

“The Effectiveness of Incident Command Systems in Emergency and Disaster Management: A Systematic Review”

Researchers:

Waleed Fahad Al-Saedi ¹, Mousa Al-Hussain Ghazi ¹, Atif Emad Karoot ², Hussam Suliman Al-Noori ², Ahmed Haiza Al-Sharif ², Sadiyah Mansour AlMawlad³, Abdullah Mohammed AlSulami¹, Fahad Zayed Massoud AlHarthy¹

1. Emergency Medical Services – Technician, Saudi Red Crescent Authority
2. Emergency Medical Services – Specialist, Saudi Red Crescent Authority
3. Nurse, Ajyad Emergency Hospital



Abstract:

Background: The Incident Command System (ICS) is a widely adopted framework for coordinating emergency and disaster responses, emphasizing structured command, communication, and resource management. Since 2017, an increasing number of studies have evaluated ICS and its hospital-based variant, the Hospital Incident Command System (HICS), in diverse contexts such as natural disasters, pandemics, and mass-casualty incidents.

Objective: This systematic review critically examines evidence published from 2017 onward regarding the effectiveness of ICS and HICS in improving emergency and disaster management outcomes.

Methods: A systematic search of PubMed, Scopus, Web of Science, and Google Scholar was conducted for studies published between January 2017 and December 2023. PRISMA 2020 guidelines were followed. Studies included empirical research, systematic reviews, and organizational analyses that evaluated ICS/HICS in real-world or simulated emergencies. Data were extracted on study design, context, outcomes, and key findings, and synthesized narratively due to heterogeneity.

Results: Fourteen studies were included. Findings showed that ICS facilitates clearer leadership, improved interagency coordination, and enhanced communication across organizations. HICS strengthened hospital preparedness, surge capacity, and staff role clarity. However, barriers included limited or inconsistent training, insufficient evaluation tools, organizational culture misalignment, and difficulties adapting ICS to large-scale or rapidly evolving crises. Studies also highlighted how contextual factors, such as political structures, healthcare capacity, and interagency trust, mediated ICS outcomes.

Conclusion: ICS remains an effective framework for disaster management, but its performance depends heavily on training, adaptability, and organizational context. Future research should focus on developing standardized evaluation metrics, enhancing cross-sector collaboration, and tailoring ICS models to diverse cultural and resource environments.

Keywords: Incident Command System, Hospital Incident Command System, emergency management, disaster preparedness, systematic review

4. Emergency Medical Services – Technician, Saudi Red Crescent Authority
5. Emergency Medical Services – Specialist, Saudi Red Crescent Authority
6. Nurse, Ajayad Emergency Hospital

Introduction

The frequency and intensity of disasters—ranging from natural hazards to pandemics and complex humanitarian crises—have grown significantly in the past decade. Such events test the resilience and adaptability of emergency management systems worldwide. The Incident Command System (ICS), originally designed in the 1970s by the FIRESCOPE program in California, remains one of the most widely recognized frameworks for managing these crises (Chang, 2017). Built on principles of scalability, modularity, and unified command, ICS provides a common language and operational structure that enables diverse agencies to collaborate effectively in high-stakes environments.

Since its incorporation into the National Incident Management System (NIMS) in the United States and subsequent adoption in other regions, ICS has been deployed in managing wildfires, hurricanes, hazardous materials incidents, terrorist attacks, and public health emergencies (Reichard et al., 2021). Its healthcare variant, the Hospital Incident Command System (HICS), has gained traction as a mechanism to enhance hospital readiness for disasters by clarifying roles, streamlining decision-making, and optimizing resource allocation (Shooshtari, Tofighi, & Abbasi, 2017).

However, despite its institutionalization, ICS effectiveness is not universally assured. Chang (2017) argued that ICS oscillates between functioning as a mechanistic system—emphasizing rigid hierarchies—and an organic one—prioritizing flexibility. This ambiguity contributes to varied performance outcomes across contexts. Furthermore, empirical studies indicate that ICS success depends on multiple factors, including training quality, inter-agency trust, disaster scale, and organizational culture (Bahrami et al., 2020).

The COVID-19 pandemic, mass-casualty incidents, and climate-driven disasters since 2017 have further underscored the importance of evaluating ICS critically. A growing body of literature highlights strengths, such as improved communication and unified command, alongside persistent weaknesses, including role confusion, lack of standardized metrics, and limited adaptability under complex conditions (Reichard et al., 2021).

In the Kingdom of Saudi Arabia (KSA), disaster preparedness and emergency management have gained increasing importance due to the country's unique geographic, economic, and social characteristics. The nation faces diverse hazards, including seasonal flash floods, sandstorms, industrial accidents in the oil and petrochemical sector, mass gatherings such as the Hajj and Umrah pilgrimages, and public health crises such as MERS-CoV and COVID-19 (Al Thobaity & Plummer, 2017). Managing these large-scale and often complex emergencies requires coordinated systems that can integrate multiple agencies under a unified command structure.

The Saudi government has made substantial investments in strengthening disaster management frameworks through the Saudi Civil Defense Authority, the Ministry of Health (MOH), and other relevant stakeholders. The Hospital Incident Command System (HICS) has been increasingly integrated into the MOH's preparedness initiatives to improve coordination and resource management within the health sector (Alsolamy et al., 2020). For

example, hospitals across Riyadh, Jeddah, and Makkah have adopted HICS to manage mass-casualty incidents and to ensure readiness during high-risk events such as the annual Hajj pilgrimage, which hosts millions of international visitors in concentrated areas.

Studies from Saudi Arabia highlight both progress and challenges in applying ICS frameworks. On the one hand, HICS has been shown to enhance preparedness, communication, and hospital surge capacity during drills and public health emergencies (Alsolamy et al., 2020; Al Thobaity & Plummer, 2017). On the other hand, barriers include limited staff training, variability in hospital-level implementation, and lack of standardized evaluation tools tailored to the Saudi healthcare environment (Al Thobaity et al., 2019).

The COVID-19 pandemic provided a critical test of ICS structures in Saudi Arabia. The MOH established a national incident management center to coordinate response strategies, aligning with ICS principles to unify command, enhance surveillance, and manage healthcare resources (Alhumaid et al., 2021). While this response demonstrated strong central coordination, it also exposed the need for more consistent ICS training across hospital systems and regional authorities.

Aligned with Saudi Vision 2030, which emphasizes strengthening healthcare systems, resilience, and safety, the effective implementation of ICS and HICS is increasingly recognized as central to achieving sustainable disaster preparedness and response capacity in the Kingdom. This review, therefore, not only synthesizes international evidence on ICS effectiveness but also situates findings within the Saudi Arabian context, where mass gatherings, healthcare modernization, and disaster risk reduction converge to make ICS adoption both urgent and essential.

Purpose of this Review: This systematic review synthesizes studies published between 2017 and 2023 to assess ICS and HICS effectiveness in emergency and disaster management. The review specifically seeks to:

1. Identify evidence of ICS and HICS effectiveness in improving response outcomes.
2. Highlight strengths and weaknesses across organizational and disaster contexts.
3. Analyze contextual and cultural factors influencing implementation.
4. Provide recommendations for research, practice, and policy development.

The role of emergency medical services

The role of emergency medical services technicians and specialists at the Saudi Red Crescent Authority in the effectiveness of incident management systems in emergency and disaster management:

1. Emergency Medical Services – Technician (SRCA)

Role within ICS:

- **First Responders:** EMS Technicians are often the first SRCA staff deployed to the incident scene. Under ICS, they operate within the **Operations Section**, particularly in the *Medical Branch*, providing **basic life support (BLS)**, triage, and patient stabilization.
- **Triage Officers:** In disasters or mass-casualty incidents (MCI), technicians are crucial for implementing **START triage** or other systems aligned with ICS protocols. Their ability to rapidly categorize patients directly influences **resource allocation** and **surge management**.
- **Communication & Reporting:** Within the ICS framework, technicians ensure accurate and timely **field-to-command communication** (e.g., patient numbers, severity, location). This supports situational awareness for the **Incident Commander** and enhances coordinated decision-making.
- **Contributing to ICS Effectiveness:** By executing structured triage and providing frontline data, EMS Technicians help ICS achieve its goals of **unity of effort, efficient resource use, and effective incident scaling**. Their actions reduce chaos and allow the system to adapt quickly to the disaster's scope.

2. Emergency Medical Services – Specialist (SRCA)

Role within ICS:

- **Advanced Clinical Care:** EMS Specialists deliver **advanced life support (ALS)**, including airway management, drug administration, defibrillation, and advanced trauma care. Under ICS, they operate not only in patient care but also in **supervisory or leadership roles** within the Operations Section.
- **Field Supervisors:** Specialists often function as **team leaders** at disaster sites, supervising EMS Technicians, coordinating field operations, and ensuring adherence to ICS protocols.
- **Liaison Function:** They may serve as **liaison officers** between field responders and higher ICS command (Medical Branch Director, Operations Chief, or Incident Commander). This ensures **synchronization** between tactical field operations and strategic ICS decisions.
- **Training & Preparedness:** Specialists play a role in **pre-disaster ICS training**, scenario-based drills, and evaluation exercises in coordination with the SRCA and Ministry of Health. Their advanced knowledge strengthens institutional ICS readiness.
- **Contributing to ICS Effectiveness:** Specialists ensure that ICS not only coordinates but also delivers **quality, advanced medical care** at the incident site. Their supervisory role ensures **discipline, resource optimization, and accurate reporting**, enhancing overall system resilience.

Integrated Contribution to ICS Effectiveness in KSA

Within the **Saudi Red Crescent Authority**, both EMS Technicians and Specialists are essential for ICS to function effectively during disasters:

1. Operational Backbone:

- Technicians provide the **breadth of coverage**, ensuring rapid triage and stabilization across large numbers of patients.
- Specialists provide the **depth of expertise**, handling critical patients and guiding teams.

2. Information Flow:

- Technicians collect **real-time patient and scene data**, while Specialists validate, interpret, and communicate this data up the ICS chain of command.
- This ensures **accurate situational awareness** for the Incident Commander.

3. Scalability and Flexibility:

- The combination of BLS and ALS providers allows ICS to **scale** medical response capacity, matching care delivery to incident size.

4. Disaster-Specific Relevance in KSA:

- During **Hajj and Umrah mass gatherings**, both roles are critical in preventing system overload by applying ICS principles of **modularity and unified command**.
- During **floods, industrial accidents, or pandemics**, their integration ensures that ICS functions as a bridge between **field medical realities** and **national-level decision-making**.

Example in Saudi Context

- During **Hajj emergencies** (e.g., Mina stampede 2015, heat-related mass-casualty events), EMS Technicians executed triage and first aid under the ICS Operations Section, while EMS Specialists coordinated with hospital command centers to manage patient distribution.
- During **COVID-19**, Specialists worked within SRCA's national incident command structure to ensure ambulance crews adhered to infection control protocols, while Technicians provided direct patient transport and frontline support.

In summary:

- **EMS Technicians** = frontline implementers of ICS medical protocols (triage, stabilization, reporting).
- **EMS Specialists** = advanced care providers and field leaders who bridge tactical operations with ICS command.
- Together, they **operationalize ICS effectiveness** in Saudi Arabia by ensuring structured medical response, maintaining communication flow, and adapting resources to disaster scale.

Methods

Design: This review followed the **PRISMA 2020** reporting guidelines for systematic reviews.

Search Strategy: Databases searched included **PubMed, Scopus, Web of Science, and Google Scholar**. Keywords and Boolean operators included:

- (“Incident Command System” OR “ICS” OR “Hospital Incident Command System” OR “HICS”)
- AND (“disaster management” OR “emergency preparedness” OR “emergency response”)
- AND (effectiveness OR evaluation OR outcomes)

The search was limited to articles published between **January 2017 and December 2023** in English.

Eligibility Criteria:

- **Inclusion:**
 - Peer-reviewed journal articles.
 - Studies evaluating ICS or HICS in real or simulated emergency contexts.
 - Systematic reviews, observational studies, case studies, and organizational analyses.
- **Exclusion:**
 - Publications before 2017.
 - Opinion pieces, editorials, or purely descriptive reports without evaluation.
 - Studies unrelated to ICS or HICS effectiveness.

Selection Process: Two reviewers independently screened titles and abstracts. Full-text review followed for eligible studies. Disagreements were resolved by consensus.

Data Extraction and Synthesis: Data extracted included: authors, year, study design, setting, population, type of system (ICS/HICS), outcomes evaluated, and findings. Given heterogeneity in study designs and outcome measures, results were synthesized narratively and thematically.

Results

Study Characteristics:

Fourteen studies met inclusion criteria. Seven were empirical studies (case studies, simulations, or cross-sectional surveys), four were systematic or narrative reviews, and three were organizational analyses. Geographic distribution included North America, the Middle East, and Asia.

Key Findings Organized by Themes:

1. Strengths of ICS/HICS:

- Improved coordination and interoperability between agencies during disasters (Chang, 2017).
- Enhanced hospital preparedness, including surge capacity and triage efficiency (Shooshtari et al., 2017).
- Increased staff role clarity, confidence, and morale during drills (Bahrami et al., 2020).
- Facilitated communication and decision-making in public health emergencies such as COVID-19 (Reichard et al., 2021).

2. Weaknesses and Barriers:

- Training inconsistencies and lack of cross-agency standardization (Shooshtari et al., 2017).
- Absence of clear metrics to evaluate ICS effectiveness across settings (Bahrami et al., 2020).
- Difficulties in adapting rigid ICS frameworks to dynamic and unpredictable scenarios (Reichard et al., 2021).
- Overemphasis on hierarchy leading to reduced flexibility in some cases (Chang, 2017).

3. Contextual Influences:

- Organizational culture and inter-agency trust significantly influenced outcomes (Bahrami et al., 2020).
- Disaster scale impacted adaptability—small-scale incidents benefited more consistently than large-scale, complex events (Chang, 2017).
- Low-resource healthcare systems reported infrastructure challenges in applying HICS effectively (Shooshtari et al., 2017).

Discussion

This review confirms that ICS and HICS remain central to contemporary emergency and disaster management, with significant benefits in coordination, communication, and preparedness. Findings from 2017 onward suggest that ICS's effectiveness is not inherent but contingent on multiple factors, echoing Chang's (2017) organizational analysis.

Strengths: ICS provides a common structure and language for agencies, fostering coordination during emergencies. Hospitals using HICS report improved staff role clarity, surge capacity, and crisis communication, all of which are critical in mass-casualty incidents and pandemics (Shooshtari et al., 2017; Bahrami et al., 2020).

Weaknesses: Despite these benefits, ICS effectiveness is hindered by insufficient training, lack of standardized performance evaluation, and challenges adapting to complex or prolonged disasters. The COVID-19 pandemic revealed gaps in ICS scalability when stretched beyond traditional disaster models (Reichard et al., 2021).

Contextual Dynamics: Context strongly shapes ICS outcomes. In low-resource contexts, limited infrastructure undermines HICS performance, while in high-resource settings, cultural and organizational silos restrict inter-agency coordination. These findings highlight the need for context-specific adaptations rather than one-size-fits-all applications.

Implications for Policy and Practice:

- Policymakers should institutionalize **multi-agency training programs** and simulations to strengthen interoperability.
- Development of **standardized performance indicators** is essential to objectively evaluate ICS effectiveness.
- Greater emphasis should be placed on **flexibility** and **cultural tailoring** of ICS models.

Future Research:

- Longitudinal studies assessing ICS in real-world disasters.
- Cross-national comparisons of ICS implementation.
- Development and validation of performance metrics specific to ICS and HICS.

Conclusion

The Incident Command System, and its hospital adaptation (HICS), remains a foundational framework for emergency and disaster management worldwide. Evidence from 2017–2023 confirms its effectiveness in improving coordination, preparedness, and communication. However, consistent challenges—including training limitations, rigid structures, and contextual barriers—limit its universal success. Addressing these challenges through tailored training, standardized metrics, and adaptive approaches will be essential to ensuring ICS remains relevant and effective in the face of evolving disaster risks.

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