therefore, this study aimed to assess the Risk Behaviour and Associated and Correlated Factors among Pilgrims during the Hajj season 2024.

Methodology

Study Design, Settings, and Population

A cross-sectional study was conducted among Hajj pilgrims, using pre-validated questionnaires administered by trained researchers. The data collection was conducted between June and July 2024. The data collection was conducted using convenience sampling. Pilgrims were mainly recruited from departure areas at airports in Jeddah after they had performed the Hajj rituals.

Inclusion and Exclusion Criteria

The inclusion criteria of participants consisted of pilgrims from different countries, irrespective of gender and age, who were able to respond to the questionnaires by providing informed consent. Female pilgrims who were pregnant or in a post-partum period were excluded from the study.

Ethical Approval

Before the data collection, the study protocol and questionnaires were reviewed and approved by King Fahad Medical City (KFMC), Ministry of Health (MoH), Riyadh (IRB-24-289E). The study was performed following the relevant

guidelines and regulations prescribed by the Declaration of Helsinki for human research. In addition, pilgrims were informed that the data would be used only for research purposes and confidentiality would be maintained throughout the research, with the option to withdraw from the study at any time being known to them.

Sample Size

Similarly to previous studies, the required sample size was estimated using an online calculator, the Raosoft® sample size calculator. The sample size was measured at a 95% confidence interval, a response distribution of 50%, and a 5% margin of error. The targeted sample size was 385 pilgrims. Adjusting for the projected 10% attrition rate, the estimated final sample size is at least 424 pilgrims. However, due to the large gathering of multinational pilgrims, we approached as many as we could to avoid sampling bias and strengthen the study. Therefore, the final sample consisted of 1250 pilgrims.

Questionnaire Design and Data Collection

For data collection, anonymous questionnaires based on available literature were prepared. The questionnaire included demographic information such as age, gender, education, and country of origin (4 items). The second part of the study collected information from pilgrims about the most common chronic diseases, assessed on a binary scale (Yes/No). The last section of the study collected information on risk behavior practices among pilgrims. It consisted of 6 items measured on a binary scale ranging from (Yes/No). After the initial draft of the questionnaire, it was reviewed by a team of experts (2 professors from the emergency department, one professor from the Ministry of Health, and a senior researcher) to provide independent feedback on the suitability, content, and flow of the questionnaire. Later, the questionnaires were piloted among a randomly selected group of 30 pilgrims. The pilot study concluded that it took 13 minutes to complete the questionnaires. The reliability was determined using Cronbach's alpha, which was found to be 0.71, suggesting that the questionnaires are valid and reliable for conducting the study.

The risky behavior was measured by computing scores for each risky behavior item by assigning a score of "1" for the risk-taking behavior question, and a score of 0 for safe practice. The overall mean risky behavior for each item was computed, and all item scores were combined to obtain the overall mean risky behavior. Furthermore, the overall risk behavior was further classified into low-risk behavior (individuals who scored <3 from the total mean score) and high risky behavior (individuals who scored >3 from the total mean risky behavior).

To accommodate the pilgrims' different languages, translators were made available to assist non-Arabic and non-English speakers from their accompanying Hajj campaigns. The data was collected until the required sample was obtained.

Statistical Analysis

The data was entered into Excel and converted into a statistical package for social science (SPSS). The data were analyzed using SPSS version 26. Descriptive statistics such as frequencies (n) and percentages (%) were used to describe categorical data, while continuous data was presented as mean and standard deviation (SD), median, minimum, and maximum. Multiple linear regression was used to assess the predictors of risky behaviors. In addition, Pearson correlation was conducted to determine the correlation between pilgrim's characters and risky behavior. A p-value <0.05 will be considered statistically significant for all tests.

Results

Participant's Characters

Out of the 1250 responses, 1183 pilgrims completely answered the survey by giving a response rate of 95%. Among respondents, 47.5% were male (n=562). The mean age was 54.98±13.96 years, with about 13.8% aged between 21–39, 47.5% between 40–59, and 33.9% 60–79 years. Among the respondents, 20.5% had a college degree, 13.6% were able to read and write, and 40.4% reported having chronic diseases. More detailed frequencies of the respondent's characteristics are presented in Table 1.

Table 1 Frequencies of the Respondent's Characteristics (n=1183)

Characters of the Pilgrims	Frequency (n)	Percentage (%)
Gender		
Male	562	47.5%
Female	621	52.5%
Age	54.98 mean, 13.96 (std)	
1–20	09	0.8
21–39	163	13.8
40–59	562	47.5
60–79	401	33.9
80 above	48	4.0
Educational Level		
Illiterate	134	11.3%
Read & Write	161	13.7%
Intermediate or Secondary	109	9.2%
University	243	20.5%
Skipped the question	536	45.3
Nationality according to WHO region		
African Region (AFRO)	206	17.4%
Eastern Mediterranean Region (EMRO)	481	40.7
European Region (EURO)	11	0.9
South-East Asia Region (SEARO)	230	19.4
Region of the Americas (AMRO)	–	–
Western Pacific Region (WPRO)	255	21.6%

Most Common Chronic Diseases

In this study, the majority (61.6%, n=729) reported having hypertension, followed by diabetes (47.7%, n=564), 14.4% reported having heart-related diseases, and 14.3% reported vision impairment. A detailed description of the presence of chronic diseases among pilgrims is presented in Figure 1.

Health Risk Behaviour Practices

Regarding risky behavior, 26.9% of the pilgrims (n = 318) never used an umbrella under direct sunlight during Hajj in 2024, while the majority 73.1% of them used it. Furthermore, 42.6% of the pilgrims performed extra physical activity to reward Ajar. In this study, 49.6% of the pilgrims walked rather than riding the bus, car, or train when available, while 50.7% of the pilgrims never walked but rather used available transportation services. Regarding medication use, 48.3% of the pilgrims used medication prescribed for an illness, while 51.7% of the pilgrims never used it as prescribed. Furthermore, only 40.1% of the pilgrims requested urgent health assistance with severe symptoms. The responses towards Health Risk Behaviour Practices among Pilgrims are presented in Table 2.

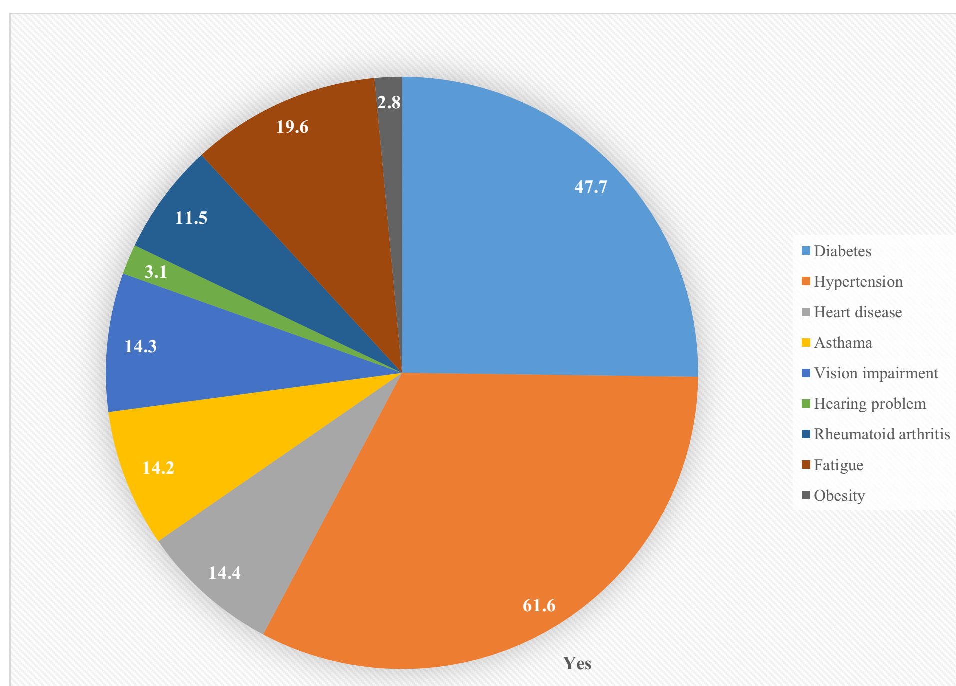

Figure 1 Chronic disease among pilgrims.

In this study, the mean risk-taking behavior among pilgrims was 3.24±1.05 (Median=3) (range 0–6), and the maximum was 6.00. The most common risk-taking behavior among pilgrims was not requesting urgent health assistance when having severe symptoms and not using medications prescribed by physicians, as shown in Figure 2.

In this study, the overall high risky behavior was reported among 36.6% of the pilgrims, while 63.4% of the reported low risky behaviour as shown in Figure 3.

The association between Risky behavior levels and the demographics of the pilgrims is shown in Table 3. A chi-square test for the association between the gender of the pilgrims and risky behavior level generated a p-value of <0.001 (χ^2 = 10.102) with female pilgrims (41.3%) being more likely to perform higher risky behavior than males (32.4%). However, the age (χ^2 = 4.504, p=0.343) presence of diabetes (χ^2 = 1.590, p = 0.227) and hypertension (χ^2 = 0.268, p=0.620) among pilgrims were not significantly associated with risky behavior. Pilgrims' education (χ^2 = 96.502, p=0.001), nationality (χ^2 = 69.681, p=0.001) presence of asthma (χ^2 = 19.454, p=0.001) hearing (χ^2 = 15.783, p=0.001) and vision impairment (χ^2 = 18.807, p=0.001) heart disease (χ^2 = 19.670, p = 0.001) were significantly associated with risky behavior as shown in Table 3.

Table 2 Health Risk Behaviour Practices Among Pilgrims

Variables	Yes n (%)	No n (%)
Using an umbrella under direct sunlight	865 (73.1)	318 (26.9)
Extra physical activity to reward Ajar	504 (42.6)	679 (57.4)
Walking in the hot direct sunlight rather than riding a bus, car, or train when available	583 (49.3)	600 (50.7)
Using medication prescribed for illness	571 (48.3)	612 (51.7)
Requesting urgent health assistance when having severe symptoms	474 (40.1)	709 (59.9)
Discharge against medical advice (DAMA)	67 (5.7)	1116 (94.3)

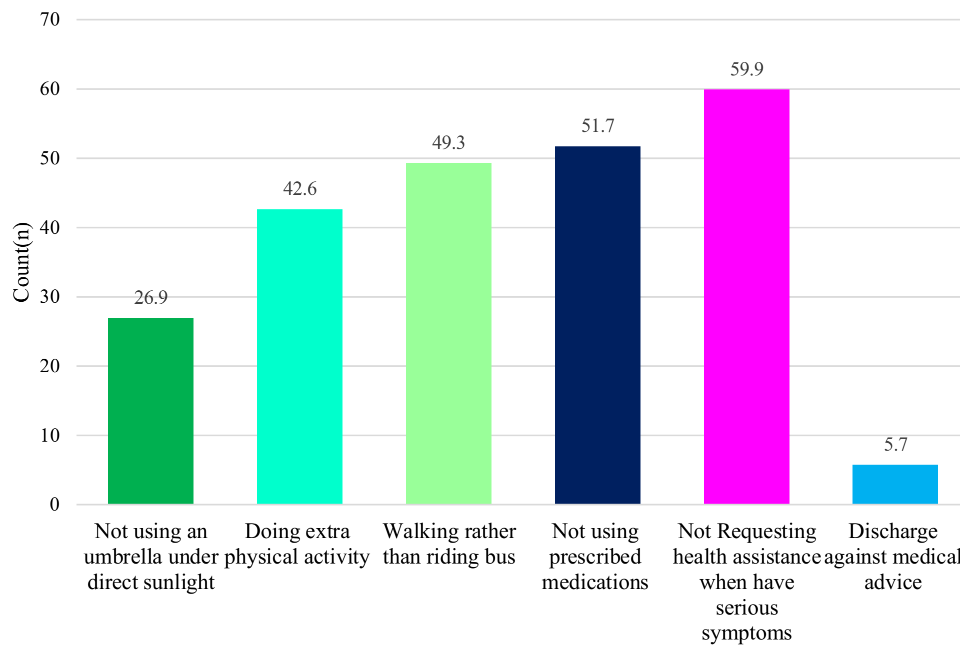

Figure 2 Risk-taking Behaviour among Pilgrims.

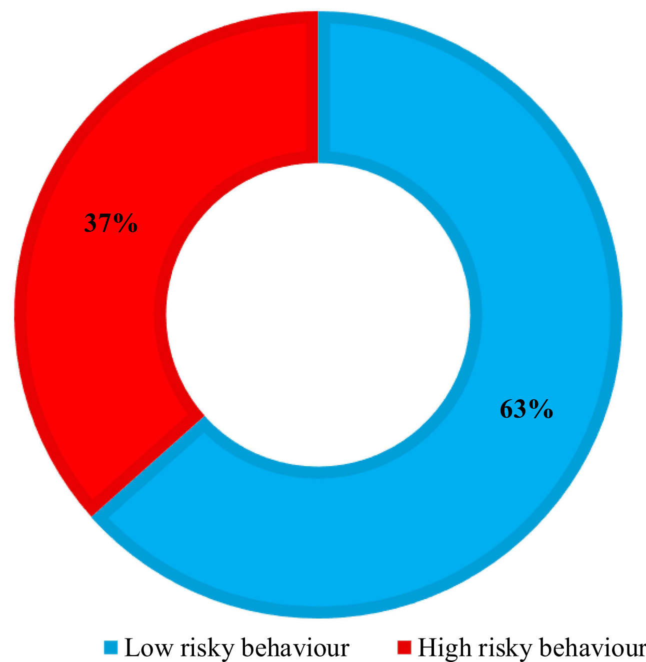

Figure 3 Overall risky behaviour among pilgrims.

The results of the multiple linear regression model revealed a significant association between the risky behavior, and pilgrim's characteristics like gender (B=0.218, SE=0.059, CI=0.102 to.334, p = <0.001) education (B = −0.044, SE=0.019, CI = −0.082 to −0.006, *P*=0.023) nationality (B=−.168, SE=0.024, CI = −0.215 to −0.122, p = <0.001) presence of chronic vision impairment (B = −3.177, SE=1.429, CI=−5.981 to −0.372, p=0.026), heart disease (B=2.118, SE=1.013, CI=0.130 to 4.106, p = 0.037) were predictors of risky behavior (p<0.001) as shown in Table 4.

Additionally, the correlation analysis revealed that the risky behavior of the pilgrims was significantly positively correlated with gender (r = 0.108, p = 0.01), presence of chronic diseases like asthma (r = 0.079, p = 0.01), vision

Table 3 Association Between Risky Behaviour and Pilgrim's Demographic Characteristics

Respondents' Characters	Number of Respondents	Overall risky behaviour		χ2	*p*-Value
		Lowe Risky Behaviour	**High Risky Behaviour**		
Gender				10.102	<0.001
Male	Respondents	420	201		
	% within gender	67.6%	32.4%		
	% within two levels	56.0%	46.4%		
Female	Respondents	330	232		
	% within gender	58.7%	41.3%		
	% within two levels	44.0%	53.6%		
Age				4.504	0.343
0–20	Respondents	3	6		
	% within a year of study	33.3%	66.7%		
	% within two levels	0.4%	1.4%		
21–39	Respondents	99	64		
	% within a year of study	60.7%	39.3%		
	% within two levels	13.2%	14.8%		
40–59	Respondents	364	198		
	% within a year of study	64.8%	35.2%		
	% within two levels	48.5%	45.7%		
60–79	Respondents	253	148		
	% within a year of study	63.1%	36.9%		
	% within two levels	33.7%	34.2%		
>80	Respondents	31	17		
	% within a year of study	64.6%	35.4%		
	% within two levels	4.1%	3.9%		
Education:				96.502	<0.001
Illiterate	Respondents	122	12		
	% within the education	91.0%	9.0%		
	% within two levels	16.3%	2.8%		
Read & Write	Respondents	76	85		
	% within the education	47.2%	52.8%		
	% within two levels	10.1%	19.6%		
Intermediate or Secondary	Respondents	84	25		
	% within the education	77.1%	22.9%		
	% within two levels	11.2%	5.8%		
University	Respondents	175	68		
	% within the education	72.0%	28.0%		
	% within two levels	23.3%	15.7%		
No response:	Respondents	293	243		
	% within the education	54.7%	45.3%		
	% within two levels	39.1%	56.1%		
Nationality				69.681	<0.001
African Region (AFR)	Respondents	165	41		
	% within nationality	80.1%	19.9%		
	% within two levels	22.0%	9.5%		
Eastern Mediterranean (EMR)	Respondents	317	164		
	% within nationality	65.9%	34.1%		
	% within two levels	42.3%	37.9%		

(*Continued*)

Table 3 (Continued).

Respondents' Characters	Number of Respondents	Overall risky behaviour		χ2	*p*-Value
		Lowe Risky Behaviour	High Risky Behaviour		
European Region (EUR)	Respondents	10	1		
	% within nationality	90.9%	9.1%		
	% within two levels	1.3%	0.2%		
South-East Asia Region	Respondents	145	85		
	% within nationality	63.0%	37.0%		
	% within two levels	19.3%	19.6%		
Western Pacific Region (WPRO	Respondents	113	142		
	% within nationality	44.3%	55.7%		
	% within two levels	15.1%	32.8%		
Presence of Asthma?				19.454	<0.001
Yes	Respondents	81	87		
	% within the Asthma	106.5	61.5		
	% within two levels	10.8%	20.1%		
No	Respondents	669	346		
	% within the Asthma	643.5	371.5		
	% within two levels	89.2%	79.9%		
Presence of Vision impairment?				18.807	<0.001
Yes	Respondents	82	87		
	% within the vision impairment	107.1	61.9		
	% within two levels	10.9%	20.1%		
No	Respondents	668	346		
	% within the vision impairment	642.9	371.1		
	% within two levels	89.1%	79.9%		
Presence of Hearing impairment?				15.783	<0.001
Yes	Respondents	12	25		
	% within the hearing impairment	23.5	13.5		
	% within two levels	1.6%	5.8%		
No	Respondents	738	408		
	% within the hearing impairment	726.5	419.5		
	% within two levels	98.4%	94.2%		
Presence of heart disease?				19.670	<0.001
Yes	Respondents	82	88		
	% within the heart disease	107.8	62.2		
	% within two levels	10.9%	20.3%		
No	Respondents	668	345		
	% within the heart disease	642.2	370.8		
	% within two levels	89.1%	79.7%		

impairment (r = 0.076, p = 0.01) and heart disease (r = 0.080, p = 0.01). However, the nationality of the pilgrims was significantly negatively correlated with risky behavior (r = −0.207, p = 0.01). Conversely, pilgrims' age was negatively correlated with their risk behavior, but the correlation was not significant, as shown in Table 5.

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Table 4 Multiple Linear Regression Model for Predictors of Risky Behaviour

Variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% CI for B	
	B	Std. Error (SE)				Lower Bound	Upper Bound
(Constant)	2.974	0.321		9.276	<0.001	2.345	3.603
Gender	0.218	0.059	0.104	3.697	<0.001	0.102	0.334
Age	−0.112	0.042	−0.082	−2.665	0.008	−0.195	−0.030
Education	−0.044	0.019	−0.068	−2.271	0.023	−0.082	−0.006
Nationality	−0.168	0.024	−0.234	−7.090	<0.001	−0.215	−0.122
Presence of Asthma	1.395	1.016	0.463	1.374	0.170	−0.598	3.388
Vision problem	−3.177	1.429	−1.057	−2.222	0.026	−5.981	−0.372
Hearing impairment	0.269	0.188	0.045	1.428	0.154	−0.101	0.639
Presence of Diabetes	0.099	0.103	0.047	0.958	0.338	−0.104	0.301
Presence of Hypertension	0.103	0.102	0.048	1.014	0.311	−0.096	0.302
Presence of Heart disease	2.118	1.013	0.707	2.090	0.037	0.130	4.106

Table 5 Correlated Factors Toward Risky Behaviour Among Pilgrims

Variables	ρ (Pearson Correlation)
Risk behaviour	1
Age	−0.043
Gender	0.108**
Education	−0.081**
Presence of asthma	0.079**
Presence of Vision impairment	0.076**
Presence of Hearing impairment	0.073*
Presence of diabetes	0.074*
Presence of Hypertension	0.017
Presence of Heart disease	0.080**
Nationality	−0.207**

Notes: **Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed).

Discussion

To the best of our knowledge, there have been few studies conducted to evaluate the health risk behaviors among Hajj pilgrims. However, there is limited literature available on this topic. Existing literature focuses on knowledge, attitudes, and practices throughout the Hajj journey to understand the health behaviors and preventative measures among pilgrims.[7,11,17–19] Studies specifically addressing heat-related illness.[6,20,21] Therefore, this study would make a significant contribution to the

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literature on risky behaviors performed by pilgrims. By addressing the factors that contribute to risky behaviors, these findings would serve as a reference for future studies. The findings could also be utilized by healthcare authorities to develop and implement appropriate initiatives aimed at reducing risky behaviors and the associated harm among pilgrims. However, in this study, the most prevalent risk-taking behavior among pilgrims was walking in direct sunlight rather than using the available transportation, which is significantly associated with adverse outcomes. One example of an unfavorable outcome is exposure to the risk of physical trauma. Hajj rituals are accomplished by walking through or near dense traffic or in vehicles themselves, leading to accidents, which may contribute to mortality or morbidity. In addition, navigating without following a planned transportation route is significantly associated with stampedes and fallings. Another risk associated with walking was exposure to temperature, leading to heat-related illness.[22] Walking in direct sunlight without transportation was commonly reported despite the Saudi government's implementation of several initiatives over the years to enhance transportation.[12–15]

In this study, 26.9% of the pilgrims did not use an umbrella under the sun, suggesting hazardous behavior that may contribute to developing HRIs. A prior study[7] conducted in 2024 on pilgrims in Makkah found a high correlation between rising temperatures and the prevalence of heat exhaustion and heat stroke.[7] Saudi Arabia is a desert country marked by extremely hot and dry temperatures, ranging from 27°C to 43°C in the inland areas and 27°C to 38°C in coastal areas, with frequent and severe heatwaves.[4,23] Long-term exposure to this temperature may lead to health risks in terms of heat-related illnesses (HRIs), which are an increasing threat for travelers in hot climate destinations; furthermore, many pilgrims are not familiar with the region's desert climate. Therefore, to protect pilgrims from this scenario, pilgrims must adopt health guidelines issued by local authorities. In addition, it is a well-known fact that heat-related illnesses were rarely discussed during pre-travel consultation, and pilgrims never worried about it.[24] The Saudi Arabian Ministry of Health also advised pilgrims to combat HRIs.[25] A prior study conducted in 2017 revealed the proportion of pilgrims using umbrellas regularly from 42 nationalities (51%)[26] compared to this study (41%). To combat HRIs and their harmful effects, such as heat stroke among pilgrims at holy sites, the Saudi Arabian Ministry of Health has implemented several preventative measures, including providing water mist sprays throughout ritual areas,[2] planting trees, and creating green space at holy sites,[27] providing free water and umbrellas to pilgrims,[6,28] providing temporary housing in air-conditioned tents,[7] providing free health services, and operating health camps, including seasonal health facilities with cooling units to expedite the body's cooling process after exposure to intense heat.[5,7] On the other hand, a significant 74.6% decrease in heat stroke cases and a 47.6% fall in the case fatality rate were linked to implementing structural and community initiatives at the holy cities.[7]

In this study, 42.6% of pilgrims engaged in risky behavior by choosing extra physical activity, while half of them engaged in walking instead of using available transportation. Existing literature has shown that walking barefoot during Hajj is common among pilgrims. Still, the large number of pilgrims in one place and competition for transportation is reasons why some choose not to use it.[29,30] Efforts should be made to improve the availability and quality of public transportation to attract more pilgrims.[30] Other risky behaviors among pilgrims included not taking prescribed medications (51.7%) and not seeking health assistance when experiencing serious symptoms. Poor medication adherence can lead to more disease complications, hospital admissions, and increased use of health services. Delaying medical care can result in more expensive interventions, hospitalizations, and treatments, making it difficult to perform activities during the Hajj journey.[31,32] Pilgrims with chronic conditions who do not adhere to medication can worsen their health status.[33] It is recommended that pilgrims receive comprehensive health education on medication adherence, disease management, and healthy behaviors before departing for Hajj.[33,34] It is also important to ensure that pilgrims have access to healthcare services, including emergency care, during Hajj.[33,34]

In the current study, a significant negative correlation was observed between certain demographic factors and risk-taking behavior among pilgrims. Specifically, gender and educational level exhibited a negative correlation with risk-taking behavior, suggesting that being male and having a higher level of education were linked to reduced risk-taking tendencies among the pilgrims. In addition, the mean risky behavior was higher among females than male pilgrims. Similarly, the dangerous behavior was higher among pilgrims with the presence of chronic diseases compared to pilgrims without chronic diseases, suggesting a significant difference between the risky behavior and the pilgrim's health status and gender. Additionally, the age of the pilgrim was significantly associated with risky behavior. The previous findings show that the extreme age of the pilgrims, chronic disease, vigorous physical activity, inadequate hydration, and the use

of certain medications were factors associated with the risk behavior of heat-related stroke.[22,35,36] Consequently, it is essential to identify the causes that may encourage or enable pilgrims to engage in risk-taking behavior and to take prompt action to overcome them. In addition, enhanced religious and health education and awareness are the key steps to changing beliefs towards healthy behaviors in Hajj seasons pre-arrival and during the residency in Makkah and Madinah.

Identifying health risk behaviors and factors can help develop targeted interventions to reduce these risks. For example, knowing the most common risky behavior among pilgrims can lead to improving or advancing health risk management, in advancing in emergency preparedness. Furthermore, knowing the pilgrim's health status helps in providing sanitation and hygiene practices. Additionally, understanding pilgrims' knowledge and awareness of health risks can guide the creation of culturally sensitive health education programs. Such research findings can influence health policy and planning, especially in the context of mass gatherings, and assist policymakers in implementing evidence-based strategies to safeguard the health and well-being of pilgrims.

Although the study has demonstrated risky health behaviors among pilgrims from many nationalities, some limitations must be acknowledged. Firstly, the sample size in the study is still small compared to the total estimated population in the 2024 Hajj. Therefore, these findings cannot be generalized to the entire 2024 Hajj population. Future studies could aim to include a larger and more diverse sample to enhance representativeness even further. Additionally, all data was collected through face-to-face interviews, taking into account the respondents' different social and economic backgrounds and languages, including those who spoke languages not provided by translation services. This may have led to social desirability bias and an overestimation of the results. Another limitation is that selection bias may have occurred as interviewed participants may be more concerned about their health. Convenience sampling used in the study may also result in bias and is considered a limitation. On the other hand, no previous studies have examined risky behavior among pilgrims from various nationalities attending Hajj rituals in holy cities. This study provided a unique opportunity to inform healthcare authorities on implementing adequate measures to deliver healthcare services in the holy cities of Saudi Arabia.

Conclusion

This study is one of the first investigations into risk-taking behaviors relating to a large sample of pilgrims during the Hajj rituals. It was found that many pilgrims engaged in risk-taking behaviors regarding not using umbrellas or doing extra physical activity. However, risk-taking behaviors were identified to be correlated with age, gender, and education. In addition, it was found that elderly pilgrims were more likely to engage in risk-taking behavior compared to young pilgrims. Female pilgrims were more probable compared to males, and pilgrims with chronic illnesses were more likely to engage in risk-taking behavior compared to pilgrims without chronic diseases. However, these findings can serve as baseline data to design effective general or targeted interventions for behavior change to address these behaviors. Further studies at larger scales, including qualitative methods and observation of actual practices, are warranted. In addition, Future studies monitoring behavior changes across multiple Hajj seasons, investigating the long-term effects of health interventions, and exploring methods to promote healthy practices among pilgrims are needed. Conducting longitudinal studies could offer valuable insights into the evolution of health behaviors and help in creating specific interventions.

Abbreviations

HRIs, Heat-related illnesses; HS, Heat stroke; HE, Heat exhaustion; KFMC, King Fahad Medical City; MoH, Ministry of Health.

Data Sharing Statement

The data used and analyzed during the current study are available from the corresponding author upon reasonable request.

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Disclosure

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