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Knowledge, practice, and associated factors of triage among medical students volunteering in the emergency department during Hajj season: a cross-sectional study

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ABSTRACT

Background: Hajj in Makkah is a major mass gathering posing healthcare challenges. Emergency departments (EDs) rely on medical student volunteers during this season. This study assessed triage knowledge and associated factors among medical students volunteering in EDs during the Hajj.

Methods: We conducted a descriptive cross-sectional survey among 600 medical students who volunteered. Data were collected using a structured online questionnaire that assessed knowledge across five domains: principles and ethics, clinical application, standardized systems, color coding and acuity classification, and operational preparedness. Data were analyzed using SPSS version 28 and descriptive statistics, independent samples *t*-tests, one-way ANOVA, and chi-square tests. A p-value < 0.05 indicated statistical significance.

Results: The mean overall awareness score percentage was 65.6%, and 83.2% of participants demonstrated good overall knowledge. The highest mean score was observed in color coding and acuity classification (78.4%), followed by operational preparedness (71.6%) and standardized systems (67.3%). Lower scores were noted in principles and ethics (59.2%) and clinical application and decision-making (47.9%). The academic phase was significantly associated with overall awareness (p = .049), where preclinical students demonstrated a higher awareness level compared to clinical students (87.2% *vs.* 80.5%), and medical school affiliation showed significant differences across several domains (p < 0.05). Gender, age, and nationality were not significantly associated with overall awareness.

Conclusion: The medical student volunteers demonstrated strong practical knowledge of triage systems but showed gaps in ethical principles and clinical decision-making. Standardized, competency-based triage training integrated across medical curricula is recommended.

Keywords: Triage, Medical students, Hajj, Emergency department, Mass gatherings, Knowledge.

Introduction

The Hajj pilgrimage, held annually in Makkah, Saudi Arabia, is one of the world's largest mass gatherings, attracting over 2 million pilgrims from diverse global backgrounds. This event poses significant challenges to the healthcare system due to the high incidence of acute medical conditions resulting from heat exposure, crowding, and physical exertion [1]. Emergency departments (EDs) in Makkah must rapidly scale their operations to manage the increased patient load, often

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relying on medical student volunteers to assist healthcare professionals during the Hajj.

Triage plays a vital role in emergency medical services, especially during mass gatherings. It involves prioritization of patients based on the severity of their conditions to ensure timely and efficient medical intervention [2]. The correct implementation of triage in high-demand settings, such as the Hajj, is essential to reduce mortality, alleviate overcrowding, and optimize the use of limited medical resources [3].

Research has demonstrated the critical importance of triage systems in emergency care, particularly in disaster and mass casualty situations, with the World Health Organization emphasizing the need for trained personnel to execute triage accurately during large-scale health events [3].

Studies in various settings have shown that both knowledge and practice of triage are frequently suboptimal, even among professional healthcare workers. For example, studies have reported that although emergency nurses generally demonstrate good triage knowledge and practice, important knowledge deficits and deficiencies in translating knowledge into practice still exist, highlighting the need for ongoing triage education and training [4], and another highlighted the significance of structured triage training in improving the early recognition of critically ill patients [5].

Medical students, especially those volunteering during emergencies, are increasingly integrated into healthcare systems, including EDs. However, few studies have assessed their competencies in triage, particularly in complex, high-pressure scenarios like the Hajj.

The existing literature suggests that while such volunteerism provides hands-on experience, the variability in training can lead to inconsistencies in performance and patient safety outcomes. Despite the recognized importance of triage and the critical role medical student volunteers play during the Hajj season, there is a paucity of research focusing on their actual knowledge, triage practice, and the factors influencing their performance in this unique setting. In particular, many available studies address triage knowledge among professional healthcare providers, with very limited data addressing student volunteers working under extreme pressure during mass gatherings. This lack of information hampers the development of effective preparatory programs tailored for medical students who support emergency services during the Hajj. This study aimed to assess the knowledge and practice of triage among medical students volunteering in EDs during the Hajj in Makkah. In addition, it sought to identify factors associated with their triage competencies, including prior training, academic level, and clinical experience. The findings can help inform educational strategies and policies to enhance emergency preparedness and ensure the safety and effectiveness of healthcare delivery during mass gatherings.

Methods

Study design and setting

This analytical cross-sectional study was conducted in Makkah, Saudi Arabia, between October 28, 2025, and January 28, 2026. We targeted medical students who volunteered in EDs during the Hajj. Although data collection occurred post-Hajj, we determined eligibility based on prior clinical volunteering experience during the season.

Study population

We included students from all academic phases who provided informed consent. We excluded those younger than 18 years, those without Hajj experience, and participants with incomplete responses.

Sample size and sampling

We included a total sample of 600 participants. Based on a 95% confidence interval and a 5% margin of error, this sample size exceeded the minimum requirement of 384 participants typically suggested for such populations to ensure statistical power. The study aimed to recruit the largest possible number of medical student volunteers during the specified Hajj season to ensure representative data. A total of 600 participants completed the survey, which constitutes a sufficient sample size to achieve adequate statistical power for the descriptive and comparative analyses performed in this study.

Data collection tool

We developed a structured, self-administered electronic questionnaire in English, which was distributed via Google Forms. A panel of subject-matter experts reviewed the tool to ensure face and content validity. Internal consistency reliability was assessed using Cronbach's alpha coefficients. The overall questionnaire demonstrated acceptable internal consistency with a Cronbach's alpha of 0.84, and the domain-specific alpha values were 0.79 for Domain 1, 0.82 for Domain 2, 0.76 for Domain 3, 0.81 for Domain 4, and 0.85 for Domain 5. The survey comprised sections on demographic and academic characteristics and on five specialized domains—principles and ethical foundations, clinical application, standardized systems, color coding, and operational procedures—assessing triage knowledge.

Variables

The variables assessed in this study included demographic and academic characteristics, such as age, gender, nationality, academic phase, and medical school affiliation. In addition, the survey evaluated triage knowledge across five specialized domains: principles and ethical foundations, clinical application, standardized systems, color coding, and operational procedures.

Statistical analysis

Statistical analyses were performed using SPSS (version 28; IBM Corp., Armonk, NY). Descriptive statistics,

including frequencies and percentages for categorical variables and means ± SD for continuous variables, were used to summarize participants' sociodemographic and academic characteristics. Knowledge and awareness of triage were assessed across five domains: principles and ethical foundations, clinical application and decision-making, standardized triage systems and scoring tools, triage color coding and acuity classification, and operational triage procedures and preparedness. Each item was scored one point for a correct/agree response and 0 points for an incorrect or "not sure" response, and domain-specific scores were calculated by summing the points within each domain. An overall awareness score was obtained by summing scores across all domains. Awareness levels were categorized using a 60% cutoff of the total possible score for each domain: participants scoring below 60% were considered to have poor awareness, while those scoring 60.0% or higher were classified as having good awareness. Associations between categorical variables, such as age, gender, nationality, academic phase, and medical school, and overall or domain-specific awareness, were assessed using chi-square tests or exact probability tests when appropriate. Comparisons of mean domain-specific knowledge scores between groups were performed using independent samples *t*-tests for two-group comparisons and one-way ANOVA for three or more groups, with post-hoc analysis applied for significant ANOVA results. Participants who identified their medical school affiliation generally as "Medical College" without specifying a particular university name (n = 21) were grouped under the category "Other Medical Colleges" to ensure consistency and statistical validity during group comparisons. A p-value < 0.05 was considered statistically significant.

Ethical considerations

The Biomedical Research Ethics Committee at Umm Al-Qura University approved the study (Approval No. HAPO-02-K-012-2025-09-2905). We obtained electronic informed consent from all participants and ensured data anonymity.

Results

Table 1 presents our sample's sociodemographic and academic characteristics. Most participants were aged 21-25 years (400, 66.7%), followed by 26-30 years (112, 18.7%) and 18-20 years (88, 14.7%). Females were the majority (460, 76.7%) compared to males (140, 23.3%). Saudi nationals were predominant (577, 96.2%) versus non-Saudi students (23, 3.8%). Regarding academic year, the largest groups were 4th year (160, 26.7%), 5th year (142, 23.7%), and 3rd year (129, 21.5%), with fewer students in 2nd year (81, 13.5%), 1st year (16, 2.7%), 6th year (68, 11.3%), and medical interns (4, 0.7%). When categorized by academic phase, 370 (61.7%) were in the clinical phase, 226 (37.7%) were in the pre-clinical phase, and 4 (0.7%) were interns. Participants came from a variety of medical schools, most notably King Abdulaziz University (186, 31.0%), Taif University (146, 24.3%), and Umm Al Qura University (113, 18.8%), with smaller contributions from Jeddah University (75, 12.5%), Taibah University (53, 8.8%), Other Medical College (21, 3.5%), Ibn Sina National College (4, 0.6%), Batterjee Medical College (2, 0.3%).

Table 2 illustrates the triage knowledge of the 600 medical student volunteers across the five domains. In the domain of principles and ethical foundations, most students correctly identified triage as the process of prioritizing patients based on clinical needs (579, 96.5%). They recognized the importance of ethical neutrality, although a small proportion (17.0%) still considered nationality-based prioritization acceptable. Awareness of prioritization based on severity rather than arrival time was high (460, 76.7%), yet only 55.7% correctly rejected the "first-come, first-served" approach. In the clinical application and decision-making domain, participants had a strong understanding that triage should be performed by trained personnel (583, 97.2%) and requires reassessment (76.3%). Most students knew that the primary objective of triage is to reduce deterioration or death (463, 77.2%)

Table 1. *Sociodemographic and academic characteristics of medical students volunteering in EDs during the Hajj season (n = 600).*

Variables	No. (%)
Age in years	
18-20	88 (14.7%)
21-25	400 (66.7%)
26-30	112 (18.7%)
Gender	
Male	140 (23.3%)
Female	460 (76.7%)
Nationality	
Saudi	577 (96.2%)
Non-Saudi	23 (3.8%)
Academic year	
1st year	16 (2.7%)
2nd year	81 (13.5%)
3rd year	129 (21.5%)
4th year	160 (26.7%)
5th year	142 (23.7%)
6th year	68 (11.3%)
Medical intern	4 (0.7%)
Academic phase	
Pre-clinical	226 (37.7%)
Clinical	370 (61.7%)
Intern	4 (0.7%)
Medical school	
King Abdulaziz University	186 (31.0%)
Taif University	146 (24.3%)
Umm Al-Qura University	113 (18.8%)
Jeddah University	75 (12.5%)
Taibah University	53 (8.8%)
Other Medical Colleges	21 (3.5%)
Ibn Sina National College	4 (0.6%)
Batterjee	2 (0.3%)

Table 2. *Knowledge of triage principles, systems, and practices among medical student volunteers in EDs during Hajj season (N = 600).*

Domain	Item	Agree	Not sure	Disagree
Principles and Ethical Foundations of Triage	Triage is the process of categorizing patients based on priority.	579 (96.5%)	2 (0.3%)	19 (3.2%)
	Triage should prioritize based on clinical needs, not social status.	542 (90.3%)	21 (3.5%)	37 (6.2%)
	Patients who arrive first should always be seen first.	334 (55.7%)	140 (23.3%)	126 (21.0%)
	Triage prioritizes severity over arrival time.	460 (76.7%)	73 (12.2%)	67 (11.2%)
	Giving priority to one's own nationality is acceptable in mass casualty events.	442 (73.7%)	56 (9.3%)	102 (17.0%)
Clinical Application and Decision-Making in Triage	Triage should be performed by trained medical personnel.	583 (97.2%)	9 (1.5%)	8 (1.3%)
	Triage is a one-time process with no reassessment.	458 (76.3%)	42 (7.0%)	100 (16.7%)
	The primary objective of triage is to reduce deterioration or death.	463 (77.2%)	83 (13.8%)	54 (9.0%)
	Triage decisions should rely only on symptoms, not the mechanism of injury.	435 (72.5%)	77 (12.8%)	88 (14.7%)
	Children's physiological responses differ from those of adults and must be considered.	502 (83.7%)	55 (9.2%)	43 (7.2%)
	Triage is only necessary in emergencies, not routine care.	478 (79.7%)	56 (9.3%)	66 (11.0%)
Standardized Triage Systems and Scoring Tools	CTAS includes separate adult and pediatric charts.	539 (89.8%)	54 (9.0%)	7 (1.2%)
	CTAS levels: 1 Resuscitation → 5 Non-Urgency.	511 (85.2%)	71 (11.8%)	18 (3.0%)
	ESI categorizes patients from level 1 (most urgent) to 5 (least urgent).	401 (66.8%)	136 (22.7%)	63 (10.5%)
	Triage Early Warning Score is abbreviated as TEWS.	414 (69.0%)	107 (17.8%)	79 (13.2%)
	Adult TEWS includes mobility, RR, HR, DBP, temperature, and AVPU.	494 (82.3%)	73 (12.2%)	33 (5.5%)
	Triage protocols are optional and can be ignored when busy.	463 (77.2%)	64 (10.7%)	73 (12.2%)
Triage Color Coding and Acuity Classification	Triage uses colors and numbers to prioritize care.	581 (96.8%)	11 (1.8%)	8 (1.3%)
	Green-triaged patients may wait longer than 10 minutes.	530 (88.3%)	51 (8.5%)	19 (3.2%)
	Green patients are less-urgent and usually seen last.	441 (73.5%)	108 (18.0%)	51 (8.5%)
	Alert, walking patient with mild abdominal pain → green.	480 (80.0%)	63 (10.5%)	57 (9.5%)
	Yellow (urgency) patients require timely attention.	516 (86.0%)	50 (8.3%)	34 (5.7%)
	Red (resuscitation) patients require immediate intervention.	498 (83.0%)	58 (9.7%)	44 (7.3%)
	Severe allergic reaction with respiratory distress → red.	522 (87.0%)	59 (9.8%)	19 (3.2%)
Operational Triage Procedures and Preparedness	Emergency sign in step 1 → immediate intervention.	543 (90.5%)	24 (4.0%)	33 (5.5%)
	Urgent sign in step 2 → triage by urgency, not automatically yellow.	488 (81.3%)	79 (13.2%)	33 (5.5%)
	PPE should be worn when the risk of infectious exposure exists.	463 (77.2%)	104 (17.3%)	33 (5.5%)
	Mass casualty incidents require a clear command structure.	471 (78.5%)	83 (13.8%)	46 (7.7%)
	In Hajj, dehydration and heatstroke require prompt triage.	497 (82.8%)	41 (6.8%)	62 (10.3%)
	I feel confident making triage decisions in Hajj.	525 (87.5%)	53 (8.8%)	22 (3.7%)

AVPU, Alert, Verbal, Pain, Unresponsive; CTAS, Canadian Triage and Acuity Scale; DBP, diastolic blood pressure; ESI, Emergency Severity Index; HR, heart rate; PPE, personal protective equipment; RR, respiratory rate; TEWS, Triage Early Warning Score.

Table 3. *Descriptive statistics of knowledge scores across triage domains among medical student volunteers during Hajj season (N = 600).*

Domain	Min-Max	Mean ± SD	Score %
Principles and ethical foundations of triage	0.0-5.0	2.96 ± 0.80	59.2%
Clinical application and decision-making in triage	1.0-6.0	2.87 ± 0.81	47.9%
Standardized triage systems and scoring tools	0.0-6.0	4.04 ± 1.18	67.3%
Triage color coding and acuity classification	3.0-9.0	5.48 ± 0.94	78.4%
Operational triage procedures and preparedness	1.0-6.0	4.30 ± 0.92	71.6%
Overall awareness score	11.0-26.0	19.65 ± 2.22	65.6%

Min-Max, minimum-maximum.

and appreciated age-specific considerations in children (502, 83.7%). Regarding the domain standardized triage systems and scoring tools, knowledge was substantial for CTAS charts and levels (539, 89.8% and 511, 85.2%, respectively), while understanding of ESI levels (401, 66.8%) and TEWS abbreviation (414, 69.0%) was comparatively lower. In triage color coding and acuity classification, participants showed excellent knowledge of color prioritization (581, 96.8%) and recognition of green, yellow, and red categories and their application in clinical scenarios, including Hajj-specific examples (480-522, 73.5%-87.0%). Finally, in operational triage procedures and preparedness, most students understood the need for immediate intervention for signs of an emergency (543, 90.5%), the importance of mass casualty command structures (471, 78.5%), the proper use of PPE

(463, 77.2%), and the importance of timely triage for dehydration and heatstroke during the Hajj (497, 82.8%). Confidence in making triage decisions during the Hajj was high (525, 87.5%).

Table 3 presents the descriptive statistics of the knowledge scores across the five triage domains. The highest mean score was observed in triage color coding and acuity classification (5.48 ± 0.94; 78.4%), followed by operational triage procedures and preparedness (4.30 ± 0.92; 71.6%) and standardized triage systems and scoring tools (4.04 ± 1.18; 67.3%), indicating strong knowledge of the practical and system-based aspects of triage. Moderate knowledge levels were noted in principles and ethical foundations of triage (2.96 ± 0.80; 59.2%), while the lowest mean score was seen in clinical application and decision-making (2.87 ± 0.81; 47.9%), showing gaps in applied decision-making skills. The overall awareness score across all domains was 19.65 ± 2.22, corresponding to 65.6%.

Figure 1 shows the distribution of knowledge levels across the five triage domains. The highest proportion of students had good knowledge of triage color coding and acuity classification (526, 87.7%), followed by operational triage procedures and preparedness (503, 83.8%) and standardized triage systems and scoring tools (459, 76.5%). Knowledge was comparatively lower in principles and ethical foundations of triage (429, 71.5%) and low in clinical application and decision-making (126, 21.0%). Overall, most participants (499, 83.2%) had good awareness of triage, showing strong foundational knowledge but revealing areas, particularly clinical application, where targeted training and reinforcement may be needed to improve practical competency.

Table 4 presents the association between the sociodemographic and academic factors of the medical student volunteers and the domain-specific triage knowledge scores. No significant differences were observed across age groups in any domain (p = 0.068-0.620) or nationality (p = 0.188- 0.784), suggesting that knowledge levels were comparable across these factors. Gender was associated with higher scores in operational preparedness, with females scoring slightly higher than males (4.34 ± 0.89 *vs.* 4.16 ± 1.01, p = 0.041), while other domains showed no significant differences. The academic phase was significantly associated with knowledge of standardized systems and operational preparedness (p = 0.001 for both), with interns achieving the highest scores in these domains. Similarly, medical school was significantly associated with scores in principles and ethics (p = 0.047), clinical application (p = 0.048), and standardized systems (p = 0.025), indicating that institutional differences may influence domain-specific knowledge. Other domains, including color coding and acuity, did not show significant variation across medical schools (p = 0.752).

Table 5 shows the association between sociodemographic and academic characteristics and overall triage awareness among the medical student volunteers. Awareness was generally high across all age groups, with 80.7% of students aged 18-20, 83.3% aged 21-25, and 84.8% aged 26-30 having good awareness, with no significant differences between age groups (p = 0.737). Similarly, no significant differences were observed by gender (males 80.7% *vs.* females 83.9%, p = 0.376) or nationality (Saudi 83.0% *vs.* non-Saudi 87.0%, p = 0.620). However, the academic phase was significantly associated with awareness (p = 0.049), with pre-clinical students showing higher awareness (87.2%) than clinical students (80.5%), and all interns

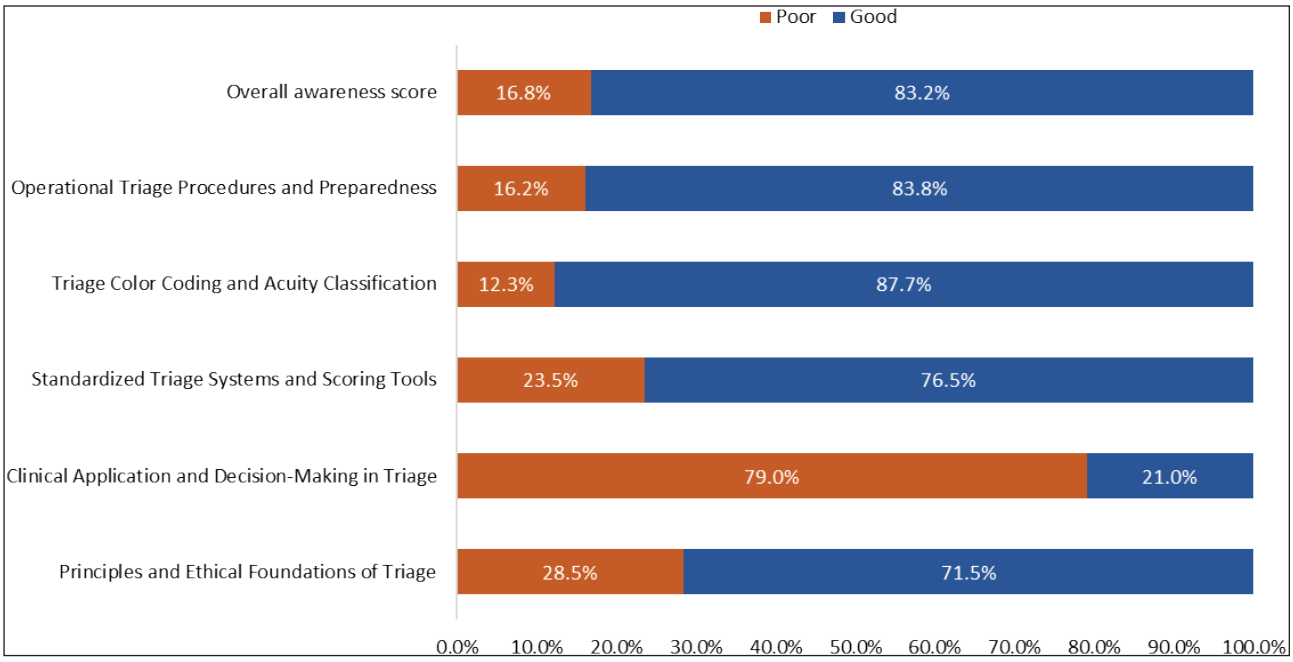

Figure 1. *The overall level of knowledge and awareness of triage domains among medical student volunteers during the Hajj season (N = 600).*

Table 4. *Association between sociodemographic and academic factors and domain-specific triage knowledge scores among medical student volunteers during Hajj season (N = 600)*

Factor	Principles and ethics	Clinical application	Standardized systems	Color coding and acuity	Operational Preparedness
Age in years					
18-20	2.93 ± 0.84	2.73 ± 0.78	4.15 ± 1.15	5.49 ± 0.84	4.39 ± 0.85
21-25	2.99 ± 0.79	2.91 ± 0.81	3.96 ± 1.25	5.48 ± 0.96	4.28 ± 0.97
26-30	2.90 ± 0.85	2.85 ± 0.83	4.23 ± 0.85	5.48 ± 0.98	4.30 ± 0.80
p-value	0.514	0.427	0.068	0.475	0.620
Gender					
Male	3.05 ± 0.79	2.81 ± 0.89	3.89 ± 1.35	5.53 ± 0.96	4.16 ± 1.01
Female	2.93 ± 0.81	2.89 ± 0.79	4.08 ± 1.12	5.47 ± 0.94	4.34 ± 0.89
p-value	0.138	0.340	0.079	0.533	0.041*
Nationality					
Saudi	2.96 ± 0.80	2.87 ± 0.80	4.05 ± 1.18	5.47 ± 0.95	4.29 ± 0.93
Non-Saudi	3.04 ± 0.98	2.83 ± 1.11	3.83 ± 1.19	5.74 ± 0.75	4.48 ± 0.67
p-value	0.620	0.784	0.378	0.188	0.337
Academic phase					
Pre-clinical	2.91 ± 0.78	2.81 ± 0.80	4.28 ± 0.87	5.50 ± 0.88	4.42 ± 0.80
Clinical	2.99 ± 0.82	2.91 ± 0.82	3.91 ± 1.29	5.47 ± 0.99	4.21 ± 0.98
Intern	3.25 ± 0.50	3.00 ± 0.00	2.25 ± 1.71	6.25 ± 0.50	5.50 ± 1.00
p-value	0.355	0.340	0.001*	0.254	0.001*
Medical school					
Batterjee	3.50 ± 0.71	3.00 ± 1.41	4.50 ± 0.71	5.50 ± 0.71	4.00 ± 0.00
Ibn Sina National College*	3.00 ± 0.00	3.00 ± 0.00	2.26 ± 0.34	5.25 ± 0.33	4.50 ± 0.00
Jeddah University	2.91 ± 0.81	2.83 ± 0.86	4.52 ± 0.78	5.47 ± 0.74	4.33 ± 0.92
King Abdulaziz University	2.89 ± 0.79	2.81 ± 0.79	4.31 ± 0.83	5.54 ± 1.01	4.30 ± 0.85
Other Medical Colleges	3.05 ± 0.74	2.76 ± 1.04	4.29 ± 1.06	5.48 ± 1.08	4.43 ± 0.75
Taibah University	3.26 ± 0.90	2.89 ± 0.82	4.13 ± 0.76	5.74 ± 0.90	4.40 ± 0.88
Taif University	2.91 ± 0.86	2.84 ± 0.74	4.27 ± 0.78	5.35 ± 0.94	4.43 ± 0.72
Umm Al-Qura University	3.02 ± 0.71	3.07 ± 0.84	2.94 ± 1.68	5.47 ± 0.95	4.00 ± 1.22
p-value	0.047*	0.048*	0.025*	0.752	0.304

P, One-Way ANOVA; #, Independent samples *t*-test; *, $p < 0.05$(significant).

(100.0%) showing good awareness. Differences were also significant across medical schools ($p = 0.001$); students from Umm Al Qura University had the lowest proportion of good awareness (67.3%), while those from Jeddah University, Taibah University, and King Abdulaziz University had higher levels (85.5%-100.0%). Although Batterjee (100.0%) and Ibn Sina National College (50.0%) displayed noteworthy proportions, their markedly limited sample sizes ($n = 2$ and $n = 4$) preclude meaningful institutional comparisons and should not be taken as representative estimates.

Discussion

This study provides an important evaluation of triage knowledge and associated factors among medical student volunteers in the high-stakes environment of EDs during the Hajj. The findings reveal the students to have generally good overall awareness, but also uncover significant, domain-specific strengths and weaknesses that have direct implications for both medical education and mass-gathering medicine preparedness.

A main finding is the difference in skill across various triage domains. The students were found to have strong proficiency in triage color coding and acuity classification (78.4%) and operational procedures and preparedness (71.6%). This high level of knowledge in applied, often protocol-driven areas likely reflects the effectiveness of focused, practical orientation sessions provided to volunteers before or during the Hajj. The Hajj setting, with its effect on rapid quantity and clear protocols for conditions such as heatstroke and dehydration, appears to reinforce these practical aspects. This is consistent with studies on other mass gatherings, which have shown that targeted, context-specific training can significantly improve operational knowledge among healthcare volunteers [6,7].

However, the lower scores in principles and ethical foundations, clinical application, and decision-making are concerning and constitute the study's most significant revelation. While the vast majority knew the definition of triage, only half correctly rejected the "first-come, first-served" principle, and a substantial minority found it acceptable to prioritize by nationality

Table 5. *Association between sociodemographic and academic characteristics and overall triage awareness among medical student volunteers during Hajj season (N = 600).*

Category	Overall awareness level		*p*-value
	Poor	Good	
Age in years			0.737
18-20	17 (19.3%)	71 (80.7%)	
21-25	67 (16.8%)	333 (83.3%)	
26-30	17 (15.2%)	95 (84.8%)	
Gender			0.376
Male	27 (19.3%)	113 (80.7%)	
Female	74 (16.1%)	386 (83.9%)	
Nationality			0.620^
Saudi	98 (17.0%)	479 (83.0%)	
Non-Saudi	3 (13.0%)	20 (87.0%)	
Academic phase			0.049*^
Pre-clinical	29 (12.8%)	197 (87.2%)	
Clinical	72 (19.5%)	298 (80.5%)	
Intern	0 (0.0%)	4 (100.0%)	
Medical school			0.001*^
Batterjee	0 (0.0%)	2 (100.0%)	
Ibn Sina National College*	2 (50.0%)	2 (50.0%)	
Jeddah University	6 (8.0%)	69 (92.0%)	
King Abdulaziz University	27 (14.5%)	159 (85.5%)	
Other Medical Colleges	2 (9.5%)	19 (90.5%)	
Taibah University	4 (7.5%)	49 (92.5%)	
Taif University	23 (15.8%)	123 (84.2%)	
Umm Al-Qura University	37 (32.7%)	76 (67.3%)	

P, Pearson X^2 test; ^, Exact Probability test; *, $p < 0.05$ (significant).

in mass casualty events. This indicates that theoretical knowledge of triage does not automatically translate into a deep understanding of its core utilitarian and equitable ethical underpinnings. The poor performance in clinical application, the domain that bridges knowledge with action, suggests that students struggle with dynamic decision-making, such as integrating the mechanism of injury or understanding that triage is a continuous process requiring reassessment. This "knowing-that" versus "knowing-how" gap is well documented in medical education literature, indicating that students often perform better on factual recall than on clinical reasoning tasks [8,9]. Our findings extend this concept to disaster medicine, indicating that even volunteers with good theoretical awareness may be ill-prepared for the cognitive demands of real-time triage under pressure.

Notably, regarding the factors associated with knowledge, our study revealed the limited role of demographics and the salience of training. As seen in similar studies [10,11], age, gender, and nationality showed no significant association with overall triage awareness. This finding is encouraging, suggesting that baseline triage competency is not inherently linked to these demographics. The significant association of medical school affiliation with knowledge in several domains (principles, clinical application, and standardized systems) and with overall awareness is a critical finding. The notably lower performance of students from Umm Al Qura University compared to others, such as Jeddah University, points to considerable variability in how triage is incorporated into undergraduate medical curricula. This supports global research revealing a lack of standardization in disaster medicine and triage education across medical schools, leading to uneven preparedness among graduates [12,13].

The academic phase (pre-clinical *vs.* clinical) was significantly associated with overall awareness and domain-specific scores. Contrary to expectations, pre-clinical students showed higher overall awareness than clinical students. This conflicting result may be explained by the specific nature of the knowledge tested, which is strictly dependent on the recall of protocols and systems material that might be freshly acquired in a focused pre-Hajj training session attended more diligently by junior students. Clinical students, while having more exposure to patients, may not have received recent formal triage training, or their experiential learning may not have been systematically assessed by our knowledge-based tool. This interpretation is supported by the interns, the group with the highest score in operational preparedness and standardized systems, revealing that formal training combined with clinical experience yields the best outcomes. This confirms the necessity of integrating formal triage education throughout the curriculum, not as a one-off lecture but as a spiral curriculum reinforced by simulation and clinical practice [14].

A predominantly prominent result is the high level of self-reported confidence (87.5% felt confident in making triage decisions) compared with the low score in clinical application and decision-making. This disconnect represents a classic confidence–competence gap, which has been identified as a potential threat to patient safety in emergency care settings [15,16]. During a mass casualty incident during the Hajj, overconfident but underprepared volunteers may make incorrect prioritization decisions with serious consequences. This defect may stem from the practical experience of volunteering, which boosts confidence without concurrent robust feedback and assessment mechanisms to calibrate actual competency. Our findings raise concerns regarding volunteer healthcare workers in disasters, where enthusiasm must be matched with validated competence [17].

Our finding of good practical knowledge but weaker ethical and decision-making foundations mirrors studies on triage knowledge among nurses and junior doctors, where protocol familiarity is higher than ethical reasoning capability [18,19].

The study's strength lies in its large sample size within the unique, high-fidelity "living laboratory" of the Hajj.

Study limitations

One important limitation of this study is that the assessment of triage competency relied on a self-administered questionnaire measuring knowledge and self-reported awareness rather than an objective

evaluation of actual triage performance in clinical settings. Therefore, the findings may not fully reflect real-life decision-making abilities during emergencies. In addition, the cross-sectional design limits the ability to establish causal relationships between the identified factors and triage knowledge. Response bias may also have occurred because some questionnaire items were negatively phrased, which could have affected participants' interpretation and responses despite reverse scoring. Furthermore, the study population was limited to medical students volunteering during the Hajj season in Saudi Arabia, which may reduce the generalizability of the findings to other healthcare settings or populations. Finally, the very small number of interns included in the sample limits the reliability of comparisons involving this subgroup.

Conclusion

Medical student volunteers at the Hajj possess a strong foundational and practical awareness of triage protocols but have significant deficiencies in the ethical principles and applied clinical decision-making that are the bedrock of safe and effective triage. This competency profile is influenced more by institutional training differences and the timing of education than by demographic factors.

Implementing a standardized, competency-based triage curriculum in Saudi medical schools, in collaboration with Hajj health authorities, is recommended. Training should include simulation-based exercises to strengthen decision-making under pressure and address the confidence–competence gap. Structured assessments, such as objective structured clinical examinations or validated simulation evaluations, should be used to ensure a minimum level of proficiency before volunteering. Finally, triage education should be integrated longitudinally across the medical curriculum, from pre-clinical modules to clinical rotations, to reinforce knowledge and apply it consistently.

List of Abbreviations

ANOVA	Analysis of Variance
EDs	Emergency departments
KSA	Kingdom of Saudi Arabia
MOH	Ministry of Health
N	Number (Total sample size)
p	*p*-value
SPSS	Statistical Package for the Social Sciences

Conflict of interests

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

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Written informed consent was obtained from all the participants.

Consent for publication

Not Applicable.

Ethical approval

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Supplementary content (If any) is available online.

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