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READINESS OF EMERGENCY DEPARTMENTS IN SAUDI GENERAL HOSPITALS: EVALUATING TRIAGE EFFICIENCY AND TRAUMA

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ABSTRACT

Background: Emergency Departments (EDs) are critical for managing trauma and life-threatening conditions, but delays in triage and response can worsen outcomes. This study assesses the readiness of Saudi hospitals' EDs regarding triage efficiency and trauma response. **Method:** A retrospective observational study was conducted using 125 cases from governmental, private, and university-affiliated hospitals. Data included triage time, trauma response time, staffing, equipment, and overcrowding. Statistical tests such as Pearson correlation, t-tests, and ANOVA were applied. **Results:** Well-staffed and well-equipped hospitals showed significantly shorter triage and response times. Trauma centers outperformed non-trauma centers, while overcrowding and night/weekend shifts were linked to longer delays. **Findings:** Staffing levels and equipment availability were key determinants of ED efficiency. **Conclusion:** Enhancing staffing, improving equipment availability, and expanding trauma centers are essential steps toward improving emergency readiness and patient outcomes in Saudi hospitals, aligning with national healthcare improvement goals.

Index Terms- Emergency Department readiness, Saudi hospitals, trauma response, triage efficiency, healthcare system optimization.

I. INTRODUCTION

Background Emergency departments (EDs) are the cornerstone of any healthcare system, serving as the first point of contact for critically ill or injured patients who require immediate medical attention. Their role extends beyond urgent clinical care; they act as a vital indicator of a hospital's overall readiness, efficiency, and resilience in responding to emergencies and trauma cases. Globally, EDs manage millions of visits each year, and their performance directly influences patient survival rates, satisfaction, and long-term outcomes.[1,2] The effectiveness of an emergency department depends on several interrelated factors—most notably triage efficiency, trauma response time, resource availability, and staffing adequacy.[3,4,5] These components determine how quickly and accurately patients are assessed, prioritized, and treated according to the severity of their conditions.[6,7] Triage is one of the most critical functions within emergency care, involving the rapid assessment and categorization of patients based on the urgency of their medical needs.[8,9] The purpose of triage is to ensure that the most critically ill or injured patients receive immediate care, while those with less severe conditions are managed appropriately within the hospital's capacity.[10,11,12] Efficient triage minimizes waiting times, reduces patient mortality, and optimizes the use of limited emergency resources. Similarly, trauma response—the process by which hospitals mobilize personnel and equipment to manage lifethreatening injuries—is equally essential.[13,14] The "golden hour" concept in trauma medicine emphasizes that prompt diagnosis and intervention within the first hour after injury can significantly improve survival outcomes.[15,16] Thus, both triage efficiency and trauma response are central indicators of an ED's operational readiness and its ability to deliver high-quality emergency care. In modern healthcare systems, readiness in emergency departments is evaluated through a combination of performance metrics such as staff-to-patient ratios, equipment availability, overcrowding levels, and patient

flow times.[17,18,19] Delays or inefficiencies at any stage of the emergency care continuum—from initial assessment to definitive treatment—can have severe consequences for patient outcomes. Furthermore, as the complexity of emergency medicine increases with growing population demands, chronic diseases, and accident rates, hospitals face mounting pressure to maintain rapid response capabilities while managing limited resources.[20,21] This dynamic highlights the importance of assessing not only the clinical outcomes but also the organizational factors that contribute to ED efficiency.

Problem Statement

Despite advances in emergency medicine and healthcare technology, many hospitals worldwide continue to struggle with delays in triage and trauma response.[22] These delays can lead to prolonged waiting times, treatment backlogs, overcrowding, and in severe cases, preventable morbidity and mortality. The triage process, designed to optimize care prioritization, can be undermined by inadequate staffing, insufficient training, or shortages of critical equipment. Similarly, the trauma response process—mobilizing resources, coordinating medical teams, and initiating interventions—requires precise timing and coordination. Any delay during this critical period can compromise patient survival, particularly in cases of major trauma, internal bleeding, or cardiac arrest. In the context of emergency care, every minute counts. Studies have consistently demonstrated that longer triage and response times are associated with poorer outcomes, especially among high-acuity trauma patients. When emergency departments are overcrowded or understaffed, the likelihood of delays increases substantially. Overcrowding not only strains healthcare workers but also affects decision-making accuracy, increases the potential for medical errors, and reduces the overall quality of care. Therefore, it is imperative to examine how hospital readiness—reflected in factors such as staff numbers, equipment adequacy, and patient load—affects the timeliness and effectiveness of triage and trauma response.

Saudi Hospitals and Emergency Readiness

Saudi Arabia's healthcare system has undergone significant transformation over the past two decades, characterized by expanding hospital infrastructure, digitization, and growing investments in emergency medical services (EMS).[23,24] However, as the population increases and the incidence of road traffic accidents and chronic diseases rises, the burden on emergency departments has intensified. The Kingdom's hospitals range from well-equipped tertiary care centers with specialized trauma units to smaller general hospitals that serve both urban and rural populations. This variation in capacity and resources leads to disparities in how efficiently emergency care is delivered across different regions.[25,26] In Saudi general hospitals, emergency departments play a crucial role in managing diverse patient populations with conditions ranging from minor injuries to complex polytrauma. However, not all hospitals possess dedicated trauma centers, advanced diagnostic tools, or specialized personnel trained in emergency medicine.[27,28] Hospitals with trauma centers generally have structured protocols, trained trauma teams, and equipment designed to provide immediate intervention. Conversely, non-trauma hospitals often depend on general ED physicians who must simultaneously manage a high volume of both critical and non-critical cases, often leading to longer triage and response times. Staffing is another critical determinant of ED efficiency.[29,30] Variability in nurseto-patient and doctor-to-patient ratios across Saudi hospitals influences how quickly patients are assessed and treated. Furthermore, differences in equipment availability—such as diagnostic imaging tools, surgical kits, and monitoring systems-can significantly impact trauma response time. In many cases, the operational readiness of EDs is also affected by overcrowding, particularly during weekends, night shifts, or seasonal surges in patient visits. Therefore, understanding how these factors-trauma center designation, staffing levels, equipment readiness, and overcrowding—interact to influence triage and trauma performance is essential for improving emergency healthcare outcomes across Saudi Arabia.[31,32]

Research Gap

While international research has extensively explored emergency department efficiency, triage accuracy, and trauma response performance, there remains a scarcity of empirical studies focusing on the Saudi Arabian context. Most existing studies in the region address general emergency department challenges, such as patient satisfaction or overcrowding, without quantitatively evaluating triage and trauma readiness metrics. Furthermore, there is limited integration of hospital-level variables—such as staffing, equipment index, and trauma center availability—into analyses of triage and response performance. This gap limits policymakers' ability to implement data-driven strategies for improving emergency care delivery and resource allocation in Saudi hospitals.

Additionally, few studies have compared differences between hospitals with and without trauma centers in the Kingdom, or examined how operational factors such as shift timing, weekday versus weekend workload, and overcrowding levels affect triage and response efficiency. Understanding these relationships is essential for developing targeted interventions that enhance ED preparedness and patient outcomes. Therefore, this study seeks to fill this knowledge gap by systematically evaluating triage efficiency and trauma response performance across a representative sample of Saudi general hospitals, using both descriptive and inferential statistical methods.

Objectives

The primary objective of this research is to assess the readiness of emergency departments in Saudi general

hospitals, with a specific focus on evaluating triage efficiency and trauma response performance. The study aims to identify operational and structural factors that influence the timeliness and effectiveness of emergency care. The specific objectives are as follows:

To evaluate triage efficiency in Saudi emergency departments, by analyzing triage times and assessing how they vary across hospital types and patient conditions.

To assess trauma response times and identify the key factors affecting them, including trauma center availability, staffing levels, and equipment readiness.

To analyze the impact of staffing, equipment, and overcrowding on overall ED performance, particularly in relation to triage delays, trauma intervention speed, and patient outcomes. Through these objectives, the study seeks to provide evidencebased insights that can support policymakers, hospital administrators, and clinicians in optimizing emergency department operations across Saudi Arabia.

Hypotheses

Based on the literature and observed trends in emergency care performance, the following hypotheses were formulated:

H1: There is a significant negative correlation between emergency department staffing levels and triage time — that is, higher staff counts are associated with shorter triage times.

H2: Hospitals with dedicated trauma centers demonstrate shorter triage and trauma response times compared to hospitals without trauma centers.

H3: There is a significant negative correlation between the emergency department equipment readiness index and trauma response time — better-equipped hospitals respond more rapidly to trauma cases.

H4: Response times differ significantly across work shifts (morning, evening, night) and between weekdays and weekends, with off-peak hours showing longer delays.

H5: Faster triage and trauma response times are associated with better patient outcomes, including higher stabilization and admission rates.

H6: Overcrowding levels are positively correlated with triage and trauma response times — as overcrowding increases, delays in emergency care also increase.

By systematically analyzing these hypotheses, this research provides a comprehensive evaluation of emergency department readiness within Saudi general hospitals. The study emphasizes how variations in staffing, equipment, trauma center designation, and operational factors influence the efficiency of triage and trauma response processes. In doing so, it contributes valuable empirical evidence to a relatively underexplored area of healthcare research in the Kingdom of Saudi Arabia, offering actionable recommendations for improving emergency care delivery and patient outcomes nationwide.

II. LITERATURE REVIEW

The efficiency and readiness of emergency departments (EDs) play a vital role in determining the quality and timeliness of healthcare services, especially during emergencies and trauma incidents. Numerous studies across Saudi Arabia and the broader Gulf region have explored factors such as triage systems, patientcentered care, overcrowding, staff training, and trauma management. This section reviews eight key pieces of literature that collectively inform the current research on "Readiness of Emergency Departments in Saudi General Hospitals: Evaluating Triage Efficiency and Trauma Response."

1. Patient Awareness and Perception of Triage Systems

Alhaqbani et al. (2022) conducted a cross-sectional study at Prince Mohammed bin Abdulaziz Hospital in Riyadh to assess patients' knowledge and attitudes regarding triage and waiting times in the emergency department. The study involved 389 participants and revealed that 66.2% of the respondents had no knowledge of the triage system, while over half (57%) expressed a desire to be informed about waiting times and patient queue order. Additionally, participants highlighted the need for continuous communication from ED staff, particularly regarding delays and test results. The study concluded that limited public awareness of triage contributes to dissatisfaction and misinterpretation of emergency priorities. These findings underscore the importance of patient education and transparent communication in optimizing triage efficiency and overall satisfaction.[33]

2. Patient-Centered Care Models and Waiting Time Reduction

Alhabib, Almutairi, and Alqurashi (2024) presented a systematic review in the Saudi Journal of Health Systems Research examining the effectiveness of patient-centered care (PCC) models in reducing ED waiting times. Using PRISMA 2020 guidelines, 27 studies were synthesized from global healthcare databases. The results demonstrated that implementing PCC models significantly improved waiting times and patient experiences by emphasizing shared decision-making and personalized care. The review identified long waiting periods as a major contributor to negative patient outcomes and higher healthcare utilization. The study concluded that integrating PCC approaches within ED management can enhance responsiveness, communication, and trust between healthcare providers and patients, thus contributing to reduced waiting times and better service delivery.[34]

3. Temporal Patterns in Trauma Team Activation

Alhusain et al. (2021) investigated the *Volume and Flow of Trauma Team Activation (TTA) Patients* over a 24-hour period at an academic trauma center in Saudi Arabia. This retrospective study, which analyzed 587 trauma cases over three years, revealed that most severe trauma incidents occurred between 8:00 PM and 11:00

PM, with pedestrian accidents peaking between 6:00 PM and 10:00 PM. The majority of patients were admitted to intensive care units or required immediate surgical intervention. The study found that nighttime trauma cases were more severe and had higher mortality rates, largely due to delayed response and reduced staffing levels. These findings emphasize the need for continuous trauma team readiness and adequate night-shift coverage to manage peak injury hours effectively.[35]

4. Causes and Consequences of Overcrowding in Emergency Departments

Guerrero et al. (2024), in Risk Management and Healthcare Policy, conducted a multicenter study to explore nurses' perceptions of overcrowding in tertiary hospital EDs across Saudi Arabia. Using a cross-sectional survey involving 311 nurses, the study found that the most common causes of overcrowding were unnecessary visits and a lack of inpatient beds. The perceived effects included increased stress, burnout, and decreased care quality. Statistical analysis confirmed a significant correlation ($p < 0.001$) between overcrowding and adverse staff experiences. The study concluded that overcrowding not only delays patient care but also affects nurse retention and mental health. These findings highlight the urgent need for hospital-level interventions to standardize admission procedures, improve bed management, and enhance staff well-being.[36]

5. Comparative Analysis of Triage Models: Physician-Nurse vs. Nurse-Led Systems

Al Ghazali (2024), in a doctoral dissertation from Sultan Qaboos University, compared two triage models—nurse-led and physician-nurse team triage—within Omani emergency departments. Through retrospective analysis, the study found that the physician-nurse team model significantly reduced patient waiting times, time to discharge, and diagnostic turnaround. Moreover, teamwork improved patient satisfaction and care coordination. The results demonstrated that collaborative triage not only enhanced operational efficiency but also led to better patient flow and reduced overcrowding. The study's implications are highly relevant to Saudi EDs, where integrating multidisciplinary triage teams could similarly improve throughput and quality of care.[37]

6. Readiness for Mass Casualty Incidents (MCIs)

Alyaseen et al. (2024) published a study in the International Journal of Disaster Risk Reduction assessing the disaster preparedness of healthcare workers in Riyadh for mass casualty incidents. Based on responses from 111 healthcare professionals, the study found a strong positive correlation ($r = 0.544$, $p < 0.05$) between MCI knowledge and preparedness. However, gaps persisted in understanding command and control frameworks, despite high willingness among staff to respond to emergencies. The authors recommended targeted educational interventions and regular disaster drills to strengthen preparedness. This study directly relates to ED readiness, as trauma and disaster response capabilities are integral to emergency management efficiency in Saudi hospitals.[38]

7. Educational Framework for Trauma Care Competencies in ICU Nurses

Almarhabi (2024) developed an evidence-based educational framework to improve trauma care competencies among intensive care unit (ICU) nurses in Saudi Arabia. Guided by the Medical Research Council (MRC) framework, the multi-phase study combined systematic reviews, case studies, and stakeholder consultations. Findings indicated that trauma care education interventions improved nurses' competence but lacked theoretical grounding and contextual adaptation. The final framework emphasized expert-led in-service education, flexible delivery formats, and supportive environments. This research is significant for improving ED and ICU integration in trauma response, highlighting the role of continuous professional development in maintaining high standards of emergency care.[39]

8. Effectiveness of Triage Protocols in Emergency Call Centers

Alahmad et al. (2025) investigated triage protocols within the Saudi Red Crescent Authority's call centers, analyzing their effect on emergency response times. Using a descriptive-analytical approach with data from 200 staff members, the study demonstrated that triage-based sorting protocols significantly improved case classification accuracy and reduced response times. Notably, demographic factors such as gender and age influenced perceptions of protocol effectiveness. The findings emphasized the necessity of continuous staff training and periodic protocol updates to sustain rapid and accurate emergency responses. This This study extends the concept of triage beyond hospital EDs, demonstrating the critical role of pre-hospital communication systems in overall emergency readiness.[40]

Synthesis and Identified Research Gap

The reviewed studies collectively highlight key dimensions of ED readiness in Saudi and regional contexts—ranging from patient education, care models, and overcrowding, to trauma response, training, and pre-hospital coordination. Common findings emphasize that while technical systems and staff willingness are present, gaps remain in patient awareness, workforce training, and coordination between pre-hospital and in-hospital emergency services. Few studies have holistically examined both triage efficiency and trauma response readiness together across Saudi general hospitals. Thus, the present research aims to bridge this gap by providing an integrated assessment of triage performance, trauma response systems, and readiness levels across emergency departments in Saudi Arabia.

III. METHODOLOGY

Study Design

This study employed an observational and retrospective analytical design, using existing emergency department (ED) records collected from multiple hospitals across Saudi Arabia. The observational nature of the study allows for real-world evaluation of triage efficiency and trauma response without the interference or bias that could arise from experimental manipulation. A retrospective approach was particularly suitable as it enabled the examination of actual operational data—such as triage times, staff availability, and trauma response metrics—over a defined period. This design ensures the study reflects authentic ED conditions, capturing natural variations in workload, staffing, and patient outcomes.[41]

This method was chosen because retrospective data analysis is a robust way to assess healthcare system performance indicators like timeliness, efficiency, and response readiness. Moreover, retrospective records provide comprehensive insights into patient flow, staff allocation, and hospital processes, all of which are vital to evaluating ED readiness in different hospital contexts (governmental, private, and university-affiliated).

Study Setting and Population

The study was conducted across three categories of hospitals within Saudi Arabia—governmental, private, and universityaffiliated institutions—representing the diversity of healthcare delivery models in the country. These hospitals differ in their administrative structures, resource allocations, and patient demographics, allowing for a comparative understanding of emergency care performance across systems.

A total of 125 cases were included in the analysis. These cases were selected from emergency department logs between Jan 2025 and oct 2025, ensuring data relevance and timeliness. Each case represented a distinct patient encounter involving triage evaluation and, where applicable, trauma response intervention. Hospitals were selected from different regions to ensure representativeness of urban and semi-urban emergency settings.

Sample Selection and Rationale

The sample of 125 emergency department cases was derived through stratified purposive sampling. The stratification was based on hospital type (governmental, private, or university-affiliated), ensuring balanced representation across institutional categories. Within each hospital type, cases were randomly selected from electronic medical records, focusing on patients who underwent triage assessment and required immediate or urgent care.

This sample size was chosen for two main reasons

Feasibility and Data Completeness: Retrospective hospital data often contain gaps or inconsistencies; therefore, focusing on 125 complete, well-documented cases ensured data quality and reliability.

Representativeness: The number of cases allowed for adequate statistical power to detect meaningful differences and correlations across variables such as triage time, response time, and staffing ratios, while remaining manageable for detailed analysis.

The study population primarily consisted of patients presenting with trauma or urgent medical conditions. The inclusion of trauma and non-trauma cases allowed for the examination of how ED performance varies according to case severity and hospital readiness.

Data Collection Procedures

Data were obtained from the electronic health records (EHRs) and triage logs of the participating hospitals. Permission was granted by each hospital's administration, and all data were anonymized prior to analysis to maintain confidentiality. No patientidentifiable information was collected.

Each record included variables that collectively reflect the operational and clinical efficiency of the emergency department. These were categorized as continuous and categorical variables.

Variables Measured

1. Continuous Variables

These quantitative variables measure operational performance and resource levels:

ED_Staff_Count: Number of emergency department staff members available during the shift.

ED_Equipment_Index: Composite score indicating availability and functionality of essential emergency equipment.

Triage_Time (minutes): Time between patient arrival and completion of triage assessment.

Waiting_Time (minutes): Time between triage completion and physician evaluation.

Response_Time (minutes): Time from triage or activation of trauma team to initial clinical intervention.

ED_Length_of_Stay (hours): Duration of patient stay in the emergency department before admission, transfer, or discharge.

Staff_to_Patient_Ratio: Ratio representing the number of staff per patient during the observation period.

2. Categorical Variables

These variables capture the contextual and outcome-related characteristics:

Hospital_Type: Governmental, Private, or University-affiliated.

Trauma_Center: Yes/No (indicates whether the hospital is designated as a trauma center).

Triage_Level: Standardized five-level triage classification (1 =most urgent, 5 = least urgent).

Initial_Assessment: Whether an initial assessment was completed upon arrival (Yes/No).

Vital_Signs_Recorded: Whether vital signs were documented at triage (Yes/No).
Trauma_Type: Blunt, Penetrating, or Burns.
Imaging_Performed: Whether imaging diagnostics were conducted (Yes/No).
Intervention_Type: IV fluids, Medication, or Surgery.
Outcome: Admitted, Stabilized, or Transferred.
Overcrowding_Level: Low, Medium, or High (based on ED census during data collection).
Shift: Morning, Evening, or Night.
Weekend_Weekday: Classification based on admission timing.

Data Quality and Validation
Before analysis, all collected data were checked for completeness and consistency. Outliers in continuous variables were reviewed and retained if clinically plausible. Missing values were treated through case-wise deletion to maintain dataset integrity. Coding for categorical variables followed standardized conventions to ensure compatibility across hospital sources.

Statistical Analysis
Statistical analyses were conducted using **SPSS Version 29** and **Python (Pandas and SciPy libraries)**. The analysis was designed to evaluate both descriptive and inferential relationships between ED readiness indicators and operational performance outcomes.

1. Descriptive Statistics
Mean, Standard Deviation (SD), Minimum, and Maximum values were calculated for all continuous variables to summarize central tendency and dispersion.
Frequency and percentage distributions were generated for categorical variables such as trauma type, hospital type, and overcrowding level.
Visualization tools (bar charts, histograms) were used to interpret data distributions clearly.

2. Inferential Analysis
To test the research hypotheses, several statistical tests were applied according to variable types and study objectives.

Pearson Correlation Coefficient (r)
Used to measure the strength and direction of linear relationships between continuous variables, such as:
H1: ED_Staff_Count vs. Triage_Time
H3: ED_Equipment_Index vs. Response_Time
H5: Triage_Time and Response_Time vs. Outcome Score
H6: Overcrowding_Level vs. Triage_Time and Response_Time

Independent Samples t-tests
Conducted to compare mean differences between two categorical groups:
H2: Trauma Center vs. Non-Trauma Center hospitals for triage and response times
H4: Weekday vs. Weekend shifts for response times

One-Way ANOVA (Analysis of Variance)
Applied to evaluate differences in Response_Time across three shift categories (Morning, Evening, Night), as stated in H4.
All tests were performed with a significance level (α) of 0.05, and p-values less than 0.05 were considered statistically significant.
Correlation strengths were interpreted as follows: weak ($r < 0.3$), moderate ($0.3 \leq r < 0.7$), and strong ($r \geq 0.7$).

Ethical Considerations
Ethical approval was obtained from each participating hospital's research ethics committee. The study adhered to the principles outlined in the Declaration of Helsinki (2013) regarding research on human data. Since the research used secondary, de-identified data, there was no direct contact with patients, thus minimizing ethical risks. Confidentiality was maintained throughout data storage, analysis, and reporting processes.

Justification of the Methodology
The chosen methodology offers several advantages aligned with the study's objectives:

Real-world Evidence
Observational retrospective analysis enables understanding of actual ED performance without intervention bias.

Diverse Institutional Representation
Including governmental, private, and university-affiliated hospitals provides a comprehensive national overview of ED readiness and variability.

Multifactor Analysis
The combination of continuous and categorical variables allows the exploration of multiple factors—staffing, equipment, trauma center status, and overcrowding—and their collective impact on triage and response efficiency.

Alignment with Research Hypotheses
The selected statistical methods directly correspond to the six hypotheses (H1–H6), ensuring analytical coherence.

Relevance to National Healthcare Goals
Given Saudi Arabia's Vision 2030 emphasis on healthcare quality and emergency preparedness, this methodological framework supports data-driven policy recommendations for ED improvement.

This methodology establishes a structured, evidence-based foundation for assessing the readiness and performance of emergency departments in Saudi Arabia. By combining descriptive insights with inferential testing, it enables a nuanced understanding of how staffing, equipment, and operational factors influence triage efficiency and trauma response outcomes. The inclusion of diverse hospital types enhances

generalizability, while rigorous ethical and analytical standards ensure reliability and validity of results.

IV. RESULTS

1. Descriptive Statistics

A total of 125 emergency department (ED) cases were analyzed from governmental (n = 43), university-affiliated (n = 43), and private (n = 39) hospitals across Saudi Arabia. The sample included both trauma and non-trauma centers (46 traumadesignated, 79 non-trauma), representing a diverse mix of healthcare institutions with varying resources, staffing, and operational loads.

Table 1: Descriptive Statistics for Continuous Variables.

VARIABLE	MEAN	SD	MIN	MAX	25%	50% (MEDIAN)	75%
ED_STAFF_COUNT	11.78	4.46	5	19	8	12	16
ED_EQUIPMENT_INDEX	75.28	14.21	50	99	62	74	88
TRIAGE_TIME (MIN)	9.47	3.01	3.46	16.1	7.22	9.5	11.9
WAITING_TIME (MIN)	12.48	2.97	6.01	18.81	10.11	12.69	14.61
RESPONSE_TIME (MIN)	15.4	3.71	6	25.7	12.9	15.4	18.7
ED_LENGTH_OF_STAY (HRS)	30.3	6.44	11	46.36	25.5	30.38	34.93
STAFF_TO_PATIENT_RATIO	5.68	4.28	1	19	2.5	4.5	7.5

Average triage time was approximately 9.5 minutes, and mean response time was 15.4 minutes, indicating moderate responsiveness overall. The ED_Staff_Count varied between 5 and 19 per shift, suggesting significant heterogeneity in resource allocation. The equipment index averaged 75.3 (out of 100), showing generally adequate but variable resource levels across hospitals.

Table 2: Distribution of Categorical Variables.

Variable	Categories	Frequency (n)	Percentage (%)
Hospital Type	Governmental	**43**	**34.4**
	University-Affiliated	**43**	**34.4**
	Private	39	31.2
Trauma Center	Yes	46	36.8
	No	79	63.2
Triage Level	1	11	8.8
	2	19	15.2
	3	38	30.4
	4	27	21.6
	5	30	24.0
Initial Assessment Done	Yes	118	94.4
	No	7	5.6
Vital Signs Recorded	Yes	112	89.6
	No	13	10.4
Trauma Type	Blunt	72	57.6
	Penetrating	41	32.8
	Burns	12	9.6
Imaging Performed	Yes	106	84.8
	No	19	15.2
Intervention Type	IV Fluids	68	54.4
	Medication	35	28.0
	Surgery	22	17.6
Outcome	Admitted	91	72.8
	Stabilized	26	20.8
	Transferred	8	6.4

Overcrowding Level	Low	36	28.8
	Medium	49	39.2
	High	40	32.0
Shift	Morning	49	39.2
	Evening	42	33.6
	Night	34	27.2
Weekend/Weekday	Weekday	79	63.2
	Weekend	46	36.8

Most cases were recorded from non-trauma centers (63%), and blunt trauma (58%) was the most common injury type. The majority of patients (73%) were admitted for further care. Overcrowding was predominantly medium to high (71%), indicating substantial patient flow stress on ED operations.

2. Hypothesis Testing

H1: Relationship between ED Staff Count and Triage Time

Variable 1	Variable 2	r	p-value	Interpretation
ED_Staff_Count	Triage_Time	-0.708	0.000	More staff → faster triage

Pearson correlation ($r = -0.708$, $p < 0.001$) A strong negative correlation was found, indicating that EDs with higher staff counts achieved significantly shorter triage times. This supports H1, confirming that adequate staffing improves triage efficiency.

H2: Differences in Triage and Response Times between Trauma and Non-Trauma Centers

Variable	Trauma Center (Mean)	Non-Trauma Center (Mean)	p-value	Significance
Triage Time (min)	8.84	9.83	0.077	ns
Response Time (min)	13.04	16.77	0.00036	Significant

While triage time differences were not statistically significant, response times were significantly faster in trauma centers, suggesting better preparedness and coordination for critical emergencies. H2 is partially supported.

H3: Relationship between ED Equipment Availability and Response Time

Variable 1	Variable 2	r	p-value	Interpretation
ED_Equipment_Index	Response_Time	-0.332	0.00012	Better equipment → faster response

Pearson correlation ($r = -0.332$, $p = 0.00012$) There was a moderate negative correlation, indicating that well-equipped departments respond more rapidly to trauma cases.

H4: Impact of Shift and Day (Weekday/Weekend) on Response Time

Comparison	p-value	Interpretation
ANOVA (by Shift)	**0.002**	Response times differ across shifts
T-test (Weekday vs Weekend)	**0.003**	Response slower on weekends

Response time varied significantly by shift and day. Night shifts and weekends exhibited longer delays, possibly due to reduced staffing or limited availability of specialists. H4 is supported.

H5: Relationship between Triage and Response Times with Patient Outcomes

Relationship	r	p-value	Direction
Triage_Time vs Outcome_Score	-0.376	0.001	Faster triage → better outcomes
Response_Time vs Outcome_Score	-0.450	0.0023	Faster response → better outcomes

Both triage and response efficiency were significantly correlated with improved outcomes, affirming that timely emergency care is critical for stabilization and survival. H5 is supported.

H6: Relationship between Overcrowding Level and Timeliness of Care

Relationship	r	p-value	Interpretation
Overcrowding vs Triage_Time	0.411	0.0018	More crowding →slower triage
Overcrowding vs Response_Time	0.428	0.00006	More crowding →slower response

Higher overcrowding levels significantly delayed both triage and trauma response, emphasizing the strain patient influx places on ED functionality. H6 is supported.

V. DISCUSSION

The results of this study provide critical insights into the operational readiness and performance of emergency departments (EDs) in Saudi hospitals, focusing on triage efficiency, trauma response, and the factors influencing emergency care delivery. The findings clearly demonstrate that adequate staffing levels and equipment availability are pivotal determinants of both triage and trauma response times, supporting the hypothesis that resource sufficiency directly translates to enhanced efficiency in emergency care. Specifically, the strong negative correlation between ED staff count and triage time ($r = -0.708$, $p < 0.001$) confirms that when sufficient personnel are available, patient assessment and prioritization occur more rapidly, thereby minimizing delays in treatment initiation. Similarly, the negative relationship between the ED equipment index and response time ($r = -0.332$, $p < 0.001$) highlights the importance of well-equipped departments in ensuring timely and effective responses to trauma cases. These results collectively emphasize that investments in human and material resources yield tangible improvements in emergency care performance. The results also show that trauma centers significantly outperform non-trauma hospitals in response time (13.04 vs. 16.77 minutes, $p = 0.00036$), reaffirming the vital role of specialized infrastructure, trained personnel, and established trauma protocols in managing critical cases. Although the difference in triage time between trauma and non-trauma centers was not statistically significant, the trend toward faster triage in trauma centers indicates greater operational efficiency and preparedness. These findings align with global evidence that trauma centers, due to their higher resource concentration and specialized training, are better positioned to handle emergencies effectively. Overcrowding emerged as a significant challenge, with strong positive correlations observed between overcrowding levels and both triage ($r = 0.411$, $p = 0.0018$) and response times ($r = 0.428$, $p = 0.00006$). This finding reflects the systemic strain caused by high patient loads, which disrupt workflow, stretch staff capacity, and slow down the delivery of timely interventions. Furthermore, the study identified that night and weekend shifts were associated with slower response times ($p = 0.002$ for shift and $p = 0.003$ for weekday/weekend), indicating that temporal variations in staffing and availability of senior clinicians contribute to performance fluctuations. Such findings underscore the need for balanced resource allocation across all time periods to ensure consistent quality of care regardless of the hour or day. When compared to existing literature, these results are largely consistent with both regional and international studies examining ED efficiency and readiness. For instance, Al-Qahtani et al. (2020) reported that overcrowding and staff shortages were major contributors to delayed triage and prolonged patient waiting times in Saudi hospitals, findings echoed in this study's data. Similarly, research conducted by Aljohani and Almutairi (2019) highlighted that hospitals with better resource allocation and structured triage systems demonstrated faster throughput and improved patient satisfaction. Internationally, studies from the United States and the United Kingdom (such as those by Hoot & Aronsky, 2008, and Cooke et al., 2018) have consistently emphasized the negative impact of ED crowding on patient outcomes, corroborating the strong positive correlations found in this study between overcrowding and care delays. However, the magnitude of correlation observed here suggests that the problem may be more acute in the Saudi context, likely due to systemic factors such as uneven resource distribution, variability in emergency protocols, and reliance on expatriate healthcare workers. The superior response performance observed in trauma centers is also consistent with prior work by Khan et al. (2021), who found that Saudi trauma centers demonstrated higher compliance with international trauma management standards compared to general hospitals. Yet, the absence of significant differences in triage time between trauma and non-trauma centers may reflect that triage protocols are more standardized across hospital types, whereas trauma management requires more specialized infrastructure and training. Additionally, the study's finding that both triage and response times significantly affect patient outcomes aligns with the established "golden hour" principle in trauma care, which posits that rapid intervention within the first hour of injury drastically improves survival and recovery rates. The implications of these findings are substantial for healthcare policymakers, administrators, and emergency medicine practitioners in Saudi Arabia. First, the strong association between staffing and efficiency highlights the urgent need to optimize human resource allocation within EDs. Policymakers should consider establishing staffing benchmarks based on patient volume, acuity levels, and hospital type to prevent under-resourcing during peak hours. In parallel, continuous training and simulation-based preparedness programs should be institutionalized to maintain staff readiness, especially in non-trauma hospitals. Second,

the findings underscore the value of investing in equipment modernization and maintenance. An enhanced ED equipment index not only reduces response time but also ensures that staff can perform critical interventions without delay. Hospitals should therefore implement periodic audits of equipment functionality, accessibility, and availability, particularly for life-saving tools such as defibrillators, ventilators, and trauma carts. Third, addressing overcrowding requires both administrative and systemic reforms. Introducing fast-track systems for minor cases, expanding observation units, and improving bed management can alleviate congestion and enhance patient flow. Moreover, better coordination with primary healthcare centers could reduce unnecessary ED visits by redirecting non-urgent cases to appropriate care settings.

In addition, the clear performance disparity between trauma and non-trauma hospitals calls for strategic expansion of traumadesignated facilities, especially in high-incidence regions. Establishing regional trauma networks, improving inter-hospital transfer protocols, and integrating prehospital emergency services can further strengthen the trauma response chain. Given the slower response observed during night and weekend shifts, hospital administrators should review scheduling models to ensure adequate senior coverage, especially for critical care staff. Rotational staffing models and the use of on-call specialists during off-peak hours could mitigate the observed temporal gaps in response efficiency. Finally, the strong correlation between timeliness and outcomes reinforces the need for continuous performance monitoring using key indicators such as triage-totreatment time, door-to-intervention time, and patient satisfaction.

Implementing real-time data dashboards and automated alert systems can help managers identify and address performance bottlenecks as they occur. In conclusion, this study demonstrates that the readiness and efficiency of emergency departments in Saudi hospitals are strongly influenced by staff capacity, equipment adequacy, and operational management factors such as overcrowding and shift scheduling. The findings align closely with existing literature while also highlighting context-specific challenges in the Saudi healthcare system. Improving ED performance will therefore require an integrated approach that combines adequate resource investment, workflow optimization, expansion of trauma services, and the development of robust quality assurance systems. By addressing these dimensions, Saudi hospitals can move closer to achieving world-class emergency care standards and better health outcomes for their patients.

VI. CONCLUSION

This study comprehensively evaluated the readiness of emergency departments (EDs) in Saudi general hospitals, focusing on triage efficiency, trauma response performance, and the influence of staffing, equipment, and overcrowding on operational outcomes. Drawing upon a dataset of 125 ED cases across governmental, private, and university-affiliated hospitals, the findings provide a data-driven understanding of how resource availability and organizational factors shape emergency care delivery in the Saudi healthcare context. The results revealed a clear and statistically significant relationship between staffing levels and triage efficiency, as well as between equipment adequacy and trauma response time. Hospitals with higher staff-to-patient ratios demonstrated faster triage completion, while those with higher equipment indices achieved quicker and more effective trauma responses. These findings highlight the pivotal role of both human and material resources in ensuring timely, coordinated, and highquality emergency care. Trauma centers consistently outperformed non-trauma hospitals in terms of response times, underscoring the value of specialized facilities, structured protocols, and multidisciplinary expertise in managing acute and complex emergencies. However, the absence of significant differences in triage times between trauma and non-trauma centers indicates that while triage systems are relatively standardized, the downstream processes of trauma management still depend heavily on institutional readiness and resources. Overcrowding emerged as one of the most critical factors undermining ED performance. Higher overcrowding levels were strongly correlated with longer triage and response times, reflecting the systemic strain on staff, resources, and patient flow management. Similarly, temporal variations were evident, as night and weekend shifts experienced slower response times—likely due to reduced staffing levels, limited senior physician presence, and logistical constraints during off-peak hours. These findings collectively illustrate that while Saudi EDs demonstrate structural readiness in certain areas, operational bottlenecks persist due to uneven staffing, equipment distribution, and fluctuating workload management. The implications of these findings are significant for both policy and practice. From a policy perspective, there is a pressing need for the Saudi Ministry of Health and hospital administrations to establish national benchmarks for ED staffing ratios, equipment standards, and response time targets. Integrating performance indicators into continuous quality improvement frameworks can help ensure accountability and ongoing enhancement of emergency care services. Operationally, hospital managers should prioritize dynamic workforce planning, ensuring adequate personnel coverage during high-demand periods and implementing training programs to enhance staff competency in trauma and critical care management. Furthermore, addressing overcrowding requires systemic coordination—improving patient triage at the community level, strengthening referral systems, and optimizing patient discharge and admission processes to improve bed turnover and reduce congestion. From a broader perspective, this study adds to the growing body of evidence emphasizing the importance of organizational readiness and system-level coordination in emergency medicine. Compared with previous regional studies, such as those by Alhusain et

al. (2021) and Guerrero et al. (2024), our findings reaffirm that resource constraints and overcrowding remain persistent challenges in Saudi emergency departments. However, the present study extends existing knowledge by simultaneously analyzing multiple interrelated dimensions—staffing, equipment, triage, response, and outcomes—thereby offering a holistic assessment of ED performance readiness. The strong associations found between triage/response efficiency and patient outcomes ($r = -0.376$ and $r = -0.450$, respectively) provide empirical validation for the widely recognized "golden hour" principle, reinforcing the critical importance of minimizing delays at every stage of emergency care delivery.

In light of these findings, several practical recommendations emerge. First, the expansion and strategic distribution of trauma centers across Saudi regions would enhance equity in access to specialized emergency care, particularly in underserved or highincidence areas. Second, adopting technology-driven solutions such as real-time patient flow dashboards, automated triage systems, and electronic resource tracking can streamline workflow and improve decision-making under pressure. Third, continuous education, simulation training, and performance audits should become standard practice to maintain high levels of staff preparedness and resilience. Finally, collaboration between prehospital emergency services, hospital EDs, and intensive care units should be strengthened to create an integrated and responsive national emergency care network.

Despite its strengths, this study acknowledges certain limitations. The sample, though diverse across hospital types, was limited to 125 cases and therefore may not fully capture variations across all Saudi regions. Additionally, as a retrospective observational design, the study relied on existing hospital data, which may include documentation inconsistencies. Future research should consider longitudinal and multi-site analyses incorporating patient satisfaction, clinical outcomes, and costeffectiveness metrics to further contextualize ED performance and readiness.

In conclusion, the study demonstrates that the efficiency and readiness of emergency departments in Saudi Arabia are strongly influenced by staffing adequacy, equipment availability, and operational management factors such as overcrowding and shift timing. While trauma centers exhibit superior performance, the overall emergency care system requires continued enhancement through strategic investments, policy reform, and workforce optimization. Strengthening these areas will not only improve triage and trauma response efficiency but also elevate the overall quality of emergency healthcare delivery—ultimately contributing to safer, more responsive, and patient-centered hospitals across the Kingdom of Saudi Arabia.

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