ORIGINAL ARTICLE

Distribution of Metabolic Diseases and Demographic Characteristics of Pilgrims in 2024 Hajj: A Descriptive Cross-sectional Study from the Ministry of Health in Saudi Arabia

Ahmed Bukhari[1], Hidaya Bukhari[2], Satam M Alharbi[3], Waleed Alazmi[4], Lujain Samarkandi[5], Waleed Samarkandi[5], Osama Samarkandi[4]

[1]Department of Family and Community Medicine, College of Medicine, Taif University, Taif, Saudi Arabia, [2]Department of Family Medicine, Salahuddin Health Centre, Second Health Cluster, Riyadh, Saudi Arabia, [3]Department of Family Medicine, King Faisal Hospital in Makkah, Makkah First Health Cluster, Ministry of Health, Makkah, Saudi Arabia. [4]Department of Basic Science, Prince Sultan College for Medical Emergencies, King Saud University, Riyadh, Saudi Arabia, [5]Department of Medicine, College of Medicine, Almaarefa University, Riyadh, Saudi Arabia

Abstract

Background and Aims: Religious pilgrimages, such as the Hajj, are well-publicized mass gatherings that attract millions of people worldwide. These events can strain the public health resources of the host nation, requiring a high level of readiness and response capacity. Therefore, this study aims to evaluate the Distribution of metabolic diseases and demographic characteristics of pilgrims in the 2024 Hajj. **Materials and Methods:** A cross-sectional study was conducted among Hajj pilgrims in Saudi Arabia from June to July 2024. Data were collected using pre-validated questionnaires. The study included pilgrims from diverse backgrounds, both male and female, who were able to complete the questionnaires. The data were analyzed using the Statistical Package for Social Sciences version 27. A Chi-square or Fisher's exact test was used to determine the association between variables, with a $P < 0.05$ considered statistically significant**. Results:** Out of the 4,721 pilgrims who responded, 48.9% were male (n = 2,308) while 51.1% were female. The mean age was 51.74 ± 13.92 years with the most reported metabolic diseases being diabetes, 16.3% followed by obesity, 0.7%. The largest age group was 60 years old (5.4%; n = 253), followed by 50 (4.5%; n = 211) and 55 (4.2%; n = 199) years old. Regarding education, 23.4% had a university degree, while 17.2% were literate. In terms of nationality, 13.1% were from Morocco (n = 617), followed by Yemen (8.7%; n = 409), Iraq (8.6%; n = 405), Indonesia (8.1%; n = 384), Algeria (7.5%; n = 355), Pakistan (6.4%; n = 302), Egypt (6.1%; n = 288), Bangladesh (5.8%; n = 275), and China (5.8%; n = 274). There was a significant difference in gender distribution by nationality (P = 0.001). **Conclusion:** This study highlights the distribution of pilgrims across nationalities, gender, age, education, and various chronic diseases. The confirmation of the various demographics present during Hajj, the Saudi Arabian leadership to create targeted interventions based on this data to provide adequate facilities.

Key words: Hajj, controlling infection, facilities, demographics, multinationals, crowd management

INTRODUCTION

Every year, millions of Muslims travel to Saudi Arabia to participate in the Hajj pilgrimage, one of the biggest and most important religious events in the world. It occurs annually according to the Islamic calendar.[1] Recent estimates show that about 2–3 million individuals from over 183 countries perform Hajj each year.[2-4] In 2023, it was reported that

Address for correspondence:
Osama Samarkand, Department of Basic Science, Prince Sultan College for Medical Emergencies, King Saud University, Riyadh, Saudi Arabia.
E-mail: osamarkandi@ksu.edu.sa

Received: 17-08-2025
Revised: 22-09-2025
Accepted: 30-09-2025

1.84 million pilgrims performed Hajj. It is projected that the crowds of pilgrims may increase in the future.[2] According to Saudi Arabia's 2030 vision, the number of religious tourists arriving for the Hajj and Umrah is estimated to reach 30 million by 2030.[5] This mass gathering presents unique logistical, health, and organizational challenges.

The annual mass gathering of Hajj begins during the peak summer season, with temperatures recorded between 40°C and 45°C. Pilgrims from various countries with diverse social and demographic backgrounds participated in this event. Enduring such high temperatures presents a challenge to the pilgrims, and the desert environment may have adverse effects on their health.

For instance, pilgrims are at the highest risk of contracting various infectious diseases. Large crowds can lead to the spread of viruses and infections through coughing, sneezing, and the consumption of contaminated food, or deliberate acts intended to cause harm.[6] In addition, the presence of chronic diseases among pilgrims can pose risks to both the pilgrims themselves and other individuals living in the country.

Despite the overcrowding, efforts are made to manage the crowds to prevent injuries or stampedes, necessitating careful planning.[7,8] The extended duration of the trip also increases the risk of pre-existing conditions worsening or developing infections and injuries. Therefore, it is crucial to understand the demographics, health characteristics, and behavioral patterns of Hajj pilgrims for effective crowd control, public health planning, and the provision of necessary services.

Although there have been studies focusing on specific health issues during Hajj, such as airborne infectious diseases,[9-12] climate-related health risks, morbidity, and mortality.[8] Earlier literature had limitations such as focusing on pilgrims from selected geographic areas, small sample sizes, or individuals with specific diseases. Understanding the demographics of the Hajj pilgrims is important for mitigating issues during the pilgrimage and aiding in pre-Hajj planning.[13,14] For example, knowing the languages spoken by pilgrims helps with communication and information dissemination.[13,14] Recognizing diverse cultural backgrounds ensures respectful service delivery and efficient distribution of pilgrims.[13-15] Grouping pilgrims by nationality facilitates communication and community support.[13-15] In addition, understanding age and other demographics informs medical resource allocation, accommodation, transportation, and emergency response planning.[13-15] Therefore, a comprehensive understanding of the demographic characteristics and distribution of pilgrims is necessary to overcome challenges during the Hajj season. This study aimed to assess the characteristics and distribution of pilgrims during the 2024 Hajj.

MATERIALS AND METHODS

A cross-sectional study was conducted among Hajj pilgrims in Mecca and Medina, Saudi Arabia, from June to July 2024. Data were collected using pre-validated questionnaires. The study included pilgrims of multinational backgrounds, both male and female, aged 18 years and above, able to respond to the questionnaires and provide informed consent. Female pilgrims who were pregnant or in a postpartum period were excluded from the study. Before data collection, the study questionnaires were reviewed and approved by the Global Center for Mass Gathering Medicine, Ministry of Health, Riyadh (IRB-24-289E). All study procedures were conducted following the Declaration of Helsinki guidelines for human research. Pilgrims were informed that the data would be used solely for research purposes and confidentiality would be maintained throughout the study. In addition, pilgrims or respondents had the option to withdraw from the study at any time.

Sample size

Similar to previous studies,[16-20] the required sample size was estimated using an online calculator, namely the Raosoft® sample size calculator. The sample size was calculated with a 95% confidence interval, a response distribution of 50%, and a 1.5% margin of error. The targeted sample size was 4259 pilgrims. Adjusting for the projected 10% attrition, the estimated final sample size is at least 4500 pilgrims.

Questionnaire design and data collection

Anonymous questionnaires, based on existing literature, were prepared for data collection. The questionnaire included demographic information such as age, gender, education, presence of chronic disease, and country of origin (5 items). Data collection was carried out by randomly selecting pilgrims, primarily from departure areas at airports in Jeddah, after they had completed the Hajj rituals. Translators were available to assist pilgrims speaking different languages, including non-Arabic and non-English speakers from their respective Hajj campaigns.

Statistical analysis

The data were entered into Excel and then converted to the Statistical Package for the Social Sciences (SPSS) for analysis. The data were analyzed using SPSS version 27. Descriptive statistics, such as frequencies (n) and percentages (%), were used to describe categorical data, while continuous data were presented as mean and standard deviation (SD), median, minimum, and maximum. To determine the association between the pilgrims' characteristics, a Chi-square or Fisher's exact test was used, with a $P < 0.05$ considered a statistically significant difference.

RESULTS

Distribution of gender, age, and education of the pilgrims

Table 1 illustrates the demographic characteristics of the participants. Out of the 4721 pilgrims, 48.9% were male (n = 2,308) while 51.1% were female. The mean age was 51.74 ± 13.92 years old, and the interquartile range was 19. Regarding the education status of the pilgrims, 23.4% held a university degree, 17.2% were able to read and write, 8.5% had an intermediate level of education, and 42.1% did not answer this question.

Age-wise distribution of the pilgrims

The age distribution of the pilgrims is outlined in Table 2. According to the findings, the youngest pilgrim was 3 years old, while the oldest was 102 years old. The largest group consisted of individuals aged 60, making up 5.4% (n = 253) of the total. This was followed by 4.5% of pilgrims who were 50 years old (n = 211), and 4.2% (n = 199) who were 55 years old. In addition, 3.3% (n = 158) of pilgrims were 40 years old, and 3.1% (n = 144) were 47 years old. Figure 1 details the age distribution of the pilgrims according to categories.

Distribution of nationalities among pilgrims

Regarding the distribution of pilgrims according to nationalities, 13.1% of them were from Morocco (n = 617), representing the highest frequency of pilgrims, followed by 8.7% from Yemen (n = 409), 8.6% from Iraq (n = 405), 8.1% from Indonesia (n = 384), 7.5% from Algeria (n = 355), 6.4% from Pakistan (n =3 02), 6.1% from Egypt (n = 288), 5.8% from Bangladesh (n = 275), 5.8% Chinese pilgrims (n = 274), 5.0% from Nigeria (n = 234), and 4.7% from Oman (n = 223). Only 0.1% of pilgrims were from Saudi Arabia, representing the lowest frequency. The detailed frequencies of the pilgrims and their nationalities are presented in Figure 2.

Table 1: The characteristics and distribution of pilgrims across the country's regions (n=4721)

Variables	Frequency (n)	Percentages
Gender		
Male	2308	48.9
Female	2413	51.1
Age		
Mean	51.74	
Median	52.00	
Standard deviation	13.92	
95% CI	51.34	
IQR	19	
Educational level	**Frequency**	**Percent**
Illiterate	409	8.7
Read and write	813	17.2
Intermediate or secondary	403	8.5
University	1107	23.4
Not responded	1989	42.1

CI: Confidence interval, IQR: Interquartile range

Gender distribution according to nationalities

With regard to gender distribution according to nationality, 13.6% (n = 313) of the male pilgrims were from Morocco, compared to 12.6% (n = 304) of females, representing the highest frequency of the total population from participating countries. Male pilgrims from Yemen accounted for 10.6% (n = 244) compared to 6.8% (n = 165) of females. On the other hand, female pilgrims were more prevalent in Iraq at 9.2% (n = 222), compared to male Iraqi pilgrims at 7.9% (n = 183). Similarly, 9.0% of male Algerians were reported compared to 6.1% of female pilgrims. Furthermore, 8.4% of male pilgrims were from Indonesia, compared to 7.9% of females. These findings suggest a significant difference in gender distribution by nationality (P = 0.001), as shown in Figure 3.

Age group distribution according to nationalities

Among the youngest age group (0–18 years), individuals from Pakistan constitute the highest proportion (33.3%), followed by Brunei and India, each contributing 14.3%. The group has a total of 21 individuals, making up only 0.4% of the total population. The 19–29 age group has the second-largest representation, with 227 individuals (4.8% of the total population). Among them, Saudi Arabia (15.4%) and Pakistan (17.2%) are the most prominent nationalities. The 30–39 age group represents a significant portion of the population, comprising 721 individuals (15.3%). The largest contributors are Turkey (11.5%) and Morocco (8.9%). In the 40–49 age range, which includes 1,065 individuals (22.6% of the population), Morocco (11.8%) and Nigeria (9.7%) are the leading nationalities, with India also holding a notable share (8.6%). The 50–59 age group shows a similar trend, accounting for 1,221 individuals (25.9%), with the highest representation from Morocco (13.2%) and Indonesia (11.9%). For the 60–69 age group, the total is 934 individuals (19.8%), with Turkey and Morocco contributing the most (17.4% each). Finally, the 70–79 age group has the lowest representation at 416 individuals (8.8%), with a notable share from China (19.5%) and Morocco (15.1%). These findings suggest a significant difference in age group distribution by nationality (P = 0.001), as shown in Figure 4.

Educational level distribution according to nationalities

Among respondents who did not disclose their education level, the highest proportions were from Yemen (18.1%),

Table 2: The age distribution of pilgrims across the countries

Variable	Frequency (n)	Percentage
Age (in years)		
3	1	0.0
5	1	0.0
11	1	0.0
14	2	0.0
15	2	0.0
16	2	0.0
17	7	0.2
18	5	0.1
19	5	0.1
20	12	0.3
21	7	0.2
22	12	0.3
23	13	0.3
24	11	0.2
25	23	0.5
26	20	0.4
27	39	0.9
28	28	0.6
29	34	0.7
30	63	1.4
31	32	0.7
32	56	1.2
33	66	1.4
34	57	1.2
35	81	1.8
36	91	2.0
37	67	1.5
38	92	2.0
39	81	1.8
40	150	3.3
41	47	1.0
42	97	2.1
43	80	1.8
44	88	1.9
45	144	3.2
46	99	2.2
47	139	3.0
48	103	2.3
49	75	1.6
50	207	4.5
51	56	1.2
52	113	2.5
53	75	1.6
54	113	2.5
55	193	4.2
56	126	2.8
57	110	2.4
58	116	2.5
59	73	1.6
60	249	5.5
61	66	1.4
62	79	1.7
63	79	1.7
64	95	2.1
65	110	2.4
65	110	2.4
66	84	1.8
67	65	1.4
68	60	1.3
69	26	0.6
70	130	2.9
71	30	0.7
72	55	1.2
73	28	0.6
74	52	1.1
75	35	0.8
76	28	0.6
77	26	0.6
78	26	0.6
79	7	0.2
80	40	0.9
81	8	0.2
82	14	0.3
83	8	0.2
84	9	0.2
85	7	0.2
86	3	0.1
87	12	0.3
88	6	0.1
90	2	0.0
91	3	0.1
93	1	0.0
96	1	0.0
102	1	0.0

(Contd...)

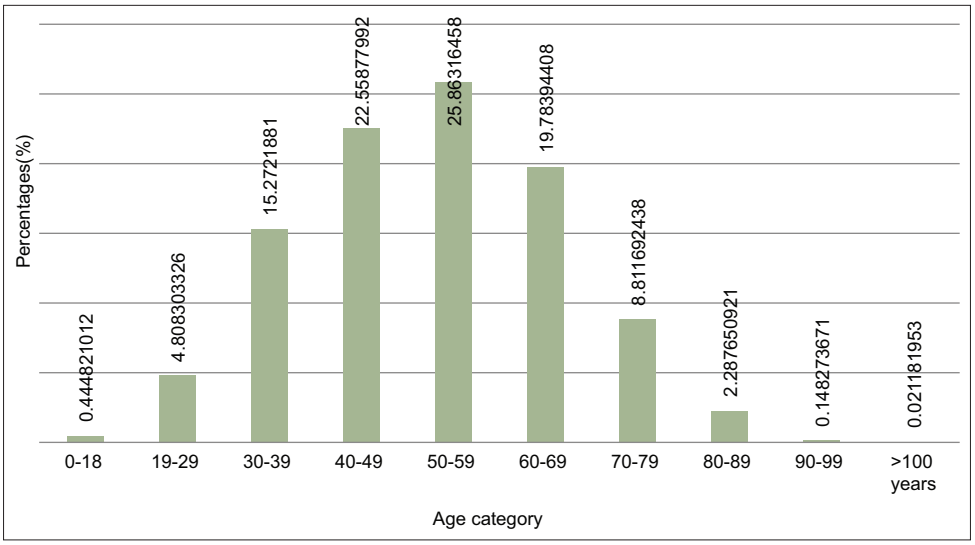

Figure 1: Distribution of age by category

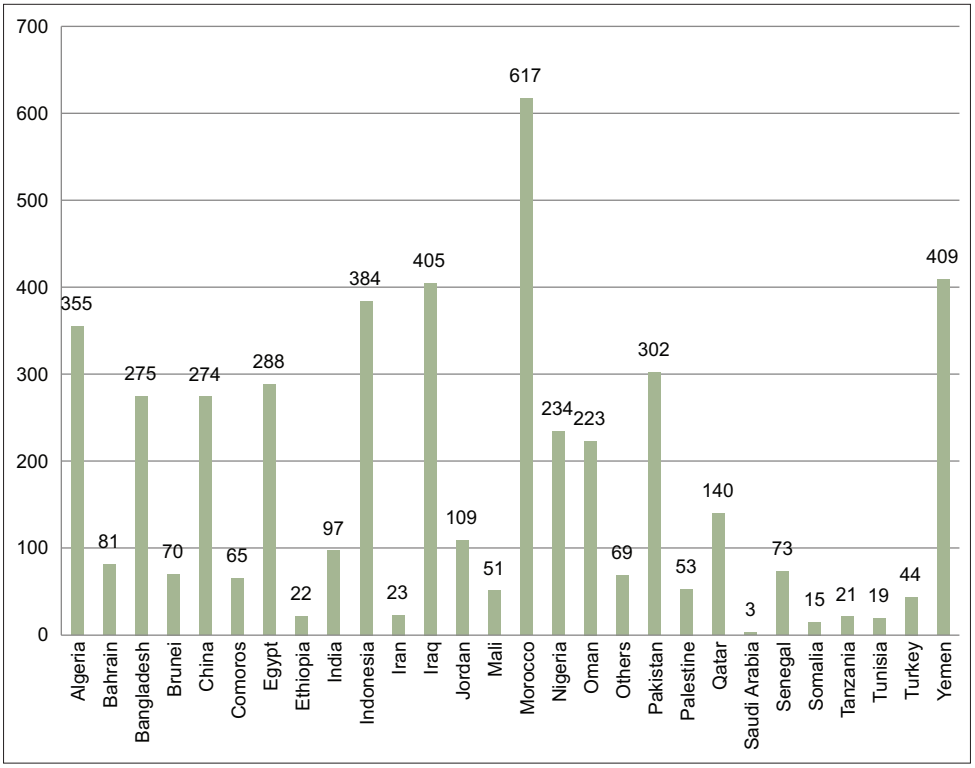

Figure 2: Nationalities of the pilgrims

followed by Indonesia and Morocco (both 9.5%), Iraq (9.6%), and Algeria (7.4%). Illiteracy was most prominent among Yemeni respondents (17.8%), followed by those from China (22.7%) and Algeria (6.8%). Individuals with intermediate or secondary education were primarily from Yemen (16.9%) and Algeria (13.2%), with smaller proportions from Iraq (10.9%) and Morocco (11.7%). Respondents who reported being able to read and write but had no formal education were predominantly from Morocco (24.1%), followed by Yemen (12.9%), Iraq (8.7%), and Indonesia (7.4%). University-level education was highest among respondents from Bahrain (81.5%), Qatar (47.1%), and Saudi Arabia (36.2%), while Algeria and Yemen also had a noticeable proportion (27.0% and 21.8%, respectively). These findings suggest a significant difference in educational level distribution by nationality ($P = 0.001$), as shown in Figure 5.

DISCUSSION

Although the Hajj pilgrimage is one of the largest and most diverse gatherings in the world, it also presents unique

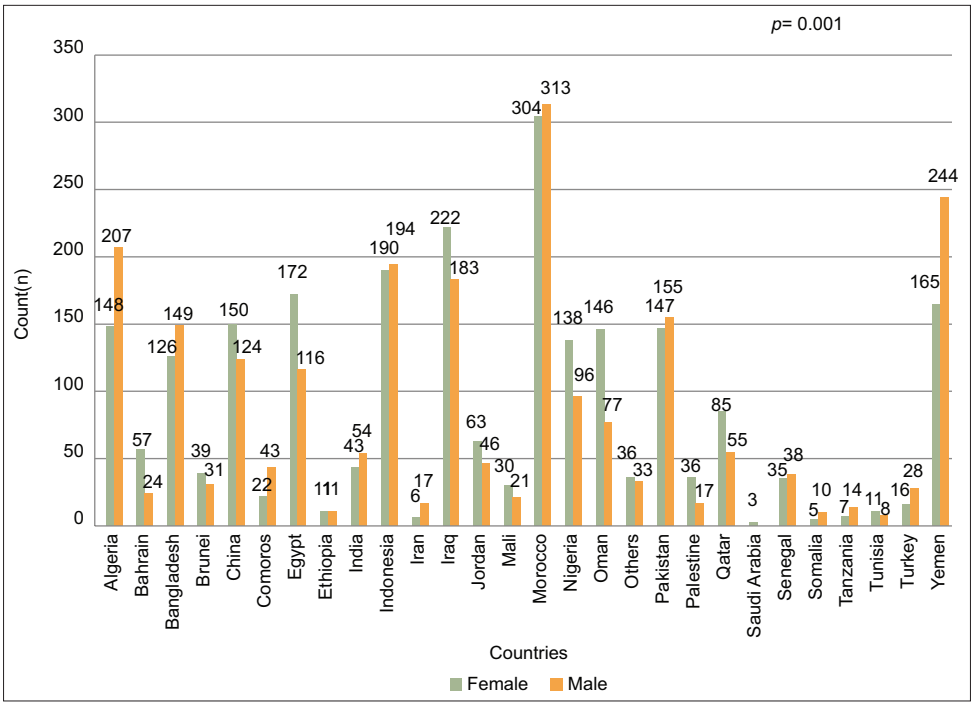

Figure 3: The distribution of gender in different countries during Hajj 2024

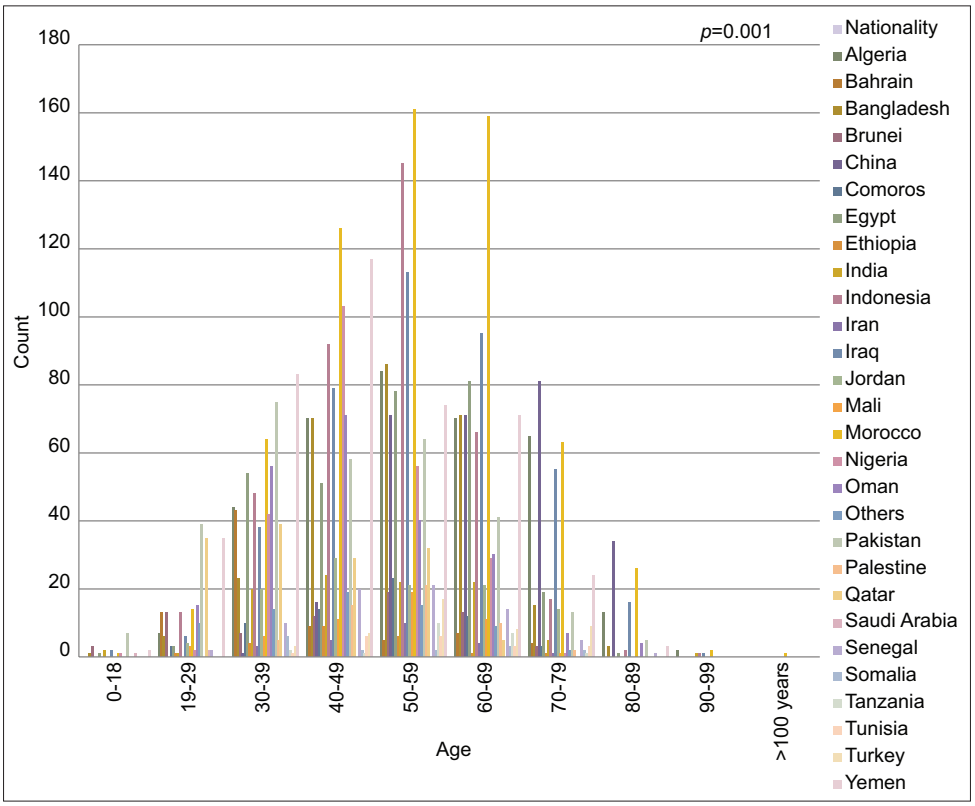

Figure 4: The distribution of age groups across different countries among participants during Hajj 2024

opportunities for social, cultural, and epidemiological research. This study was conducted to investigate the characteristics and distribution of pilgrims during the 2024 Hajj. The examination of pilgrims in this study provides valuable new insights into nationality distributions, educational backgrounds, and demographic trends that are crucial for logistical planning, cultural sensitivity, and healthcare planning.

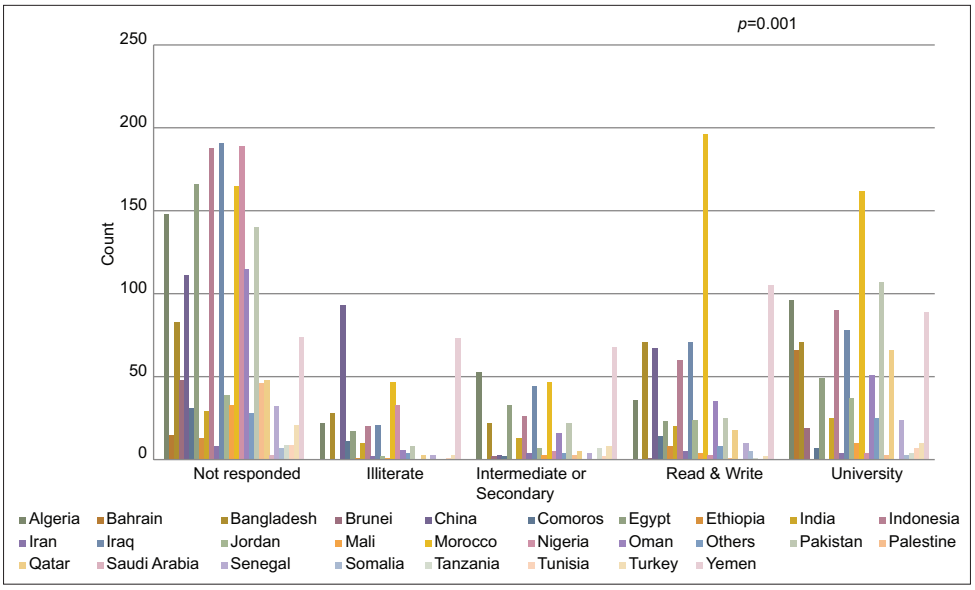

Figure 5: The distribution of educational levels across different countries among participants during Hajj 2024

The 2024 Hajj pilgrim population displayed distinct demographic characteristics. For example, in this study, males comprised 48.9% and females 51.1%, indicating a slight female predominance. This gender distribution differs from previous Hajj data.[21] A previous study reported similar findings, with 50.28% females and 49.72% males.[21] However, other studies have reported different gender distributions.[11,22,23] In a study from 2024, there were nearly equal numbers of men (53.7%) and women (46.3%) pilgrims.[22] Similarly, in a recent review of 58 studies with a sample of 27,799 pilgrims, a male-to-female ratio of 1.3:1 was reported.[11] Another study found that pilgrims with severe respiratory symptoms were 65.95% male and 34.05% female.[24] In a 2017 study, a higher number of males (69%) were reported compared to females (31%), which is opposite to the current findings.[23] These findings suggest the need for tailored healthcare facilities for males and females based on their specific needs.

Regarding the distribution of age, the mean age of the pilgrims in the current study was 51.74 ± 13.92 years, with the majority falling between the ages of 30 and 69 years. The highest frequency of pilgrims' ages was between 50 and 59 years, making up 25.9% of the total. This was followed by the 40–49 age group at 22.6%, and the third highest age category was 60–69 years at 19.8%. The youngest age category among the pilgrims was 30–39 years, comprising 15.3% of the total surveyed population. This age distribution is consistent with previous studies. For example, in a previous study, the age distribution varied, with 11.3% of participants being under 30 years old, while 85% were aged between 31 and 60 years.[22] In the pooled sample of reviews, there were pilgrims aged between 2 days and 105 years.[11] Similarly, in another study, the age of the pilgrims ranged from 2 days to 88 years, with a mean of 58 ± 14.74 years. More than half (60.54%) of them were aged 60 years and older.[24] In another study, the most significant category was pilgrims aged from 51 to 60 years old, constituting 51.85% of the total number.[21] In a study of African pilgrims during the 2017 Hajj, the mean age of the pilgrims was 49.2 years (SD = 13.3), the minimum age was 18 years, while the maximum was 81 years.[25] In another study, the ages of the pilgrims ranged from 13 years to 88 years, and the average was 49 years. The age while performing Hajj ranged from 6 years to 82 years with an average of 47 years.[4] Managing congestion and ensuring timely access to necessary medical facilities are crucial factors for the success of the Hajj pilgrimage.[21] It is also essential to consider the age of the pilgrims, as many international pilgrims can only afford to undertake the Hajj and Umrah in their later years after saving up.[21,26] This results in a higher mortality rate among elderly pilgrims.[21,26] Understanding the age demographics of the pilgrims helps in tailoring healthcare services to address age-related mobility issues, enabling the hosting country to navigate obstacles and make necessary arrangements in advance.[21,26]

In the current study, the majority of the pilgrims were international, which is similar to a previous finding where the author reported that 88% of the respondents were international pilgrims.[22] Among the pilgrims, the highest frequency belonged to Morocco, representing the highest percentage of pilgrims, followed by 8.7% from Yemen, 8.6% from Iraq, 8.1% from Indonesia, 7.5% from Algeria, 6.4% from Pakistan, 6.1% from Egypt, 5.8% from Bangladesh, 5.8% Chinese pilgrims, 5.0% from Nigeria, and 4.7% from Oman. Only 0.1% of pilgrims were from Saudi Arabia, representing the lowest frequency.

An earlier study revealed the distribution of pilgrims from 37 countries, with the majority from Asia (64%), followed by Africa (30.3%), Europe (2.70%), North America (2.2%), and Oceania (0.54%).[24] The nationality of the pilgrims is a crucial factor in ensuring a successful and safe Hajj event. Research has shown that pilgrims from certain countries are more susceptible to various diseases, such as respiratory viruses.[24] Therefore, providing specific vaccinations upon arrival based on nationality could help alleviate this issue.

The education of the pilgrims was a crucial factor in the success of the infection-free gathering and in following the infection-prevention measures provided by the Ministry of Health.[21,27] For example, pilgrims with education were more likely to adhere to wearing masks and practicing hand sanitation, which are necessary to reduce the risk of disease transmission.[21,28,29] In this study, 45.5% of the pilgrims were graduates, and 38.2% had secondary education. Another study of 1138 pilgrims who attended the 2017 Hajj found that 91% had at least a secondary education, and almost all could read (99.7%) and write (99.6%).[25] Educated pilgrims understand the importance of vaccinations, hygiene practices, and disease prevention measures. They also know symptoms and prevention strategies for infectious diseases such as COVID-19, MERS-CoV, and influenza. In addition, education can help familiarize pilgrims with evacuation routes, emergency shelters, and communication protocols.[30-33] Understanding the demographics of the pilgrims allows healthcare authorities and the host nation to plan appropriately for future Hajj seasons.[25,33] This includes providing accommodations based on gender and nationality, facilitating efficient communication among pilgrims, and anticipating the need for cost-effective healthcare services during the Hajj.[25,33]

The collected demographic data will prove to be instrumental in the future, as it provides a frame of reference for the resources that will be required, from providing translations to literacy assistance to tailored medical care, depending on gender. These data are crucial in predicting the potential problems that may arise in the future and planning for them in advance. The demographic data will also serve to highlight areas in need of improvement, such as accounting for the number of female pilgrims from various countries to cultural clashes, and providing support to the elderly and the young. The data on chronic illness will also provide information on how resources can be allocated in future pilgrimages.

Although this study has several limitations, first, the data were collected using a cross-sectional design, which may hinder establishing cause and effect. Second, the data were collected using random sampling from the holy cities in the selected areas; therefore, the conclusions drawn from these findings cannot be applied to the entire population who attended the Hajj. In addition, the sample size was small compared to the total number of pilgrims who performed Hajj, as the pilgrims in our study had a very low response rate. Future studies examining the demographic characteristics and associated health outcomes and mortality during Saudi Arabia's Hajj seasons are necessary.

CONCLUSION

This study confirms that pilgrims of various demographics participate in Hajj rituals, with the majority being aged 50 and above. The research also highlights Saudi Arabia's leadership in managing diverse crowds during the Hajj season by providing adequate facilities. The study offers recommendations to optimize resource distribution, improve transportation strategies, expand healthcare capacity, and enhance cultural competency for multinational pilgrims. These recommendations aim to enhance healthcare access, reduce congestion, provide faster medical responses, and create a safer pilgrimage experience, ultimately promoting a world-class pilgrimage management system.

ACKNOWLEDGMENT

The authors would like to acknowledge the Deanship of Graduate Studies and Scientific Research, Taif University in Saudi Arabia for funding this work.

DATA AVAILABILITY

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

REFERENCES

1. Hashim HT, Babar MS, Essar MY, Ramadhan MA, Ahmad S. The Hajj and COVID-19: How the pandemic shaped the world's largest religious gathering. Am J Trop Med Hyg 2021;104:797-9.
2. Annual Number of Hajj Pilgrims to Saudi Arabia from 1999 to 2023. Available from: https://www.statista.com/statistics/617696/saudi-arabia-total-hajj-pilgrims [Last accessed 2025 May 20].
3. Saudi Arabia: Hajj & Umrah Pilgrimages. CDC Yellow Book; 2024. Available from: https://wwwnc.cdc.gov/travel/yellowbook/2024/itineraries/saudi-arabia-hajj-and-umrah-pilgrimages#:~:text=Normally%2C%20%E2%89%882%E2%80%933%20million,of%20pilgrims%20(hajjis)%20attend [Last accessed 2025 May 20].
4. Quaium A, Al-Nabhan NA, Rahaman M, Salim SI, Toha TR, Noor J, *et al*. Towards associating negative experiences and recommendations reported by Hajj pilgrims in a mass-scale survey. Heliyon 2023;9:e15486.
5. The Economics of Hajj. Available from: https://www.statista.com/chart/32443/key-facts-and-figures-about-the-hajj-pilgrimage/#:~:text=As%20part%20of%20the%20Kingdom%27s,30%20million%20pilgrims%20by%202030 [Last accessed 2025 May 20].
6. Salmon-Rousseau A, Piednoir E, Cattoir V, de La Blanchardiere A. Hajj-associated infections. Med Mal Infect 2016;46:346-54.
7. Abalkhail AA, Al Amri SM. Saudi Arabia's management of the hajj season through artificial intelligence and sustainability. Sustainability 2022;14:14142.
8. Mahomed O, Jaffer MN, Parker S. Morbidity amongst

South African Hajj pilgrims in 2023-a retrospective cohort study. Sci Rep 2024;14:12622.
9. Alandijany TA, Qashqari FS, Alfelali M, Hariri SH, Hassan AM, Faizo AA, *et al.* Detection of COVID-19 incidence among attendees of the 2022 Hajj season. IJID Reg 2024;13:100439.
10. Haseeb A, Saleem Z, Faidah HS, Saati AA, AlQarni A, Iqbal MS, *et al*. Threat of antimicrobial resistance among pilgrims with infectious diseases during hajj: Lessons learnt from COVID-19 pandemic. Antibiotics (Basel) 2023;12:1299.
11. Mahdi HA, Alluhidan M, Almohammed AB, Alfelali M, Shaban RZ, Booy R, *et al.* Epidemiological differences in hajj-acquired airborne infections in pilgrims arriving from low and middle-income versus high-income countries: A systematised review. Trop Med Infect Dis 2023;8:418.
12. Safarpour H, Safi-Keykaleh M, Farahi-Ashtiani I, Bazyar J, Daliri S, Sahebi A. Prevalence of influenza among hajj pilgrims: A systematic review and meta-analysis. Disaster Med Public Health Prep 2022;16:1221-8.
13. World Health Organization. Managing Health Risks during Mass Gatherings. Geneva: World Health Organization; 2019.
14. Shafi S, Dar O, Khan M, Khan M, Azhar EI, McCloskey B, *et al*. The annual Hajj pilgrimage-minimizing the risk of ill health in pilgrims from Europe and opportunity for driving the best prevention and health promotion guidelines. Int J Infect Dis 2016;47:79-82.
15. Felemban EA, Rehman FU, Biabani SA, Ahmad A, Naseer A, Majid AR, *et al*. Digital revolution for Hajj crowd management: A technology survey. IEEE Access 2020;8:208583-609.
16. Syed W, Samarkandi O, Alanazi AA, Alotaibi N, Al-Rawi MB. Assessment of myocardial infarctions knowledge, attitudes and beliefs among adults living in Riyadh Saudi Arabia-insights from cross-sectional study. Sci Rep 2024;14:31457.
17. Syed W, Bashatah A, Alharbi K, Bakarman SS, Asiri S, Alqahtani N. Awareness and perceptions of ChatGPT among academics and research professionals in Riyadh, Saudi Arabia: Implications for responsible AI use. Med Sci Monit 2024;30:e944993.
18. Syed W, Al-Rawi MB. Assessment of hand-washing knowledge and practice among nursing undergraduates in Saudi Arabia. Can J Infect Dis Med Microbiol 2024;2024:7479845.
19. Syed W, Al-Rawi MB. Community pharmacists awareness, perceptions, and opinions of artificial intelligence: A cross-sectional study in Riyadh, Saudi Arabia. Technol Health Care 2024;32:481-93.
20. Samreen S, Siddiqui NA, Wajid S, Mothana RA, Almarfadi OM. Prevalence and use of dietary supplements among pharmacy students in Saudi Arabia. Risk Manag Healthc Policy 2020;13:1523-31.
21. Alahmari AA, Khan AA, Alamri FA, Almuzaini YS, Alradini FA, Almohamadi E*, et al*. Hajj 2021: Role of mitigation measures for health security. J Infect Public Health 2022;15:1350-4.
22. Alqathama AA, Ahmad R. Muslim pilgrims' knowledge, attitudes, and practices regarding complementary and alternative medicine (CAM); a study conducted during Hajj season. Saudi Pharm J 2024;32:101988.
23. Yezli S, Mushi A, Yassin Y, Maashi F, Khan A. Knowledge, attitude and practice of pilgrims regarding heat-related illnesses during the 2017 hajj mass gathering. Int J Environ Res Public Health 2019;16:3215.
24. Alsayed SM, Alandijany TA, El-Kafrawy SA, Hassan AM, Bajrai LH, Faizo AA, *et al*. Pattern of respiratory viruses among pilgrims during 2019 Hajj season who sought healthcare due to severe respiratory symptoms. Pathogens 2021;10:315.
25. Mushi A, Yassin Y, Khan A, Alotaibi B, Parker S, Mahomed O, *et al.* A longitudinal study regarding the health profile of the 2017 South African hajj pilgrims. Int J Environ Res Public Health 2021;18:3607.
26. Ebrahim SH, Doumbia S, Elachola H, Memish ZA. "Healthy Hajj 2019"-what you need to know, before you go. Travel Med Infect Dis 2019;30:1.
27. Alamri F, Amer S, Alhraiwil N. Knowledge and practice after health education program among Hajj 1438 H (2017) pilgrims. Saudi Arabia J Epidemiol Health Care 2018;1:7.
28. Tobaiqy M, Alhasan AH, Shams MM, Amer SA, MacLure K, Alcattan MF, *et al*. Assessment of preventative measures practice among Umrah pilgrims in Saudi Arabia, 1440H-2019. Int J Environ Res Public Health 2021;18:257.
29. Rundle CW, Presley CL, Militello M, Barber C, Powell DL, Jacob SE, *et al*. Hand hygiene during COVID-19: Recommendations from the American Contact Dermatitis Society. J Am Acad Dermatol 2020;83:1730-7.
30. Migault C, Kanagaratnam L, Hentzien M, Giltat A, Nguyen Y, Brunet A, *et al*. Effectiveness of an education health programme about Middle East respiratory syndrome coronavirus tested during travel consultations. Public Health 2019;173:29-32.
31. Ridda I, Mansoor S, Briggs R, Gishe J, Aatmn D. Preparedness for mass gathering during Hajj and Umrah. In: Handbook of Healthcare in the Arab World. Berlin: Springer; 2021. p. 1215-35.
32. Showail AJ. Solving hajj and umrah challenges using information and communication technology: A survey. IEEE Access 2022;10:75404-27.
33. Taibah H, Arlikatti S, Andrew SA, Maghelal P, DelGrosso B. Health information, attitudes and actions at religious venues: Evidence from hajj pilgrims. Int J Disaster Risk Reduct 2020;51:101886.

Source of Support: Deanship of Graduate Studies and Scientific Research, Taif University. **Conflicts of Interest:** None declared.