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Research Article

MULTILEVEL ANALYSIS OF DETERMINANT OF DEATH OF INDONESIAN HAJJ PILGRIMS 2022-2024

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ABSTRACT

Background:
The Hajj pilgrimage is an annual religious activity carried out at specific times, locations, and activities, attended by millions of Muslims from around the world (mass gathering). Indonesia, as the country with the largest number of Hajj pilgrims, faces serious challenges in terms of relatively high pilgrim mortality rates each year. Data indicates that the mortality rate of Indonesian Hajj pilgrims peaking at 3.38‰ in 2023. Pilgrim deaths are influenced by various factors, including individual factors, factors related to the the Hajj, and environmental factors. This study aims to identify the factors influencing mortality among Indonesian hajj pilgrims during the Hajj pilgrimage period from 2022 to 2024.
Methods: This cross-sectional study consisted of 1,686 samples from the Hajj Health Center data source, Indonesian Ministry of Health (SISKOHATKES SHAR'I) and environmental data from NASA POWER.
Results: The determinants of death with $p<0.05$ were age, gender, history of anemia, history of hypertension, high-risk health status, and history of chronic respiratory disease. The individual level was the most significant contributor to the outcome, accounting for 75,29%.
Conclusion: Knowing the determinants of pilgrim mortality enables health education to be implemented from the first health examination and can also be carried out in collaboration with the Hajj Organizing Agency through the existing KBIH.

Keywords: Hajj mortality, Mass gathering, Multilevel analysis

INTRODUCTION

The Hajj pilgrimage is the fifth pillar of Islam and is obligatory for Muslims who meet the requirements. It involves long journeys and strenuous physical activity in extreme environmental conditions, such as high temperatures and low humidity. (1) The Hajj is also one of the largest mass gatherings in the world, with more than 1.8 million people from various countries participating in 2024, including 221,000 pilgrims from Indonesia. (2) The Hajj is one of the largest religious mass gatherings, attended by approximately 2.5 million people, where a mass gathering is defined as a large number of people (> 1,000) in a specific location for a specific purpose. Travelers participating in mass gatherings face unique risks due to the event's association with environmental hazards, challenging security situations, and increased opportunities for the transmission of infectious diseases, including the entry of participants, crowds, and poor hygiene in food and sanitation facilities.(3)

Indonesia, as the country with the largest Muslim population in the world, consistently sends hundreds of thousands of pilgrims every year. However, based on data from the Indonesian Ministry of Health, the mortality rate of Indonesian pilgrims is still relatively high and fluctuates from year to year. In 2017, there were 658 deaths (2.98‰), which decreased to 386 deaths (1.75‰) in 2018, and then increased again in 2019 to 453 deaths (1.96‰). After two years of the Hajj being suspended due to the COVID-19 pandemic, it resumed in 2022 with age restrictions for pilgrims, resulting in 89 deaths (0.89‰). However, in 2023, the death toll surged to 774 cases (3.38‰). (4) It then slightly decreased to 461 cases (1.91‰) in 2024.(5)

The health condition of Hajj pilgrims is highly vulnerable to illness and death, as the majority of pilgrims are over 60 years old and more than 60% are at high risk due to illness or age. This condition is further exacerbated by the high level of physical activity during the Hajj pilgrimage and the extremely harsh environmental conditions, which are very different from those in their home countries. The period with the highest number of deaths among Hajj pilgrims is during and after the Armina period, accounting for 75% of all deaths. This period marks the peak of the pilgrimage. During this time, the physical condition of pilgrims is already severely fatigued, and forcing them to continue activities poses a significant risk to their lives. The Armina and post-Armina periods are critical periods for the occurrence of pilgrim deaths. (6)

The high mortality rate is thought to be related to various factors. Individual factors such as advanced age, gender, chronic disease status (e.g., hypertension, diabetes, and heart disease), and anemia status also influence pilgrims' vulnerability. From the perspective of the Hajj, departure waves and location of death contribute to mortality patterns. Additionally, the hot and dry environmental conditions in Saudi Arabia, with temperatures reaching 51.8°C during the 2024 Hajj season, also pose a significant risk factor for heatstroke, heat exhaustion, and other related illnesses.(7)

Data shows that most deaths among Indonesian pilgrims are caused by cardiovascular disease and severe infections. For example, in 2023, the leading causes of death were severe sepsis (199 cases), cardiovascular diseases (168 cases), and septic shock (80 cases). The age distribution of pilgrims also shows that 45.1% of pilgrims in 2022 and 58.9% of pilgrims in 2023 were over 50 years old, which is a

group vulnerable to morbidity and mortality(8).

Indonesian pilgrims arrived in Saudi Arabia in two waves. Route 1 landed at Amir Muhammad bin Abdul Aziz Airport in Medina and route 2 landed at King Abdul Aziz International Airport in Jeddah. The mortality rate among pilgrims traveling in the second wave reached its peak earlier during the Hajj period compared to those in the first route. This is likely due to insufficient time to acclimate to the environment, heat, and intense physical activity during the Hajj. The mortality rate from the time of arrival for route 1 and route 2, and for each year, showed that route 2 consistently reached its peak earlier than route 1.(9)

Despite various efforts to improve Hajj health services through the Integrated Hajj Computerization System for Health (Siskohatkes), the mortality rate of pilgrims remains above 1‰. To date, research on the determinants of Hajj pilgrim mortality remains limited and generally only covers certain clinical or demographic factors. Few studies have integrated individual factors, Hajj implementation factors, and environmental factors simultaneously into a comprehensive analytical model.

Therefore, this study aims to analyze the multilevel determinants of death among Indonesian pilgrims in 2022–2024, with the hope of providing a scientific basis for more targeted policy-making and health interventions in the future.

MATERIAL AND METHODS

This study is a quantitative cross-sectional study. The population in this study is all regular pilgrims from provinces on the island of Java who performed the Hajj in 2022-2024 based on data from the Hajj Health Centre of the Indonesian Ministry of Health. The sample is the selected population to be studied. The study sample meeting the inclusion criteria consists of all regular Indonesian Hajj pilgrims from provinces on the island of Java in 2022-2024 who are registered in the Hajj Health Information System (HHIS) of the Indonesian Ministry of Health and have complete data. The minimum sample size was determined using Lemeshow's formula (1997), resulting in a sample size of:

$$n = \frac{Z^2_{1-\frac{\alpha}{2}} P(1-P)}{d^2} = 1.686$$

From 302,844 pilgrims who met the inclusion criteria, stratified random sampling was used to obtain a sample distribution for 2022 of 317 pilgrims, 720 pilgrims for 2023, and 649 pilgrims for 2024. The inclusion criteria for this study are regular pilgrims departing from embarkation points on Java Island who originate from provinces on Java Island and departed during the 2022-2024 Hajj season, with complete sociodemographic data and second health examination data available in the HHIS Shar'i system. The exclusion criteria were pilgrims who departed during the 2022-2024 Hajj season with incomplete data.

The independent variables in this study at the individual level are age, gender, BMI, high-risk status, anaemia, hypertension, diabetes mellitus, coronary heart disease, and chronic respiratory disease. At the level of Hajj pilgrimage implementation, the variables are departure wave and year of departure. At the environmental level, the variables are temperature and humidity. The analysis conducted is a multilevel analysis. Multilevel analysis is a measurement of variability between groups and within groups. Multilevel analysis is a data analysis method that combines the hierarchical structure of

data at the lower level (individual/compositional) with the higher level (environmental/contextual). [10]

RESULTS

Table 1. Association Between Individual Levels and Deaths Of Hajj Pilgrims In 2022-2024

Variables	Died		Life		p-value	POR	95%CI
	f	%	f	%			
Age					0.0000	8.11	3.98-18.16
≥ 60 years	45	7.18	582	92.82			
< 60 years	10	0.94	1049	99.06			
Gender					0.028	1.87	1.04-3.45
Man	35	4.25	788	95.75			
Woman	20	2.32	843	97.68			
Risk Status					0,000	10.28	2.68-87.40
High Risk	53	4.32	1175	95.68			
No High Risk	456	99.56	2	0.44			
BMI					0.680	0.87	0.49-1.56
Normal	26	3.49	719	96.51			
Abnormal	29	3.08	912	96.92			
Anemia					0.029	5.17	0.94-18.49
Yes	3	14.29	18	85.71			
No	52	3.12	1613	96.88			
Hypertension					0.020	2.03	1.10-3.68
Yes	20	5.31	357	94.69			
No	35	2.67	1274	97.33			
DM					0.191	1.6	0.67-3.39
Yes	9	4.84	177	95.16			
No	46	3.07	1454	96.93			
PJK					1.00	0.77	0.01-4.78
Yes	1	2.56	38	97.44			
No	54	3.28	1593	96.72			
Chronic Respiratory Disease					0.032	8.75	0.86-47.37
Yes	2	22.22	7	77.78			
No	53	3.26	1624	96.84			

The individual level variables analyzed in this study were age, gender, Body Mass Index, risk status based on the second health examination, anemia status, hypertension, diabetes mellitus, coronary heart disease, and chronic respiratory disease. In this study, the proportion of women was slightly higher than that of men, at 51.19%. In the results of the second health examination before the departure of Hajj pilgrims, it was found that 1,175 pilgrims (95.68%) had a high-risk status, with hypertension diagnoses outnumbering non-hypertension diagnoses at 77.64%, diabetes mellitus diagnoses were more common than non-diabetes mellitus diagnoses at 88.97%, coronary heart disease diagnoses were more common than non-coronary heart disease diagnoses at 97.69%, and chronic respiratory disease diagnoses were more common than non-chronic

respiratory disease diagnoses at 99.47%. The survival rate of Hajj pilgrims was higher than the mortality rate at 96.74%.

Based on Table 1, it is known that age, gender, high-risk status, anemia, hypertension, and chronic respiratory disease have a significant association with pilgrim mortality (p-value <0.05), with the highest-risk group being high-risk status with a POR of 10.28, chronic respiratory disease with a POR of 8.75, followed by anemia with a POR of 5.17, age with a POR of 8.11, and gender with a POR of 1.87. Meanwhile, the variables BMI and DM are not associated with pilgrim mortality (p-value > 0.05).

Table 2. Association between the level of Hajj implementation and the deaths of Hajj pilgrims in 2022-2024

Variables	Died		Life		p-value	POR	95%CI
	f	%	f	%			
Departure Route					0.059	1.72	0.94-3.24
Route 2	37	4	887	96			
Route 1	18	3.26	744	97.64			
Year of departure					0.741	0.91	0.49-1.63
2022	6	1.89	311	98.10			
2023	29	4.02	691	95.97			
2024	20	3.08	629	96.91			

Based on Table 2, departure route and year of departure have no association with Hajj pilgrim deaths (p-value > 0.05).

Table 3. Association between Environmental Level and Hajj Pilgrim Deaths in 2022-2024

Variables	p-value	Correlation
Temperature	0.0003	0.2471
Humidity	0.0013	-0.2190

Based on Table 3, the temperature with a p-value of 0.0003 (<0.05) indicates that the average temperature of Mecca and Medina from 2022 to 2024 during the Indonesian Hajj operational period has a significant association with the number of Hajj pilgrim deaths. Similarly, the average humidity of Mecca and Medina from 2022 to 2024 during the Indonesian Hajj operational period has a significant association with the number of Hajj pilgrim deaths. The results of the correlation coefficient between temperature and pilgrim deaths indicate a weak and positive association with a value of r = 0.2471. The results of the correlation coefficient between humidity and pilgrim deaths indicate a weak and negative association with a value of r = -0.2190.

Table 4. Total Variance Proportion Value (Variance Partition Coefficient) at each Level

Level	Variance	VPC
Individual level (Level 1)	$\pi^2/3 = 3.29$	75.29%
Hajj Implementation Level (Level 2)	0.31	7.09%
Environmental Level (Level 3)	0.77	17.62%

The individual level is the most influential level on the outcome, contributing 75.29% of the total variance. This indicates that variations in the outcome are largely caused by differences between individuals. The environmental level also has an influence on the outcome (17.62%), indicating that variations in the environmental level explain the total variance in the outcome, and the level of Hajj performance contributes 7.09% to the variance in the outcome.

Table 5. Strength of the Association between Variables at Each Level and the Death of Hajj Pilgrims (Final Multilevel Model Analysis)

Independent Variables	Coefficient (β)	OR	95%CI	P-value
Intercept	3,4011			
Age	1,827	4.98	1,108-2,547	0,000
Anemia	1,454	2.11	0.105-2.802	0.035
Chronic Respiratory Disease	1,976	2.25	0.252-3.701	0.025
High Risk Status	1,669	2.27	0.230-3.109	0.023

The results of the multilevel generalized linear model analysis show that the strength of the association between each variable at the individual level can be seen in age, which indicates that as a person gets older, the risk of death during the Hajj also increases, with an OR value of 4.98 times the risk of death during the Hajj. Similarly, pilgrims suffering from anemia and chronic respiratory diseases during the second health check-up before the Hajj departure are at risk of death during the Hajj, with an OR value of 2.11 times and 2.25 times, respectively. High-risk status also indicates that pilgrims with high risk before the Hajj departure have an OR of 2.27 times for death during the Hajj pilgrimage.

Variables at the environmental level, when combined with individual variables in multilevel analysis, showed that average daily temperature in Mecca and Medina and average daily humidity in Mecca and Medina were not associated with pilgrim deaths during the operational period of Indonesian pilgrims in 2022–2024.

DISCUSSION

The statistical test results of this study found a association between age and the mortality of Indonesian Hajj pilgrims. The study revealed that as age increases, the risk of mortality among Indonesian Hajj pilgrims also increases. Specifically, Hajj pilgrims aged 60 years or older have an 8.11 times higher likelihood of death compared to those under 60 years of age. This finding aligns with the results of Sakanti's 2024 study, which also identified a correlation between age and mortality among Hajj pilgrims in 2023 from the Jakarta embarkation point. Pilgrims aged over 60 had a 1.55 times higher risk of experiencing illness and death compared to those under 60, as reported by Anggiasih Sakanti. (11) This is in line with Rahman, MA's 2024 study, which states that age affects the mortality rate of pilgrims due to cardiovascular disease, with pilgrims aged 60 years and older having a 6.314 times higher risk of cardiovascular death compared to pilgrims under 60 years of age. (12) This is in line with the statement from the Indonesian Ministry of Health that pilgrims over the age of 60 are considered high-risk pilgrims, regardless of whether they have a medical condition or not. (13) However, these results are inconsistent with the findings of a study conducted by Liani PS, et al in 2020, which stated that there was no association between age and death caused by respiratory diseases among Hajj pilgrims ($p>0.05$).(14)

The statistical test results of this study found a association between gender and pilgrim mortality. This study found that men are at a higher risk of death compared to women, with male pilgrims having a 1.87 times higher likelihood of dying than female pilgrims. The results of this study differ from most previous studies, such as the 2020 study by Liani PS et al., which stated that there is no association between gender and deaths caused by respiratory diseases among pilgrims ($p > 0.05$). (14)

The statistical test results of this study found a association between anemia status and pilgrim mortality, with the probability of

pilgrim mortality being 5.17 times higher in those with anemia than in those without anemia, but the 95% interval exceeded 1 (0.94–18.49), so the effect cannot be considered consistent. This aligns with Sakanti's 2024 study, which found that Hajj pilgrims with a history of anemia had a 1.93 times higher risk of experiencing illness or death compared to those without a history of anemia before the Hajj journey. (11) Anemia is associated with increased morbidity and mortality in the elderly, as it can be an early symptom of undiagnosed malignant diseases. Anemia often does not show symptoms and is detected through laboratory examinations. (15)

The statistical analysis in this study revealed a significant association between hypertension status at the second health examination and mortality among Hajj pilgrims, with pilgrims who had a history of hypertension having a twofold higher risk of death compared to those without hypertension. This finding aligns with Rahman, MA's 2024 study, which reported that pilgrims diagnosed with hypertension at the third health examination at the embarkation point had a 1.472-fold higher risk of death compared to those without hypertension. Additionally, Ardiana et al.'s 2017–2019 study found that pilgrims with hypertension at the embarkation point had a 1.472-fold higher risk of death compared to those without hypertension. -3 at the embarkation point had a 1.472 times higher likelihood of dying compared to pilgrims without hypertension, and Ardiana et al.'s 2017-2019 study, which found that mortality among 0.29% of Indonesian Hajj pilgrims in 2017-2019 with a history of hypertension. (12,16)

The statistical test results in this study showed ($p>0.05$), indicating no association between diabetes mellitus status at the second health examination and mortality among Hajj pilgrims. This finding is inconsistent with previous studies that reported that pilgrims diagnosed with type I or type II diabetes mellitus prior to traveling to the holy land had a higher risk of dying from cardiovascular disease, with a value of 2.001 times higher compared to pilgrims without a history of diabetes mellitus. The results of the study conducted by Ardiana et al. using multivariate analysis on the diabetes variable consistently and significantly increased the risk of hospitalization and mortality among Indonesian pilgrims in 2017-2019. (12,16)

The Hajj pilgrimage presents unique challenges for pilgrims with diabetes. During the Hajj, pilgrims are faced with physically demanding religious rituals, changes in eating patterns and habits—including meal schedules, suboptimal hydration, and high temperatures—which can affect physiology, insulin absorption, and storage. Poor adherence to treatment while preoccupied with Hajj rituals, as well as a lack of knowledge about self-management of diabetes in general and during the Hajj in particular, are also common. Although the rates of hospitalization and death due to complications directly related to diabetes are lower compared to other causes; these rates continue to rise, and people with diabetes constitute a significant proportion of Hajj pilgrims hospitalized in hospitals. (17)

The statistical test results in this study showed $p>0.05$, indicating no correlation between coronary heart disease status in the second health examination and the mortality of Hajj pilgrims. The statistical test results in this study showed $p >0.05$, indicating no association between chronic respiratory disease status at the second health checkup and mortality among Hajj pilgrims.

The statistical test results of this study found no correlation between departure waves and pilgrim mortality. The mortality rate among pilgrims traveling in the second wave reached its peak earlier during the Hajj period compared to those traveling in the first wave. This is likely due to insufficient time to acclimate to the surrounding environment, heat, and intense physical activity during the Hajj. The mortality risk per 100,000 pilgrims per hour throughout the day for the year 2004 and all other years. Mortality rates from the time of arrival for waves 1 and 2 and for each year show that wave 2 consistently reached its peak earlier than wave 1. This highlights the need for more health interventions for wave 2 upon their arrival. This could include pre-departure health education and physical preparation. (9)

The statistical test results of this study found no correlation between the year of departure and the mortality rate of Indonesian Hajj pilgrims. From 2022 to 2024, the mortality rate of Indonesian Hajj pilgrims fluctuated. In 2022, there were 89 deaths (0.89‰), and in 2023, the mortality rate increased to 774 cases (3.38‰).(4) Then it decreased slightly to 461 cases (1.91‰) in 2024. (5)

The results of the Spearman correlation test in this study found that the average daily temperature and average daily humidity on the operational days of the Hajj pilgrimage are related to the deaths of pilgrims. This aligns with research stating that temperature is a risk factor for heatstroke, which can lead to death. In Yezli et al, 2024, a study on health risks among Hajj pilgrims, it was noted that from 1980 to 2019, the average temperature in Mecca increased by 0.4°C and 0.2°C per decade, respectively. Both temperatures are strongly correlated with the occurrence of heatstroke and heat exhaustion ($P<0.0001$). During the Hajj, average temperatures are higher during the hot cycle compared to the cold cycle, a trend reflecting global warming patterns due to climate change, which exacerbates the risk of heat-related illnesses and deaths among already vulnerable pilgrims. According to Yezli et al, 2023, the average daily temperature during the Hajj season from 2006 to 2014 was 30°C (19°C–37°C). There were 8,543 and 10,457 non-accidental deaths reported during the study period among the residents of Mecca and pilgrims. Heat-related deaths among Hajj pilgrims were 4.5 times higher than among the population of Mecca. As temperatures continue to rise and predictions indicate further deterioration, it becomes increasingly important to understand the combined effects of rising temperatures on the health of vulnerable Hajj pilgrims. (18)

During the summer, high temperatures are associated with heat-related illnesses, which can range from mild (e.g., heat cramps, edema, heat rash, and fainting) to very serious (e.g., heat exhaustion and heat stroke). Many factors play a role in the outcome of heat-related illnesses, including advanced age, chronic illness, population density, excessive physical activity, lack of acclimatization, and dehydration. Without proper treatment, patients may experience organ failure, seizures, coma, and increased intracranial pressure. (19)

CONCLUSION

There are differences in the roles of each level, namely the individual and environmental levels, in the mortality of Hajj pilgrims during the Hajj season. The individual level contributes the most to the outcome, accounting for 75.29%. The environmental level contributes 17.62% to the outcome, and the Hajj operational level contributes 7.09% of the total variance. The

most dominant level in increasing Hajj pilgrim mortality is the individual level, with significant associated factors including age, anemia, high-risk status, and chronic respiratory diseases. The environmental level variables included in the multilevel modeling analysis did not show a statistically significant association. Therefore, health interventions are needed to enhance knowledge, enabling pilgrims to adopt healthy and balanced lifestyles from the initial health examination onwards, integrated with activities at the Hajj Health Center (KBIH), particularly for high-risk pilgrims. Additionally, strategies for adapting to extreme climatic conditions are crucial for reducing pilgrim mortality rates.

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