



Saudi Toxicology Journal (STJ)

Journal home page: <https://uqu.edu.sa/s.toxicology.s/S.T.J>

Research article

Awareness, Perception, and Acceptance of AI Technology in Healthcare Among Pilgrims in Makkah: Understanding Applications and Willingness to Adopt Solutions

Omar Babateen¹, Aljofool Daood Aldandani^{2*}, Sari Abdulrahman Alrehaili³, Afnan Mousa Alhawsawi³, Fadwa raja Alharbi³, Renad Hashem AlQurashi³, Alaa Abdulfattah Namankani³.

¹Department of Physiology, Faculty of Medicine, Umm Al-Qura University, Makkah, Saudi Arabia.

²Medical Student at Jouf University.

³Medical Student at Umm Al-Qura University.

*Correspondence: Email: aljofool55@gmail.com

Citation: Babateen, O. Aldandani, A. D., Alrehaili, S. A., Alhawsawi, A. M., Alharbi, F. R., AlQurashi, R. H. & Namankani, A. A. Awareness, Perception, and Acceptance of AI Technology in Healthcare Among Pilgrims in Makkah: Understanding Applications and Willingness to Adopt Solutions). *STJ*, 2026, 2, 50 – 61 <https://doi.org/10.70957/uqu.edu.sa/s.toxicology.s/stj.2025.2.5>

Received: 12 Mar. 2026

Accepted: 09 Apr. 2025

Published: 13 Apr. 2025



Copyright: © 2025 by the authors.

Licensee Umm Al-Qura University, Makkah, Saudi Arabia

Abstract:

Background: Artificial intelligence (AI) represents a major technological advancement in the last decade and enables the analysis of complex data to help physicians in disease diagnosis and treatment of patients with greater efficiency and accuracy. This study aims to evaluate awareness, perceptions, and acceptance of AI technology in healthcare among pilgrims with a focus on how these factors relate to education levels. **Methods:** A general population based cross-sectional study was conducted in Makkah region included 457 adults aged 18 and above. Data was collected through structured questionnaire. Data analysis employed descriptive statistics and chi-square tests with significance at $p < 0.05$. **Results:** The study population was predominantly aged 18-30 years (55.8%), followed by those aged ≥ 50 years (22.3%) and 31-49 years (21.9%). Most participants were female (69.6%), and 82.3% were Saudi nationals. While 78.6% were familiar with artificial intelligence (AI) in healthcare, only 42.7% believed AI could surpass traditional physicians in diagnosis and treatment. However, 85.1% thought AI could enhance administrative tasks. Concerns about trusting AI with patient care were notable, with 73.7% expressing doubts. Participants with lower education levels were significantly more likely to believe AI would outperform physicians in diagnosis (53.7% vs. 36.6%, $p < 0.05$) and professionalism (42% vs. 30.2%, $p < 0.05$). Conversely, those with higher education were more concerned about trusting AI with patient lives (77.3% vs. 67.3%, $p < 0.05$). **Conclusion:** While most participants recognize AI's potential in healthcare, many doubt it might outperform physicians Yet support its use during Hajj and Umrah.

Keywords: Artificial intelligence, Medical care, Pilgrim, Hajj.

1. Introduction

Artificial intelligence (AI), a branch of computer science, has the potential to decipher complex medical data and unlock meaningful relationships within datasets, making it a valuable tool in healthcare for diagnosis, treatment, and outcome prediction [2,3]. In medical settings, AI systems are designed to mimic human cognitive functions, offering significant advantages in improving healthcare delivery. By utilizing advanced algorithms, AI can process vast amounts of healthcare data, identifying critical patterns and learning from them to enhance decision-making accuracy. These systems often incorporate self-correcting mechanisms driven by feedback, continuously improving their performance over time [4].

AI technology enables physicians to diagnose and treat patients with greater efficiency and accuracy, minimizing human errors that may arise during medical practice [5,6]. AI systems analyze large patient populations, quickly identifying potential health concerns, alerting users to emerging risks, and projecting future outcomes based on historical data [5,6]. According to a recent nationwide survey, 7% of Saudi radiology residents reported using AI daily, signaling its growing role in healthcare [7]. The successful integration of AI into clinical research depends on healthcare professionals' understanding and future implementation of these technologies.

AI advancements are already being applied in several medical fields. In ophthalmology, AI techniques are evolving in areas such as age-related macular degeneration, retinopathy of prematurity, and diabetic retinopathy [8]. In nephrology, AI is used to enhance follow-up care for transplant patients, optimize hemodialysis treatments, and improve medical management [9]. Moreover, AI has become integral to drug design, aiding in synthesis planning and the creation of novel chemical compounds and peptides [10]. However, studies on the awareness and acceptance of AI in healthcare among pilgrims in Saudi Arabia are limited. A recent cross-sectional study of Saudi medical professionals found that 55.2% of respondents were familiar with AI, and 48.1% were aware of its applications in their respective fields. While the majority of respondents viewed AI positively and recognized its potential benefits, many also

expressed concerns about job displacement due to AI [11].

An earlier study conducted in 2023 underscored the broader societal benefits of AI-integrated systems, including improved road safety, faster emergency response times, and better air quality, all contributing to community and environmental well-being [12]. This study aims to evaluate the awareness, perceptions, and acceptance of AI technology in healthcare among pilgrims in Makkah, Saudi Arabia, and to explore its relationship with the pilgrims' education levels.

2. Materials and Methods

Study design and population:

A cross-sectional observational study was conducted in Makkah, Saudi Arabia, from (03/06/2024) to (01/10/2024). The study aimed to assess the awareness and perceptions of AI technology in healthcare among residents and visitors during the Hajj and Umrah seasons in Makkah.

The study population included adult residents and visitors (aged ≥ 18 years) in Makkah during the Hajj and Umrah sessions. The inclusion criteria encompassed adults residing in Makkah and pilgrims participating in Hajj and Umrah. Exclusion criteria included individuals unable to read and understand Arabic or English, those without internet access, and those who did not provide consent to participate in the study.

Sample size determination:

The sample size was determined using the Raosoft sample size calculator based on the estimated number of residents and visitors during Hajj and Umrah. The minimum required sample size was determined to be (n=385 participants) to ensure sufficient statistical power for this study.

Data collection:

Data was collected through an online questionnaire, which was designed in both Arabic and English using Google Forms. The questionnaire consisted of two primary sections. The first section gathered sociodemographic data from participants, while the second assessed their awareness of AI technology in healthcare. The questionnaire was adapted from previously published studies to ensure relevance and clarity for the target population [2]. Links to the

Table 1. Distribution of the participants according to their demographic characteristics and relationship with health field (N= 457)

Variable	No. (%)
Age (years)	
18-30	255 (55.8)
31-49	100 (21.9)
≥50	102 (22.3)
Gender	
Female	318 (69.6)
Male	139 (30.4)
Nationality	
Non-Saudi	81 (17.7)
Saudi	376 (82.3)
Educational level	
Lower than high school	36 (7.9)
High school	106 (23.2)
Diploma	20 (4.4)
College or higher	295 (64.6)
Employment status	
Employed	132 (28.9)
Non-employed	71 (15.5)
Retired	79 (17.3)
Student	175 (38.3)
Do you have a relationship with the health field, whether a student, current employee, or retiree?	
No	91 (19.9)
Yes	215 (47)
Maybe	151 (33)

electronic questionnaire, along with information about the study's objectives and voluntary nature, were shared with participants during the Hajj and Umrah sessions.

Data analysis:

Data analysis was conducted using SPSS statistical software (version 26), with descriptive statistics such as frequencies and percentages used to summarize the study quantitative findings. Relationships between categorical variables were assessed using the Chi-squared test (χ^2), considering a p-value<0.05 as statistically significant.

Ethical considerations:

Ethical approval for the study was obtained from [Biomedical Research Ethics Committee] of Umm Al-Qura University (UQU), Makkah, Saudi Arabia. (Approval No." HAPO-02-K-012-2024-10-2207" and date of approval: 20/08/2024). All participants provided informed consent, and their confidentiality was maintained throughout the study.

3. Results

The study included 457 participants, with the majority aged 18-30 years (55.8%), followed by those aged ≥50 years (22.3%) and 31-49 years (21.9%). Most participants were female (69.6%), and 82.3% were Saudi nationals. Regarding education, 64.6% held a college degree or higher, while 23.2% completed high school. In terms of employment, 38.3% were students, 28.9% were employed, and 17.3% were retired. Nearly half (47%) had a relationship with the health field, while 33% were unsure, and 19.9% had no connection to the health sector (Table 1).

Most participants (78.6%) were familiar with artificial intelligence in healthcare. Less than half (42.7%) believed that AI systems would surpass traditional physicians in diagnosing and prescribing treatments, while the majority (85.1%) thought AI-powered software could improve administrative tasks. However, 73.7% expressed concerns about fully trusting AI with patients' lives, and 70.2% felt that AI systems, lacking human traits, could not fully replicate the traditional doctor-patient relationship.

Table 2. Awareness, perception, and acceptance of AI technology in healthcare among studied pilgrims (N=457)

Variable	No	Yes
	No. (%)	No. (%)
Are you familiar with the use of AI in healthcare research?	98 (21.4)	359 (78.6)
Do you consider this as a possibility that AI systems could surpass traditional physicians' role in diagnosing disease indication and prescribing medicine?	262 (57.3)	195 (42.7)
Do you believe software applications supported by AI tools could improve the management of administrative tasks, such as handling large patient data?	68 (14.9)	389 (85.1)
Are you concerned about being fully dependent on AI algorithms for patient care?	120 (26.3)	337 (73.7)
Do you think AI tools lacking human traits like emotional intelligence such as empathy and compassion or can effectively replicate the traditional doctor-patient relationship?	136 (29.8)	231 (70.2)
Can AI systems independently uphold a professional attitude within the healthcare setting as compared to traditional?	221 (48.4)	236 (51.6)
Do you think AI systems have the required knowledge to function efficiently in healthcare domain?	170 (37.2)	287 (62.8)
Do you think AI systems possess all the necessary skills to accurately perform healthcare-related tasks in day to day work life?	154 (33.7)	303 (66.3)
Could AI systems surpass physicians in professionalism, including attitude, knowledge, and required skills?	300 (65.6)	157 (34.4)
As a visitor or resident in Makkah, do you fear treatment with AI or do you not have enough confidence for it?	171 (37.4)	286 (62.6)
Do you think first-time visitors to Makkah should be required to attend courses on managing AI systems in addition to traditional clinical research practices?	161 (35.2)	296 (64.8)
Could integrating AI help in addressing challenges of healthcare system, such as low doctor to patient ratios, inefficiency, and financial burden to patients?	130 (28.4)	327 (71.6)
Have you used or have experience with any AI applications in healthcare?	315 (68.9)	142 (31.1)
Do you support incorporating AI technology to upgrade the healthcare system in Makkah during Hajj and Umrah sessions?	94 (20.6)	363 (79.4)

Nearly half (51.6%) believed AI could maintain a professional attitude in the healthcare system, while 62.8% thought AI would have the necessary knowledge to perform efficiently. Additionally, 66.3% believed AI systems would possess the skills required to carry out healthcare tasks accurately. However, only 34.4% thought AI would outperform physicians in professionalism, encompassing attitude, knowledge, and skill.

As visitors or residents in Makkah, 62.6% reported concerns or lacked confidence in receiving AI-based treatments. Moreover, 64.8% thought that first-time visitors to Makkah should attend courses on AI management alongside traditional clinical studies. The majority (71.6%) believed AI could address current healthcare system challenges, such as inefficiency and workforce shortages, and 79.4% supported the integration of AI technology to enhance Makkah's healthcare system during Hajj and Umrah. Only 31.1% had experience using AI applications in healthcare.

The most common source of AI knowledge among participants was social media (68.1%), while books and

magazines were the least common sources (4.4%) (Figure 1). Table 3 and Figures 2-6 illustrate the relationship between participants' educational levels and their awareness, perception, and acceptance of AI technology in healthcare.

Participants with a lower education level (less than college) had a significantly higher percentage who believed AI would surpass traditional physicians in diagnosing and prescribing treatments (53.7% vs. 36.6%) and that AI would outperform physicians in professionalism—encompassing attitude, knowledge, and skill—compared to those with higher education levels (42% vs. 30.2%) ($p < 0.05$). As shown in Figure 2, participants with higher educational levels were more likely to believe AI systems could surpass traditional physicians in diagnosis and treatment. Figure 3 illustrates that worry about fully trusting AI with patients' lives decreased as educational level increased. Participants with college education or higher were more likely to express concerns about fully trusting AI with patients' lives (77.3% vs. 67.3%) ($p < 0.05$). According to Figure 4, belief in AI

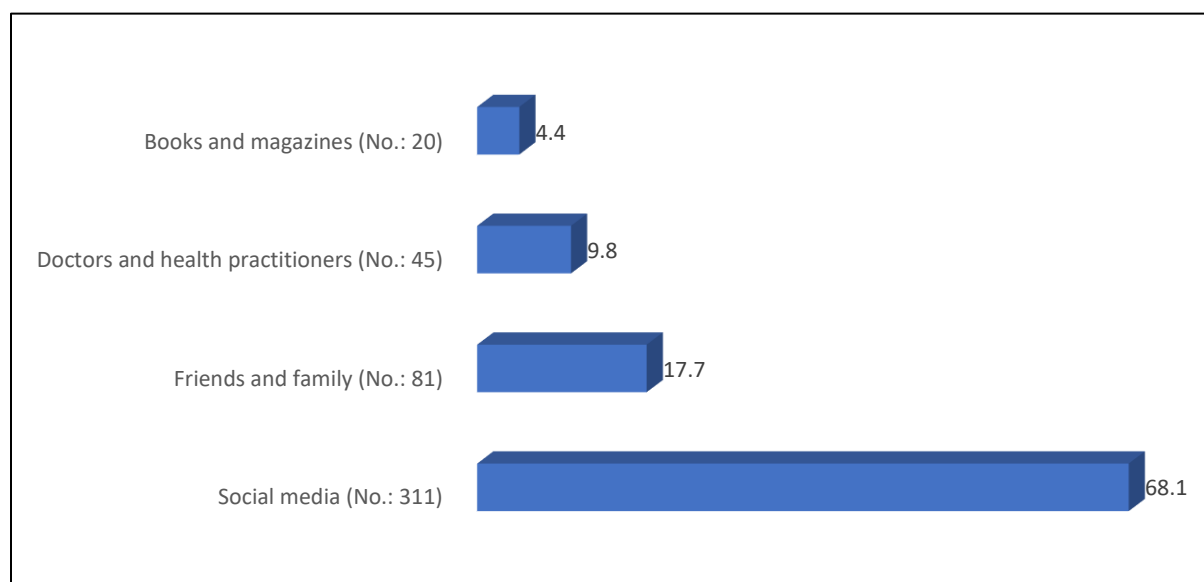


Figure 1. Sources of knowledge about AI among studied participants (N=457)

Table 3. Relationship between participants' educational level and their awareness, perception, and acceptance of AI technology in healthcare (N=457)

Variable	Educational level		χ^2	p-value
	Less than college education No. (%)	College education and above No. (%)		
Are you familiar with the use of AI in healthcare research?				
No	35 (21.6)	63 (21.4)	0.004	0.951
Yes	127 (78.4)	232 (78.6)		
Do you consider this as a possibility that AI systems could surpass traditional physicians' role in diagnosing disease indication and prescribing medicine?				
No	75 (46.3)	187 (63.4)	12.49	<0.001
Yes	87 (53.7)	108 (36.6)		
Do you believe software applications supported by AI tools could improve the management of administrative tasks, such as handling large patient data?				
No	30 (18.5)	38 (12.9)	2.62	0.105
Yes	132 (81.5)	257 (87.1)		
Are you concerned about being fully dependent on AI algorithms for patient care?				
No	53 (32.7)	67 (22.7)	5.4	0.02
Yes	109 (67.3)	228 (77.3)		
Do you think AI tools lacking human traits like emotional intelligence such as empathy and compassion or can effectively replicate the traditional doctor-patient relationship?				
No	54 (33.3)	82 (27.8)	1.53	0.216
Yes	108 (66.7)	213 (72.2)		
Can AI systems independently uphold a professional attitude within the healthcare setting as compared to traditional?				
No	77 (47.5)	144 (48.8)	0.06	0.793
Yes	85 (52.5)	151 (51.2)		
Do you think AI systems have the required knowledge to function efficiently in healthcare domain?				
No	51 (31.5)	119 (40.3)	3.51	0.061

Yes	111 (68.5)	176 (59.7)		
Do you think AI systems possess all the necessary skills to accurately perform healthcare-related tasks in day to day work life?				
No	48 (29.6)	106 (35.9)	1.85	0.173
Yes	114 (70.4)	189 (64.1)		
Could AI systems surpass physicians in professionalism, including attitude, knowledge, and required skills?				
No	94 (58)	206 (69.8)	6.46	0.011
Yes	68 (42)	89 (30.2)		
As a visitor or resident in Makkah, do you fear treatment with AI or do you not have enough confidence for it?				
No	73 (45.1)	98 (33.2)	6.26	0.012
Yes	89 (54.9)	197 (66.8)		
Do you think first-time visitors to Makkah should be required to attend courses on managing AI systems in addition to traditional clinical research practices?				
No	57 (35.2)	104 (35.3)	0.01	0.973
Yes	105 (64.8)	191 (64.7)		
Could integrating AI help in addressing challenges of healthcare system, such as low doctor to patient ratios, inefficiency, and financial burden to patients?				
No	52 (32.1)	78 (26.4)	1.64	0.2
Yes	110 (67.9)	217 (73.6)		
Have you used or have experience with any AI applications in healthcare?				
No	109 (67.3)	206 (69.8)	0.31	0.574
Yes	53 (32.7)	89 (30.2)		
Do you support incorporating AI technology to upgrade the healthcare system in Makkah during Hajj and Umrah sessions?				
No	44 (27.2)	50 (16.9)	6.67	0.01
Yes	118 (72.8)	245 (83.1)		

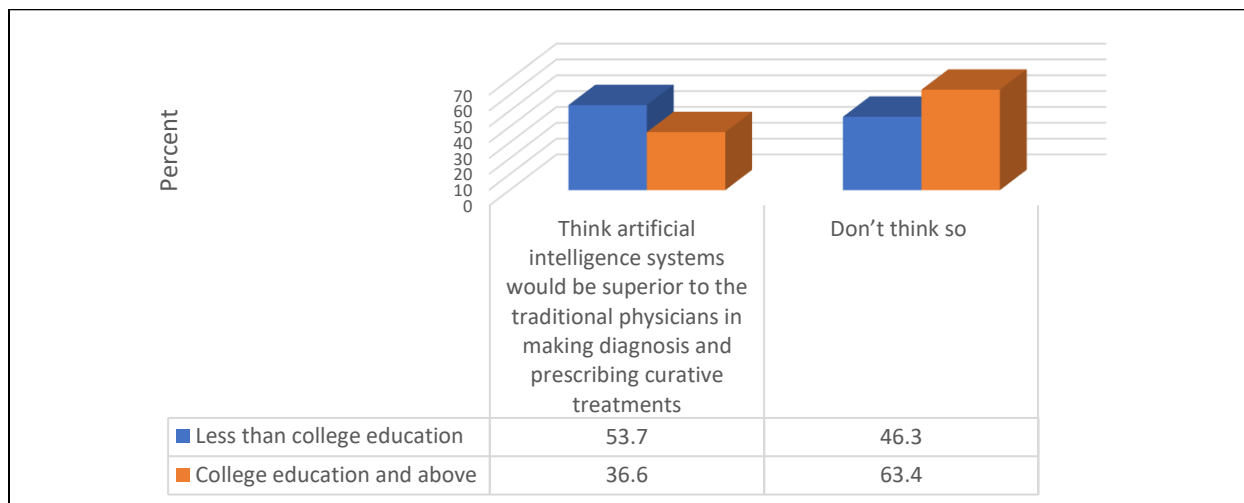


Figure 2. Relationship between participant educational level and their opinions on AI systems would surpass traditional physicians in diagnosis of indication and prescribing medicine for treatments. (N=457), N.B.: ($\chi^2 = 12.49$, p-value = <0.001)

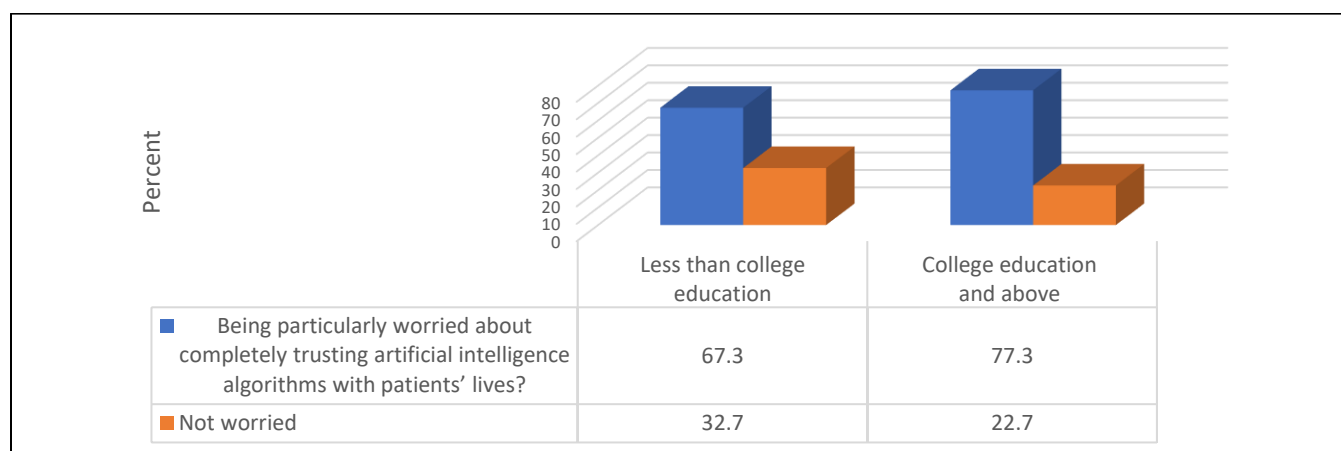


Figure 3. Relationship educational level and worry about completely trusting AI algorithms with patients' lives (N=457), N.B.: ($\chi^2 = 5.4$, p value = 0.02)

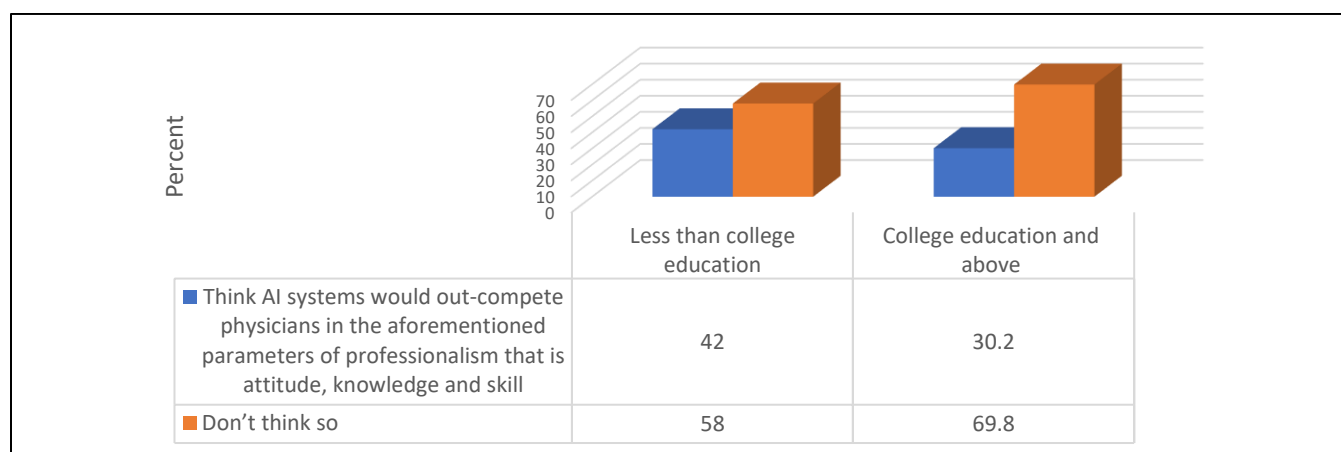


Figure 4. Relationship educational level and if AI systems would out-compete physicians in the aforementioned parameters of professionalism that is attitude, knowledge and skill (N=457), N.B.: ($\chi^2 = 6.46$,

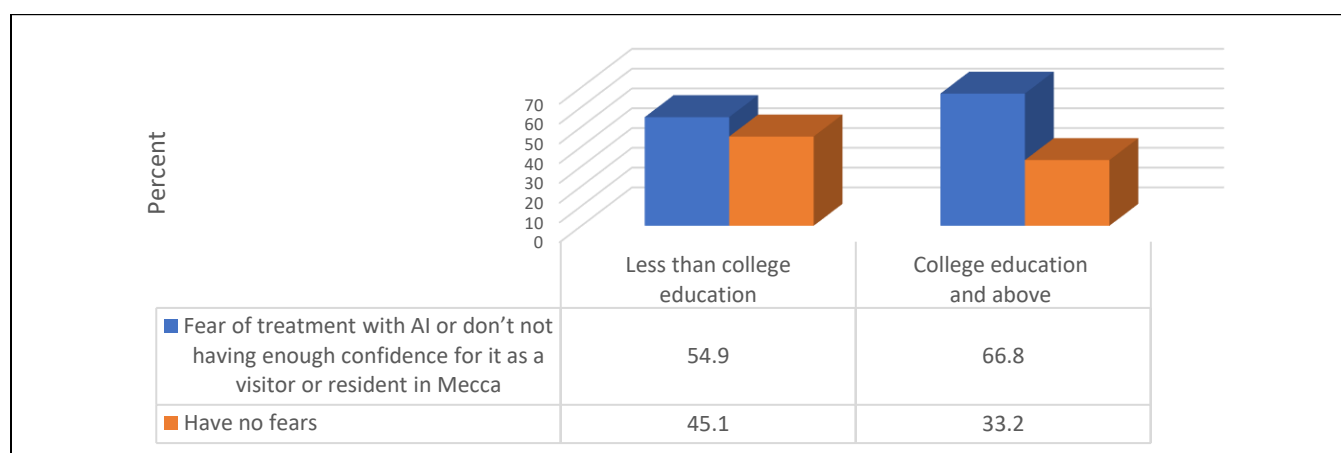


Figure 5. Relationship educational level and fear of treatment with AI or don't having enough confidence for it as a visitor or resident in Mecca (N=457), N.B.: ($\chi^2 = 6.26$, p-value = 0.012)

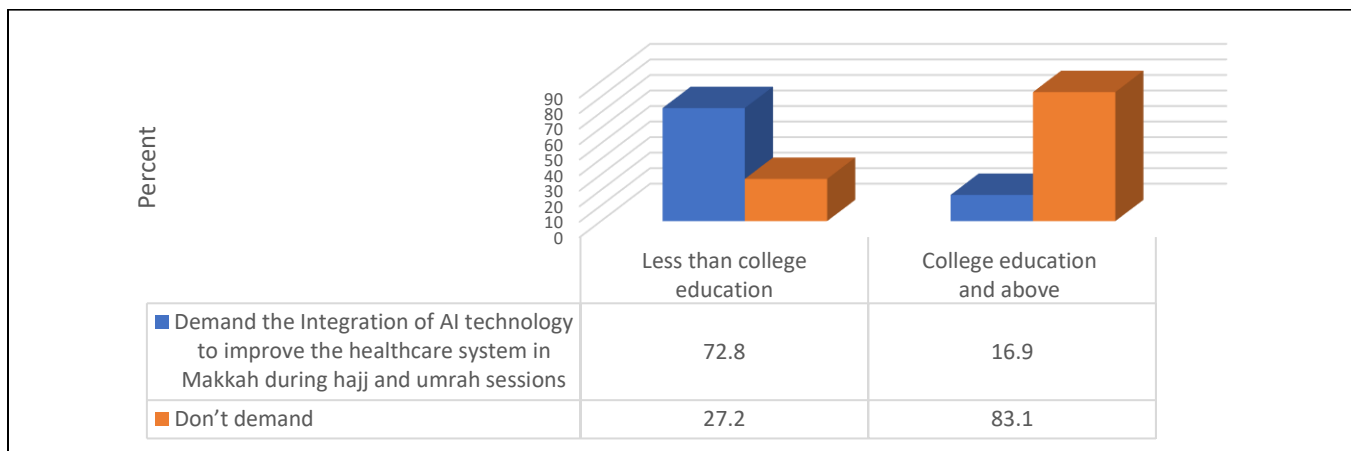


Figure 6. Relationship educational level and demanding the Integration of AI technology to improve the healthcare system in Makkah during hajj and umrah sessions (N=457), N.B.: ($\chi^2 = 6.67$, p-value = 0.01)

outperforming physicians in professionalism—attitude, knowledge, and skill—was more prevalent among highly educated participants.

Figure 5 indicates that fear or lack of confidence in AI treatment was more common among participants with lower educational levels. Additionally, those with higher education reported significantly greater fear or lack of confidence in AI-based treatments (66.8% vs. 54.9%). As depicted in Figure 6, support for integrating AI into Makkah's healthcare system during Hajj and Umrah rose with higher educational attainment. Moreover, participants with college education or higher were more likely to demand the integration of AI technology to improve the healthcare system during Hajj and Umrah sessions compared to those with lower education (83.1% vs. 72.8%) ($p < 0.05$). These findings suggest that education level influences both the perceived potential of AI in healthcare and concerns about its use.

4. Discussion

This study is the only observational research conducted in an academic institution in Makkah, Saudi Arabia, to evaluate the awareness, perceptions, and acceptance of AI technology in healthcare among pilgrims, and its relationship with their educational level. Unlike Saudi citizens, pilgrims come from diverse regions globally, bringing variation in their educational, socioeconomic, and technological awareness levels. This diversity was the focal point of our study.

Our findings revealed an overall negative attitude toward the use of AI in healthcare services among pilgrims, despite their good knowledge of AI, which

may be linked to the younger age group of 18-30 years. Despite having good awareness, the majority expressed concerns about the potential consequences of AI replacing physicians in clinical roles, such as diagnosis and medication prescription. This aligns with previous studies, where 24.7% of participants expressed fear of job loss due to AI potentially replacing healthcare providers [13]. On the other hand, many participants showed a positive attitude toward using AI-powered software for administrative tasks. These findings are unique, as there are no prior studies in the literature evaluating such factors among healthy individuals in Saudi Arabia. However, previous studies have explored these variables among healthcare providers, such as radiologists and medical students [14-23]. Our findings will serve as a valuable reference for upcoming studies, particularly those focusing on pilgrims in Makkah, Saudi Arabia.

The study also found that most participants had good knowledge of AI, consistent with previous research conducted among healthcare undergraduates and the general population [24, 25]. For instance, Liehner et al. reported that the public perceives AI as a tool that can operate autonomously, adapt, and assist in daily life, although trust in the technology was lower [26]. Our findings also showed that the average AI awareness score was significantly related to gender, age, and educational level. This is consistent with earlier research among healthcare workers, where factors such as age, profession, and experience significantly influenced perception scores [27]. This study will make a meaningful contribution to AI adoption in healthcare and provide a valuable reference for future research.

Educational and healthcare institutions can utilize this data to design training programs that enhance AI understanding and awareness in healthcare. Furthermore, AI has the potential to improve public health by promoting wellness for all communities, but careful consideration of implementation strategies is essential to fully realize this potential [28, 29]. Health authorities must evaluate their AI adoption methods thoughtfully [30, 31, 32].

Despite its potential benefits, AI raises ethical concerns, particularly regarding data privacy, algorithmic bias, and the impact on patient-provider relationships. Healthcare decisions may be influenced by the data used to train AI systems, potentially exacerbating disparities in healthcare outcomes across different demographic groups. Concerns about data sharing and triangulation arise due to the lack of diversity in AI datasets, which underscores the need for robust federal regulations governing the use and sharing of health data. Data breaches could result in consequentialist or deontological ethical consequences, or both. Technologies like federated learning, differential privacy, and cryptography are emerging as models to safeguard patient privacy and address these concerns [33, 34, 35, 36].

This study has several limitations. First, findings are limited to respondents from the Makkah region, which may not reflect views across Saudi Arabia. Broader geographic inclusion would improve generalizability. The self-administered questionnaire may have introduced recall or social desirability bias, with participants potentially giving socially acceptable answers. Convenience sampling also limits representativeness and may not capture the full diversity of the pilgrim population.

Additionally, uneven age and gender distribution suggest future studies should aim for a more balanced sample. The large number of pilgrims, varied languages, and geographic origins made it challenging to achieve a representative sample. Communication barriers also arose due to the advanced age of many participants, who may be less familiar with AI technology. Nonetheless, the study offers valuable insights into perceptions of AI integration in healthcare among Makkah pilgrims.

This study has several strengths. It is one of the few studies worldwide to explore the awareness,

perceptions, and acceptance of AI in healthcare among healthy individuals, such as pilgrims in Makkah. A sufficient sample size was gathered to accurately reflect the public's views on AI technology and its applications. The study objectives were met through detailed interpretation of the findings, providing a comprehensive evaluation of awareness, perceptions, and acceptance of AI in healthcare among pilgrims.

The findings highlight the need for targeted AI education and awareness initiatives tailored to the diverse and multilingual pilgrim population. Policymakers could use these insights to develop culturally sensitive AI training materials for healthcare providers and educational campaigns for pilgrims, especially older individuals. Integrating AI literacy into Hajj and Umrah health services may enhance acceptance and effectiveness of AI-supported care. Additionally, addressing communication barriers and ensuring equitable access to AI tools could support more inclusive, efficient healthcare delivery during mass gatherings like Hajj and Umrah.

5. Conclusions

This study reveals that while most participants were aware of AI in healthcare, fewer than half believed AI systems could outperform traditional physicians in diagnosis and treatment. Participants were more open to using AI for administrative tasks but remained hesitant to trust AI in clinical decision-making. Although about half believed AI could function autonomously in healthcare, only a third thought it could surpass physicians in critical areas. Interestingly, those with lower education levels were more optimistic about AI's potential to outperform doctors, whereas higher-educated individuals expressed more skepticism. Despite these reservations, most participants supported integrating AI into healthcare, viewing it as a solution to existing challenges during Hajj and Umrah. These findings highlight the need to address trust and ethical concerns surrounding AI in healthcare and can inform future strategies to enhance AI adoption and effectiveness during religious pilgrimages.

Author Contributions: All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by [Aljofool Daood Aldandani], [Sari Abdulrahman Alrehyli], [Afnan Mousa Alhawsawi], [Fadwa Raja Alharbi],

[Renad Hashem AlQurashi] and [Alaa Abdulfattah Namankani]. The first draft of the manuscript was written by [Aljofool Daood Aldandani] and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest: The authors stated that they have no conflicts of interest associated with the study.

Funding: This research received no external funding.

Informed Consent Statement: Informed consent was obtained from all participants before their involvement in the study.

References:

1. AN Ramesh, C Kambhampati, JRT Monson, PJ Drew, Artificial intelligence in medicine, *AnnR CollSurgEngl* 2004; 86: 334–338. doi: 10.1308/147870804290. PMID: 15333167; PMCID: PMC1964229.
2. Umer, M., Naveed, A., Maryam, Q., Malik, A. R., Bashir, N., & Kandel, K. (2024). Investigating awareness of artificial intelligence in healthcare among medical students and professionals in Pakistan: A cross-sectional study. *Annals of Medicine & Surgery*, 86(5), 2606–2611. doi: 10.1097/MS9.0000000000001957. PMID: 38694316; PMCID: PMC11060211.
3. Amisha, Malik P, Pathania M, Rathaur VK. Overview of artificial intelligence in medicine. *J Family Med Prim Care*. 2019 Jul;8(7):2328-2331. doi: 10.4103/jfmpc.jfmpc_440_19. PMID: 31463251; PMCID: PMC6691444.
4. Bajwa J, Munir U, Nori A, Williams B. Artificial intelligence in healthcare: transforming the practice of medicine. *Future Healthc J*. 2021 Jul;8(2):e188-e194. doi: 10.7861/fhj.2021-0095. PMID: 34286183; PMCID: PMC8285156.
5. Krishnan G, Singh S, Pathania M, Gosavi S, Abhishek S, Parchani A, Dhar M. Artificial intelligence in clinical medicine: catalyzing a sustainable global healthcare paradigm. *Front Artif Intell*. 2023 Aug 29;6:1227091. doi: 10.3389/frai.2023.1227091. PMID: 37705603; PMCID: PMC10497111.
6. Basu K, Sinha R, Ong A, Basu T. Artificial Intelligence: How is It Changing Medical Sciences and Its Future? *Indian J Dermatol*. 2020 Sep-Oct;65(5):365-370. doi: 10.4103/ijd.IJD_421_20. PMID: 33165420; PMCID: PMC7640807.
7. Syed, W., & Basil A. Al-Rawi, M. (2023). Assessment of awareness, perceptions, and opinions towards artificial intelligence among healthcare students in Riyadh, Saudi Arabia. *Medicina*, 59(5), 828. doi: 10.3390/medicina59050828. PMID: 37241062; PMCID: PMC10221309.
8. Hashimoto D.A et al. Artificial intelligence in anaesthesiology: current techniques, clinical applications, and limitations. *Anaesthesiology*. 2020; 132:379–394. doi: 10.1097/ALN.0000000000002960. PMID: 31939856; PMCID: PMC7643051.
9. Hessler G, Baringhaus K.H. Artificial intelligence in drug design. *Molecules*. 2018; 23:2520. doi: 10.3390/molecules23102520. PMID: 30279331; PMCID: PMC6222615.
10. Chan K.S, Zary N. Applications, and challenges of implementing artificial intelligence in medical education: integrative review. *JMIR Med Educ*. 2019;5(e):13930. doi: 10.2196/13930. PMID: 31199295; PMCID: PMC6598417.
11. Elnaggar M, Alharbi Z A, Alanazi A M, et al. (August 02, 2023) Assessment of the Perception and Worries of Saudi Healthcare Providers About the Application of Artificial Intelligence in Saudi Health Facilities. *Cureus* 15(8): e42858. doi: 10.7759/cureus.42858
12. Gazzawe, F., & Albahar, M. (2024). Reducing traffic congestion in Makkah during Hajj through the use of AI technology. *Heliyon*, 10(1). <https://doi.org/10.1016/j.heliyon.2023.e23304>
13. Syed W, Babelghaith SD, Al-Arifi MN. Assessment of Saudi Public Perceptions and Opinions towards Artificial Intelligence in

- Health Care. *Medicina* (Kaunas). 2024 Jun 4;60(6):938. doi: 10.3390/medicina60060938.
14. Abuzaid MM, Elshami W, McConnell J, Tekin HO. An extensive survey of radiographers from the Middle East and India on artificial intelligence integration in radiology practice. *Health Technol (Berl)*. 2021;11(5):1045-1050. doi: 10.1007/s12553-021-00583-1. Epub 2021 Aug 6. PMID: 34377625; PMCID: PMC8342654.
 15. Qurashi AA, Alanazi RK, Alhazmi YM, Almohammadi AS, Alsharif WM, Alshamrani KM. Saudi Radiology Personnel's Perceptions of Artificial Intelligence Implementation: A Cross-Sectional Study. *J Multidiscip Healthc*. 2021 Nov 23;14:3225-3231. doi: 10.2147/JMDH.S340786. PMID: 34848967; PMCID: PMC8627310.
 16. Abuzaid MM, Elshami W, Tekin H, Issa B. Assessment of the Willingness of Radiologists and Radiographers to Accept the Integration of Artificial Intelligence Into Radiology Practice. *Acad Radiol*. 2022 Jan;29(1):87-94. doi: 10.1016/j.acra.2020.09.014. Epub 2020 Oct 29. PMID: 33129659.
 17. Ooi SKG, Makmur A, Soon AYQ, Fook-Chong S, Liew C, Sia SY, Ting YH, Lim CY. Attitudes toward artificial intelligence in radiology with learner needs assessment within radiology residency programmes: a national multi-programme survey. *Singapore Med J*. 2021 Mar;62(3):126-134. doi: 10.11622/smedj.2019141. Epub 2019 Nov 4. PMID: 31680181; PMCID: PMC8027147.
 18. Tajaldean A, Alghamdi S. Evaluation of radiologist's knowledge about the Artificial Intelligence in diagnostic radiology: a survey-based study. *Acta Radiol Open*. 2020 Jul 31;9(7):2058460120945320. doi: 10.1177/2058460120945320. PMID: 32821436; PMCID: PMC7412626.
 19. Coppola F, Faggioni L, Regge D, Giovagnoni A, Golfieri R, Bibbolino C, Miele V, Neri E, Grassi R. Artificial intelligence: radiologists' expectations and opinions gleaned from a nationwide online survey. *Radiol Med*. 2021 Jan;126(1):63-71. doi: 10.1007/s11547-020-01205-y. Epub 2020 Apr 29. PMID: 32350797.
 20. Li R, Yang Y, Wu S, Huang K, Chen W, Liu Y, Lin H. Using artificial intelligence to improve medical services in China. *Ann Transl Med*. 2020 Jun;8(11):711. doi: 10.21037/atm.2019.11.108. PMID: 32617331; PMCID: PMC7327308.
 21. Syed W, Samarkandi OA, Alsadoun A, Harbi MKA, Al-Rawi MBA. Evaluation of clinical knowledge and perceptions about the development of thyroid cancer-An observational study of healthcare undergraduates in Saudi Arabia. *Front Public Health*. 2022 Aug 15;10:912424. doi: 10.3389/fpubh.2022.912424. PMID: 36052013; PMCID: PMC9426299.
 22. Kolachalama VB, Garg PS. Machine learning and medical education. *NPJ Digit Med*. 2018 Sep 27;1:54. doi: 10.1038/s41746-018-0061-1. PMID: 31304333; PMCID: PMC6550167.
 23. Singh RP, Hom GL, Abramoff MD, Campbell JP, Chiang MF; AAO Task Force on Artificial Intelligence. Current Challenges and Barriers to Real-World Artificial Intelligence Adoption for the Healthcare System, Provider, and the Patient. *Transl Vis Sci Technol*. 2020 Aug 11;9(2):45. doi: 10.1167/tvst.9.2.45. PMID: 32879755; PMCID: PMC7443115.
 24. Khanagar, S.; Alkathiri, M.; Alhamlan, R.; Alyami, K.; Alhejazi, M.; Alghamdi, A. Knowledge, attitudes, and perceptions of dental students towards artificial intelligence in Riyadh, Saudi Arabia. *Med. Sci*. 2021, 25, 1857–1867. https://discoveryjournals.org/medicalseience/current_issue/v25/n114/A8.htm
 25. Syed W., Basil A., Al-Rawi M. Assessment of awareness, perceptions, and opinions towards artificial intelligence among healthcare students in Riyadh, Saudi Arabia. *Medicina*. 2023;59:828. doi: 10.3390/medicina59050828.
 26. Ipsos Spotlight KSA. Views on AI. Understanding of AI. [(accessed on 28 April

- 2024)]. Available online: <https://www.ipsos.com/en-sa/spotlightksa-views-ai#:~:text=The%20report%20reveals%20that%2077,32%20countries%20which%20were%20surveyed.>
27. Liehner G.L., Biermann H., Hick A., Brauner P., Ziefle M. Perceptions, attitudes and trust towards artificial intelligence—An assessment of the public opinion. *Artif. Intell. Soc. Comput.* 2023;72:32–41. doi: 10.54941/ahfe1003271.
 28. Elnaggar M., Alharbi Z.A., Alanazi A.M., Alsaiani S.O., Alhemaidani A.M., Alanazi S.F., Alanazi M.M. Assessment of the Perception and Worries of Saudi Healthcare Providers About the Application of Artificial Intelligence in Saudi Health Facilities. *Cureus.* 2023;15:e42858. doi: 10.7759/cureus.42858.
 29. Jungwirth D., Haluza D. Artificial Intelligence and Public Health: An Exploratory Study. *Int. J. Environ. Res. Public Health.* 2023;20:4541. doi: 10.3390/ijerph20054541.
 30. Fisher S., Rosella L.C. Priorities for successful use of artificial intelligence by public health organizations: A literature review. *BMC Public Health.* 2022;22:2146. doi: 10.1186/s12889-022-14422-z.
 31. Ramezani M., Takian A., Bakhtiari A., Rabiee H.R., Ghazanfari S., Mostafavi H. The application of artificial intelligence in health policy: A scoping review. *BMC Health Serv. Res.* 2023;23:1416. doi: 10.1186/s12913-023-10462-2.
 32. Flores L., Kim S., Young S.D. Addressing bias in artificial intelligence for public health surveillance. *J. Med. Ethics.* 2024;50:190–194. doi: 10.1136/jme-2022-108875.
 33. Panch T., Pearson-Stuttard J., Greaves F., Atun R. Artificial intelligence: Opportunities and risks for public health. *Lancet Digit. Health.* 2019;1:e13–e14. doi: 10.1016/S2589-7500(19)30002-0.
 34. Sauerbrei A., Kerasidou A., Lucivero F., Hallowell N. The impact of artificial intelligence on the person-centred, doctor-patient relationship: Some problems and solutions. *BMC Med. Inform. Decis Mak.* 2023;23:73. doi: 10.1186/s12911-023-02162-y.
 35. Yadav N., Pandey S., Gupta A., Dudani P., Gupta S., Rangarajan K. Data Privacy in Healthcare: In the Era of Artificial Intelligence. *Indian Dermatol. Online J.* 2023;14:788–792. doi: 10.4103/idoj.idoj_543_23.
 36. Price W.N., Cohen I.G. Privacy in the age of medical big data. *Nat. Med.* 2019;25:37–43. doi: 10.1038/s41591-018-0272-7.