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Post-hajj acute respiratory infections: Proportion and associated factors pilgrims from an Indonesian hajj guidance group

Ninda Devita,*[1] Farida Juliantina Rachmawaty,[1] Eko Andriyanto,[1] Afivudien Muhammad[1]

[1]Department of Medicine, Faculty of Medicine, Universitas Islam Indonesia, Yogyakarta, Indonesia

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***Corresponding author:**
167110410@uii.ac.id

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Original Article

ABSTRACT

Background: The Hajj pilgrimage is the largest mass gathering, posing a high risk of acute respiratory infection (ARI) transmission. Post-Hajj ARI represents a major public health concern, as returning pilgrims may serve as carriers and potentially transmit pathogens to their home communities. Identifying the proportion and risk factors of post-Hajj ARI is essential for developing effective preventive strategies.
Objectives: This study aimed to determine the proportion of post-Hajj ARI and associated risk factors among pilgrims from KBIHU (Indonesian hajj and umrah guidance group) Multazam Ad-Dakwah Yogyakarta 2025.
Methods: This cross-sectional study used an online questionnaire. Respondents were pilgrims from KBIHU Multazam Ad-Dakwah Yogyakarta who experienced ARI symptoms after the 2025 Hajj. Sociodemographic characteristics, vaccination history, preventive behaviors, and metabolic risk factors were collected. Data were analyzed using multivariate logistic regression. Odd ratios with 95% CIs were calculated. P-values <0.05 were considered statistically significant.
Result: In total, 112 pilgrims were included. Of these, 20.5% were aged 60 years or older. More than half (57.1%) reported comorbidities, mainly hypertension and dyslipidemia. Most participants were non-smokers (82.1%). They reported moderate adherence to preventive behaviors, including mask use (54.5%) and hand hygiene (56.3%). Meningococcal vaccination coverage was universal. Coverage for influenza (75.0%), COVID-19 (46.4%), and pneumococcal vaccination (6.3%) was lower. Overall, 100 pilgrims (89.3%) experienced ARI symptoms. Bivariate analysis showed that age over 60 years was significantly associated with ARI (cOR 4.697; 95%CI: 1.206–18.295; p=0.026). Multivariate logistic regression confirmed that older age was the only significant determinant of ARI (aOR 4.88; 95% CI: 1.22–19.53; p=0.02).
Conclusion: Age 60 or over is a significant risk factor for post-Hajj ARI. Focused preventive strategies targeting elderly pilgrims are essential to reduce ARI-related morbidity and mortality after the Hajj.

INTRODUCTION

Hajj is among the most significant annual religious pilgrimages, bringing together millions of worshippers within a confined space and timeframe. According to official data from the Saudi Arabian government, approximately 1,673,230 pilgrims participated in the 2025 Hajj.[1] A combination of environmental factors, population density, and physical exhaustion contributes to the heightened risk of acute respiratory infections (ARI) during this period.[2] Observational studies have reported ARI attack rates among pilgrims ranging from 8% - 80%, depending on the study design and case definitions used.[3]

Beyond environmental factors, a variety of demographic and behavioral risk factors contribute to ARI susceptibility. Advanced age and pre-existing comorbidities such as diabetes have been consistently identified as major predictors.[4] Study shows a correlation link between

metabolic syndrome and respiratory health, indicating that individuals with metabolic syndrome are at higher risk of developing respiratory infections.[3] A cohort study further identified obesity as an independent risk factor, with obese pilgrims having over four times the risk of ARI compared to non-obese counterparts.[5]

Behavioral determinants also play a crucial role in influencing ARI occurrence. Pilgrims with greater awareness of hygiene practices are more likely to wash their hands regularly, a behavior shown to substantially lower the incidence of ARI.[5] Preventive practices such as mask use and hand hygiene are therefore recommended to reduce ARI transmission, although compliance among pilgrims remains highly variable.[6] In contrast, close physical contact with fellow pilgrims, irregular use of alcohol-based hand sanitizers, inconsistent mask-wearing, and smoking are strongly linked to an increased risk of infection. Evidence indicates that failure to use alcohol-based hand disinfectants is associated with an adjusted odds ratio (aOR) exceeding 8, while frequent close contact raises the risk with an aOR of approximately 13.[7]

Vaccination is another cornerstone of prevention. To secure a Hajj visa, the Saudi Arabian government strictly mandates the meningococcal vaccine for all international pilgrims. In the Indonesian context for the 2025 (1446 H) season, the Ministry of Health has integrated this requirement into the national Hajj health system, providing it alongside COVID-19 and Poliomyelitis immunizations at designated public health facilities. COVID-19 vaccinations are specifically for high-risk groups, including pilgrims over 65 years old and those with chronic comorbidities (e.g., respiratory, cardiac, or renal diseases).[8] In contrast, vaccines targeting other major respiratory pathogens, such as influenza and pneumococcal vaccines, remain highly recommended but are not mandatory.[9] The protective effect of these non-mandatory vaccines in mass-gathering contexts like the Hajj remains a subject of discussion. While some studies demonstrate a decline in ARI among vaccinated pilgrims, other investigations have found no statistically significant benefit.[10–12]

ARI can occur both during and after the pilgrimage. Post-Hajj ARI poses a major public health concern, as returning pilgrims may act as carriers and subsequently transmit pathogens to their home communities.[13] For instance, in France, more than 80% of pilgrims reported at least one respiratory symptom after returning from Hajj.[14] Similarly, Indonesian pilgrims revealed a high burden of ARI, with one study reporting that 71.8% of participants experienced respiratory symptoms post-Hajj.[12]

In Indonesia, data on post-Hajj ARI remain limited. Most available studies focus on clinical presentations or the overall prevalence of ARI during the pilgrimage.[4] Routine records from the Indonesian Hajj Health Clinic (*Klinik Kesehatan Haji Indonesia*, KKHI) capture ARI cases annually; however, risk factors specific to post-Hajj ARI have not been systematically investigated. Given the substantial burden and public health implications of ARI among returning pilgrims, a clearer understanding of its magnitude and determinants is needed. Therefore, this study aimed to estimate the prevalence of post-Hajj ARI and to identify its associated risk factors among Indonesian pilgrims. Such evidence is essential to inform targeted preventive strategies and to strengthen health preparedness before and after the pilgrimage.

METHODS

Study design

This was an observational, cross-sectional study. The study was conducted among pilgrims from the Hajj and Umrah Guidance Group (*Kelompok Bimbingan Ibadah Haji dan Umrah*, KBIHU*)* Multazam Ad-Dakwah who performed the Hajj in 2025. Data collection was carried out in July 2025 using a structured online questionnaire. The independent variables included sociodemographic characteristics, vaccination history, preventive behaviors, and comorbidities. The dependent variable was the occurrence of post-Hajj ARI.

Population and sample

The study involved pilgrims affiliated with KBIHU Multazam Ad-Dakwah, Yogyakarta, Indonesia, who had returned from the 2025 Hajj. Inclusion criteria were pilgrims who: completed

the 2025 Hajj pilgrimage, returned to Indonesia within the study period, were aged > 18 years, experienced ARI within 21 days after returning to Indonesia, defined as fever (or history of fever) accompanied by at least one respiratory symptom (cough, sore throat, or runny nose).[15] Exclusion criteria were incomplete questionnaire responses or refusal to participate.

The minimum sample size was determined using an exploratory estimation approach, with a target of at least 30 respondents who met the inclusion criteria to allow for a preliminary descriptive analysis. A consecutive sampling technique was applied, recruiting all eligible participants until the minimum sample size was reached.

Data collection

Data were collected using a self-administered online questionnaire developed with Google Forms and distributed via the official WhatsApp group of KBIHU Multazam Ad-Dakwah pilgrims. The questionnaire assessed several independent variables, including sociodemographic characteristics, comorbidities, vaccination status, and preventive behaviors. Sociodemographic variables comprised age, sex, education level, and smoking status. Age was recorded in years and categorized into 18–30, 31–60, and >60 years. Sex was classified as male or female. Education level was defined as the highest formal education completed and categorized into junior high school, senior high school, and university degree. Smoking status was classified as non-smoker, current smoker, or past smoker based on self-report. We use room occupancy density during the Hajj pilgrimage in both Makkah and Madinah as an indicator of physical proximity. We categorize pilgrims into two groups: those who share a room with more than four people during their stay in Makkah or Madinah (crowded) and those who do not (non-crowded).

Comorbidities were assessed based on self-reported physician-diagnosed conditions, including hypertension, diabetes mellitus, and dyslipidemia. Dyslipidemia was operationally defined as a history of "high cholesterol or lipid disorder diagnosed by a healthcare professional," and this explanation was provided in the questionnaire to improve participant comprehension. Subjects were categorized as having comorbidities if they reported at least one of these conditions. This study did not assess disease control (controlled vs. uncontrolled conditions), as the primary objective was to identify the presence of comorbidities as potential risk factors. Obesity was also assessed using body mass index (BMI), calculated as weight in kilograms divided by height in meters squared (kg/m^2). Body weight and height were measured prior to departure for Hajj as part of a routine health assessment. Participants were classified as obese according to the World Health Organization Asia-Pacific criteria (BMI ≥25 kg/m^2).[16]

Vaccination status was determined based on self-reported receipt of vaccines prior to Hajj, including meningococcal, influenza, COVID-19, and pneumococcal vaccines, and recorded as yes or no for each vaccine. Preventive behaviors included mask use, hand hygiene, and physical distancing. Mask use was defined as the frequency of mask wearing during daily activities and categorized as irregular or consistent. Hand hygiene was defined as the habitual practice of washing hands with soap and water or using hand sanitizer and categorized as irregular or consistent. The dependent variable, ARI, was defined as the presence of fever (or a history of fever) and at least one respiratory symptom (cough, sore throat, or runny nose) within 21 days of returning from the Hajj.

Data analysis

Data were analyzed using SPSS version 21 (IBM Corp., Armonk, NY, USA). All categorical variables were summarized and presented as frequencies and percentages, whereas continuous variables were described using means and standard deviations. An initial bivariate analysis was conducted using simple logistic regression to assess the association between each independent variable and ARI. Variables with p-values <0.25 in the bivariate analysis were selected as candidates for inclusion in the multivariate logistic regression model, even if they were not statistically significant at the conventional level (p<0.05), to avoid excluding potential confounders. Multivariate logistic regression analysis was then performed to control for potential confounding factors and to determine which variables independently and most strongly

influenced the occurrence of ARI. The results were expressed as adjusted odds ratios (aORs) with corresponding 95% confidence intervals (CIs). A *p*-value <0.05 was considered statistically significant.

Ethical statement

This study was reviewed and approved by the Health Research Ethics Committee, Faculty of Medicine, Universitas Islam Indonesia, under approval number 14/Ka.Kom.Et/70/KE/VII/2025.

RESULTS

Characteristic demographic of the subject

A total of 112 pilgrims were subjects of this study. The gender distribution was nearly similar, with 51.8% females and 48.2% males. The majority of participants were within the 31–60 years age group (75.9%), while 20.5% subjects were older than 60 years. Regarding educational background, most respondents held a university degree (74.1%) (Table 1).

More than half of the participants reported pre-existing comorbidities, with hypertension (37.5%) being the most common, followed by dyslipidemia (18.8%), diabetes (13.4%), and obesity (8.9%). Regarding smoking status, the vast majority of participants were non-smokers (82.1%), while only a small fraction were current smokers. Vaccination coverage demonstrated full compliance for the mandatory meningococcal vaccine (100%). However, uptake of other vaccines was suboptimal: only 46.4% of participants received the COVID-19 vaccine, and 6.3% received the pneumococcal vaccine, while influenza vaccination coverage was relatively higher (75.0%) but still left one-quarter of participants unprotected. In terms of preventive behaviors, only about half of the respondents in our study reported consistent adherence to mask use (54.5%) and hand hygiene (56.3%) (Table 1).

Table 1. Characteristic Demographic of Subject (n=112)

Characteristics	n (%)
Gender	
Female	58 (51.80)
Male	54 (48.20)
Age (years)	
18-30	4 (3.60)
31-60	85 (75.90)
>60	23 (20.50)
Education	
Junior high school certificate	4 (3.60)
Senior high school certificate	25 (22.30)
University degree	87 (74.10)
Pre-existing comorbidities	
Diabetes	15 (13.40)
Hypertension	42 (37.50)
Dyslipidemia	21 (18.75)
Obesity	10 (8.92)
Smoking status	
Non-smoker	92 (82.14)
Current smoker	3 (2.67)
Past smoker	18 (16.07)
Meningitis vaccine	112 (100)
Influenza vaccine	82 (73.20)
COVID-19 vaccine	52 (46.43)
Pneumococcus vaccine	8 (7.10)

Characteristics	n (%)
Consistent Mask use practice	61 (54.50)
Consistent Hand hygiene practice	63 (56.30)
Room Occupancy Density (>4 persons/ room)	
Non-crowded	30 (26.78)
Crowded	82 (73.22)

Following descriptive analysis, association testing was conducted using logistic regression to identify factors associated with post-Hajj ARI pilgrims. The analysis revealed that older age (>60 years) was the only variable significantly associated with post-Hajj ARI (p = 0.03). Subsequently, multivariate logistic regression was performed, including variables with $p < 0.25$ in the bivariate analysis: age and pneumococcal vaccination status. In the multivariate model, age remained the only variable independently associated with post-Hajj ARI, with an adjusted odds ratio (aOR) of 4.88 (95% CI: 1.22–19.53) and a statistically significant p value of 0.02 (Table 2).

Table 2. Associations of risk factors with post hajj acute respiratory infection (N=112)

Variable	Risk Factor	n (%)	cOR (95%CI)	*p* value	aOR (95%CI)	Adjusted *p* value
Gender	Female (ref)	58 (51.8)	1.00	-		
	Male	54 (48.2)	1.39 (0.45-4.28)	0.56		
Age (years)	18-60 (ref)	89 (79.5)	1.00	-		
	>60 y.o	23 (20.5)	4.69 (1.21-18.29)	**0.03***	4.88 (1.22-19.53)	**0.02***
Education	Non-university (ref)	29 (25.9)	1.00	-		
	University degree		0.81(0.31-2.15)	0.67		
Pre-existing comorbidities	No (ref)	48 (42.9)	1.00	-		
	Yes	64 (57.1)	1.14(0.431-3.09)	0.78		
Smoking status	Non-smoker (ref)	92 (82.1)	1.00	-		
	Current smoker	21 (18.8)	1.38 (0.36-5.22)	0.64		
Influenza vaccine	No	28 (25.0)	1.12 (0.29-2.71)	0.84		
	Yes (ref)	84 (75.0)	1.00	-		
COVID-19 vaccine	No	60 (53.6)	1.45 (0.07-1.49)	0.45		
	Yes (ref)	52 (46.4)	1.00	-		
Pneumococcus vaccine	No	105 (93.8)	3.01 (0.67-14.07)	0.15	3.18 (0.67-15.13)	0.14
	Yes (ref)	7 (6.3)	1.00	-		
Mask use	Consistent (ref)	61 (54.5)	1.00	-		
	Irreguler		1.03 (0.39-2.71)	0.98		
Hand hygiene	Consistent (ref)	63 (56.3)	1.00	-		
	Irreguler	49 (43.8)	1.26 (0.47-3.71)	0.64		
Room Occupancy Density	Non-crowded (ref)	30 (26.78)	1.00	-		
	Crowded	82 (73.22)	1.61 (0.35-2.34)	0.36		

*A p-value < 0.05 was considered statistically significant. All analyses were performed using logistic regression.

DISCUSSION

The majority of pilgrims in this study were within the productive age (31–60 years), while 23% were elderly (>60 years). This proportion is similar to that reported in previous studies of Indonesian Hajj pilgrims.[17] The relatively high proportion of older pilgrims urges attention, as the elderly are a well-recognized risk factor for increased susceptibility to respiratory infections and related complications.[3,18] Interestingly, although older pilgrims may be more aware of their vulnerability, the practical application of preventive behaviors was observed in only half of the participants. This discrepancy suggests that physical exhaustion and the demanding nature of Hajj rituals may hinder consistent hygiene practices, regardless of awareness.

The significant association between older age (>60 years) and ARI occurrence aligns with previous studies highlighting the vulnerability of elderly pilgrims. Older age substantially

increases susceptibility to respiratory infections and age-related physiological decline, exacerbating respiratory morbidity and mortality due to immune system degeneration and structural changes in the lungs.[3,19] Immunologically, cellular aging and the microenvironment inhibit both the innate and adaptive immune systems. The innate immune system decreased phagocytosis, antigen uptake, and bactericidal activity. Meanwhile, the adaptive immune system shows decreased T-cell proliferative capacity and impaired B-cell function, leading to reduced antibody production after infection.

Structural changes in the respiratory system also exacerbate this risk. Aging causes loss of lung elasticity. Lung expansion is reduced due to weakened respiratory muscles and calcification of the chest cavity. Changes in mucociliary clearance impair mucosal clearance.[20] While these structural changes may not directly cause clinical disease in healthy elderly individuals, their impact becomes significant when individuals are exposed to external stressors such as lower respiratory tract infections during the Hajj pilgrimage. Thus, elderly pilgrims remain a high-priority group for targeted interventions.

Comorbidities also increase ARI susceptibility and severity in a multifaceted manner. In pilgrims with diabetes, chronic hyperglycemia impairs leucocyte function and reduces the host's ability to clear pathogens. This metabolic derangement is often accompanied by vascular insufficiency and neuropathy, which further compromise mucosal barriers against respiratory viruses and bacteria.[21] Furthermore, cardiovascular risk factors such as hypertension and dyslipidemia, core components of metabolic syndrome, are associated with a chronic low-grade inflammatory state and endothelial dysfunction. Hypertension may promote immune dysregulation or facilitate infection through pre-existing endothelial damage.[22] Metabolic syndrome is instrumental in predisposing patients to more severe outcomes, such as acute respiratory distress syndrome (ARDS), due to its systemic pro-inflammatory environment.[23]

In our study, hypertension, diabetes, dyslipidemia, and obesity were not significantly associated with RTI. A prospective study among Marseille pilgrims had reported that diabetes was correlated with an increased risk of febrile cough.[24] Earlier studies also highlighted the high burden of metabolic and cardiovascular conditions among Hajj pilgrims, which may contribute to increased susceptibility to acute respiratory infections.[3] This lack of significance may be influenced by the mandatory pre-departure health screenings in Indonesia, which ensure that pilgrims with chronic conditions are in a stable 'fit to travel' state.

However, it is important to note that this study did not assess medication adherence or the clinical control of these comorbidities during the Hajj period**.** The absence of a significant association might be confounded by the unknown extent to which these conditions were managed on-site. One study reported that the Hajj *Posbindu* (integrated post-coaching) was not optimally functional in managing pilgrims' health problems; the lack of real-time monitoring remains a challenge.[25] Those comorbidities need to be strictly controlled not only before departure but throughout the entire Hajj journey, which is essential to reduce the physiological vulnerability of pilgrims to respiratory infections.

Regarding smoking status, the vast majority of participants were non-smokers. This is encouraging, as smoking has been shown to compromise respiratory immunity and exacerbate infection severity.[7,26] The low rate of active smoking in this population may partly mitigate the risk of respiratory complications, though the presence of past smokers (16.1%) still indicates potential underlying health vulnerabilities.

Education level is a fundamental determinant of health literacy, which can influence a pilgrim to adopt preventive measures. In this study, the relationship between education and ARI incidence was $p = 0.67$, which is in line with Samarkandi et al., who observed 36.6% still exhibited high-risk behaviors, although the mean risk-taking behavior was 3.24±1.05. They found a strong association between risk behavior and educational level, suggesting that those with lower levels of education may be more prone to neglecting health protocols.[27]

However, higher education or knowledge does not always translate into safer practices during the Hajj. This knowledge-practice gap is highlighted by Mahdi et al., who showed no significant association between the level of hand hygiene knowledge and factors such as

education, age, or employment status.[28] This implies that even well-educated pilgrims may possess adequate knowledge but fail to implement it consistently due to the logistical challenges of the pilgrimage.

The impact of this behavioral gap is evident in clinical outcomes. Samarkandi et al. reported that 51.7% of pilgrims did not take their prescribed medications and 59.9% failed to seek urgent care even when experiencing severe symptoms.[27] This neglect of medical advice, which may be more prevalent among certain educational groups, increases the physiological vulnerability of the pilgrim. In the context of our study, this suggests that while education may improve awareness, the extreme environmental stressors and the demanding ritual schedule of the Hajj often override educational advantages, leading to suboptimal self-care and increased ARI risk.

In our study, vaccination coverage demonstrated full compliance for the mandatory meningococcal vaccine (100%). However, uptake of other vaccines was suboptimal. These findings are consistent with a systematic review reporting that, despite recommendations, Hajj pilgrims remain at increased risk of ARI, with vaccination uptake highly variable across populations. Influenza vaccine coverage ranged widely (0.7–100%) across studies, with higher uptake typically among elderly pilgrims and those with pre-existing comorbidities. In contrast, uptake of non-influenza vaccines, such as pneumococcal and diphtheria vaccines, was generally low, echoing our findings, in which pneumococcal vaccination was reported in only a small minority of participants.[10]

The absence of a statistically significant protective effect from influenza (p=0.84) and COVID-19 (p = 0.45) vaccinations in this cohort should be interpreted with caution and does not negate the established clinical benefits of these vaccines. A systematic review showing reduced risk of laboratory-confirmed influenza among Hajj pilgrims.[14,29] Other studies have also shown that pneumococcal and influenza vaccination is associated with reduced acquisition of *S. pneumoniae*.[14] However, prospective data from a study among Indonesian pilgrims in West Java similarly reported no significant association between influenza vaccination and ARI incidence.[12,24] These inconsistencies are likely attributable not to a lack of vaccine importance but to contextual factors specific to the Hajj. Such factors include potential strain mismatch, the phenomenon of 'environmental saturation' in which high viral loads may overwhelm vaccine-induced immunity in densely populated settings, and the timing of vaccination relative to departure. Additionally, reliance on clinical ARI symptoms as an endpoint, rather than laboratory-confirmed cases, may obscure the vaccine's effectiveness in preventing severe disease. Vaccination remains a critical public health strategy for Hajj pilgrims; however, achieving optimal impact necessitates broader coverage and targeted interventions for high-risk groups to address the intense transmission environment. Similarly, pneumococcal vaccine uptake has historically been low among pilgrims, despite evidence of potential benefit. The low coverage rate (6.3%) observed in this study likely limited the ability to detect meaningful associations.

Regarding preventive behaviours, this study found no significant association between mask-wearing (p=0.98), hand hygiene (p=0.64), or room occupancy density (p=0.363) and the incidence of ARIs. These results may be explained by the overwhelming exposure during peak rituals. Benkouiten et al. demonstrated an 8-fold increase in respiratory virus prevalence (from 4.8% to 38.6%) immediately after pilgrims performed their first Tawaf in Mecca, suggesting that the most significant transmission occurs during these core rituals where physical distancing is impossible.[30]

The lack of significance for hand hygiene in our study aligns with Mahdi et al., who identified several structural and religious barriers to compliance. During the pilgrimage, rituals often leave pilgrims "too busy" or likely to forget hygiene practices. Furthermore, the rules of *Ihram*, which prohibit the use of scented soaps and perfumes, and the religious preference to avoid alcohol-based products can significantly limit the use of standard hand sanitizers. Mahdi et al. also noted that limited access to washrooms and intense crowding further exacerbate these challenges.[28] While another study previously reported that non-use of alcohol-based disinfectants could carry an 8-fold risk of ARI (aOR 8.4), such high-level protection may be difficult to achieve in practice due to the aforementioned barriers.[7]

Similarly, our finding that mask-wearing was not protective (p=0.98) is consistent with Al-Felali et al. that showed a facemask did not significantly protect against laboratory-confirmed viral infections (OR 1.4, p=0.18). This may be due to intermittent use or mask contamination. As masks become wet from sweat or breath in the intense heat, they may become more porous or allow the passage of viruses when handled, potentially even increasing transmission risk.[31] Consequently, in the unique environment of the 2025 Hajj, individual behavioral variations appear to be overshadowed by the sheer intensity of environmental exposure and the practical difficulties of maintaining consistent hygiene during rituals.

Overall, our findings reinforce the critical role of age as a non-modifiable risk factor, while emphasizing the need to strengthen vaccine coverage and ensure effective behavioral interventions. Improving pre-Hajj health education, particularly regarding correct mask use and hand hygiene, and ensuring broader uptake of influenza, pneumococcal, and COVID-19 vaccines may substantially reduce the burden of ARIs among Indonesian pilgrims.

Although this study offers important insights, several limitations should be acknowledged. First, the cross-sectional design precludes establishing causal relationships between risk factors and ARI occurrence. Second, reliance on self-reported questionnaires may have introduced recall or social desirability bias, particularly regarding preventive behaviors such as mask use and hand hygiene. Third, the relatively small sample size and low uptake of certain vaccines, such as pneumococcal, may have reduced the statistical power to detect significant associations. Fourth, clinical control of comorbidities was not assessed. While participants reported conditions such as diabetes and hypertension, medication adherence and objective clinical markers, including blood glucose and blood pressure levels, were not evaluated during the Hajj period. As a result, the relationship between the stability of these chronic diseases and ARI risk could not be fully determined. Fifth, several potential confounding factors were not captured in this analysis. Smoking habits were assessed in general terms, but the use of electronic cigarettes or vapes was not specifically recorded, which may influence respiratory health outcomes differently from traditional tobacco. Additionally, socioeconomic factors such as income levels were not collected; these data could have provided further insights into the accessibility of elective vaccinations and high-quality personal protective equipment among pilgrims. Finally, clinical confirmation of ARI was not performed; diagnoses were based solely on self-reported symptoms, which may have led to misclassification.

Future studies with a larger, multicenter, prospective cohort design are needed to enhance statistical power and generalizability. To improve upon the current study, a mixed-methods approach is recommended, incorporating multiplex PCR-based nasopharyngeal swabs to differentiate between viral and bacterial pathogens, moving beyond clinical symptom-based definitions; implementing mobile-health (mHealth) applications for daily symptom logging and medication adherence tracking to minimize recall bias during the physically demanding Hajj rituals; assessing pilgrims at three time points (pre-departure, during the peak of rituals in Mecca/Mina, and post-arrival) to capture the full incubation and transmission cycle; and incorporating objective measures of physical proximity and air quality in shared accommodations and public transport to quantify the impact of environmental density more precisely. Such a design would enable a more granular understanding of the complex interplay among host vulnerability, behavioral consistency, and extreme environmental exposure.

CONCLUSION

This study found a high prevalence of ARI among Indonesian pilgrims returning from the 2025 Hajj, with the elderly (>60 years) emerging as a significant risk factor. These findings highlight the urgent need to strengthen preventive strategies for Hajj pilgrims, particularly through expanding vaccination coverage beyond meningitis, enhancing pre-Hajj health education, and promoting consistent adherence to evidence-based preventive measures. Special attention should be given to elderly pilgrims, who are most vulnerable to respiratory infections during the mass gathering of Hajj.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this manuscript.

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AUTHOR CONTRIBUTIONS

ND was responsible for data processing, data analysis, and drafting the manuscript. FJR contributed to the preparation and critical revision of the manuscript. EAY assisted in data collection and supported the research process. AM was involved in data collection. All authors read and approved the final version of the manuscript.

DECLARATION OF USING AI IN THE WRITING PROCESS

In the preparation of this manuscript, the authors used artificial intelligence–assisted tools to support language editing and improve clarity and readability of the text. The authors reviewed, edited, and approved all content, and take full responsibility for the accuracy, integrity, and originality of the manuscript.

LIST OF ABBREVIATIONS

ARI: Acute Respiratory Infection; KBIHU: Kelompok Bimbingan Ibadah Haji dan Umrah; BMI: Body Mass Index

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