TURKISH JOURNAL OF EMERGENCY MEDICINE

Invited Review Article

Access this article online
Quick Response Code:

Website:
https://turkjemergmed.com/

DOI:
10.4103/tjem.tjem_77_25

A review of mass casualty incident triage tools for hospital-based triage

Sarah S. Abdul-Nabi, Eveline Hitti*

Department of Emergency Medicine, American University of Beirut, Beirut, Lebanon
**Corresponding author*

Abstract:

Mass casualty incidents (MCIs) pose significant challenges to the healthcare systems, particularly in low-and lower-middle-income countries where prehospital triage is often limited, and hospitals face sudden surges of casualties. While triage tools have been widely studied for field use, their effectiveness in hospital-based MCI response remains unclear. This review examines peer-reviewed studies on hospital-based triage tools used during mass casualties, focusing on their accuracy and applicability. A comprehensive search of MEDLINE identified six relevant studies, conducted across various income settings and utilizing different methodologies, including simulation-based research, retrospective analyses, and real-world debriefings. Several tools were assessed, including Simple Triage and Rapid Treatment, the Modified CareFlight system, and homegrown triage models developed in Berlin and Iran. While some tools showed potential in prioritizing critically ill patients and managing resource allocation, their application in the real-world hospital settings remains insufficiently studied. Existing research is limited by small sample sizes, reliance on simulations, and a lack of validation in live MCI scenarios. Given these gaps, further research is essential to evaluate triage models in real-time, high-volume, and resource-limited environments to ensure effective hospital-based mass-casualty response.

Keywords:

Hospital preparedness, mass casualty incident, triage tools

Submitted: 24-02-2025
Revised: 29-04-2025
Accepted: 26-05-2025
Published: 01-10-2025

ORCID:
SSA: 0000-0002-2770-4740
EH: 0000-0001-9576-895X

Address for correspondence:
Dr. Eveline Hitti, P. O. Box 11-0236, Riad El-Solh, Beirut 1107 2020, Lebanon.
E-mail: Eh16@aub.edu.lb

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Introduction

Mass casualty incidents (MCIs) are increasingly recognized as a global threat due to the rising frequency of disasters, particularly in the resource-limited settings.[1] Effective MCI management relies on a well-structured triage system to prioritize patients for treatment and transport, preventing critical strain on the healthcare systems while at the same time directing resources toward patients who would most likely benefit from emergent care.[2] While field triage is standard in high-resource healthcare systems, many MCI prehospital care protocols in low- and lower-middle-income countries (LLMICs) prioritize patient transport over triage,[3] highlighting the need for hospital-based tools to optimize care during MCI responses.

In high-income countries (HICs), well-established emergency medical services (EMS) play a central role in filtering and distributing patients across the health system.[3] Strong command and control centers ensure that casualty care is coordinated across several hospitals, avoiding single hospital overwhelm.[4] In addition, the use of field triage protocols help filter minor injuries away from hospital-based care and direct critically injured patients to appropriate hospitals for specialized care.[5] Field triage in these settings has been extensively studied and reported,[5] leading to the development of multiple field triage strategies designed to address different types of incidents.[3]

How to cite this article: Abdul-Nabi SS, Hitti E. A review of mass casualty incident triage tools for hospital-based triage. Turk J Emerg Med 2025;25:251-5.

LLMICs face significant challenges in MCI response due to disproportionately high casualty rates, especially in the conflict zones. These challenges are exacerbated by underdeveloped EMS infrastructure, limited prehospital care, and strained hospital resources.[6,7] In many LLMICs, prehospital services primarily focus on patient transport rather than field care or triage, shifting the burden of both critically and noncritically injured patients entirely to hospitals and reducing the lead time needed to mobilize resources.[8,9] Furthermore, transport protocols in these settings typically direct patients to the closest available facility, leading to the majority of the casualty load being received at a single hospital within a short-time frame.[9] In these settings, hospital-based triage systems that can help medical teams quickly prioritize care and resources are essential for an effective MCI response.

While many hospital-based triage systems have been developed with extensive studies assessing reliability and effectiveness in resource allocation,[10] they can be complex and time-consuming. This complexity limits their applicability in MCI response,[11] especially in LLMIC contexts where receiving hospitals face rapid influx of large volumes of casualties. Furthermore, hospital-based triage systems focus on identifying and prioritizing the sickest patients for comprehensive care.[10] In contrast, MCI triage protocols are meant to be rapid, resource-conscious, and identify patients who would benefit the most from immediate care, with a focus on doing the greatest good for the greatest number of patients,[12] rather than optimizing individual patient care. Multiple MCI triage tools have been developed to address the need for speed, simplicity, and shifting priorities in MCI response.[13] The most studied MCI triaging tools, however were designed for field triage, with limited data on reliability and effectiveness in triaging MCI patients within the hospital-based context.[5]

Given the need for reliable and effective MCI triage tools, especially in LLMICs where hospitals face a rapid influx of large casualty loads, hospital-based triage is crucial. These tools help allocate limited resources efficiently, ensuring that patients who would benefit most receive immediate care. Therefore, identifying the most effective MCI triage tool for this context is essential. This paper aims to review and summarize all peer-reviewed studies that have explored the effectiveness of triage tools for use in MCI responses within a hospital-based context, to understand the strengths of existing tools for hospital-based use and identify gaps in the literature for future research.

Methods

The present study is a narrative review examining triage tools used for patient prioritization during MCI responses within the hospital settings. A comprehensive literature search was conducted in MEDLINE to identify the relevant peer-reviewed articles published in English between 2000 and January 2025. The search strategy incorporated Medical Subject Headings terms and keywords such as "mass casualty triage," "hospital triage," "disaster response," and "emergency department triage." Additional sources were reviewed through cross-referencing bibliographies of selected articles to ensure a broad and inclusive dataset.

Studies were included if they provided empirical data on hospital-based triage protocols applied in MCIs, reported on triage accuracy and sensitivity, or evaluated hospital-specific modifications of established triage systems. We excluded general review articles on triage, studies that lacked details on triage protocols, and those focusing on prehospital or field triage. Data extraction focused on the types of hospital triage tools implemented, their reported sensitivities and specificities, key operational challenges, and any noted limitations in their application.

The findings were synthesized to identify the patterns in triage tool performance, operational feasibility, and gaps in current knowledge. The review also highlighted country-specific adaptations and challenges, particularly in the resource-limited regions.

Results

Our review identified six studies that examined triage tools during MCIs for use within a hospital-based context. Table 1 summarizes our findings. Of these studies, 50% (3/6) were conducted in HICs, 16.7% (1/6) in an upper-middle-income country, and 33.3% (2/6) in a lower-middle-income country. Three studies evaluated MCI field triage tools at the ED entrance, including the Simple Triage and Rapid Treatment (START) triage tool (33.3%) and the modified Care Flight system (33.3%), while the remaining two studies (33.3%) developed homegrown triage systems for use in this context. The studies followed different approaches, including simulation-based studies, retrospective analyses, prospective observational studies, mixed-methods research, and real-world event debriefings. Their objectives varied, including assessing the effectiveness of the START protocol (16.7%), validating the Berlin Triage Algorithm (16.7%), comparing triage accuracy between START and Canadian Triage and Acuity Scale (CTAS) (16.7%), describing experiences in dealing with MCIs (33.2%), and developing a context-bound model of hospital triage (16.7%).

Discussion

This review summarizes the peer-reviewed studies on triage tools used at hospitals during MCI response,

Table 1: Hospital-based and adapted field triage systems used for mass casualty incident response in healthcare settings

Article name	Location (year of publication)	Aim of the study	Methodology	Number of casualties	Hospital triage (tool used)	Findings	Limitations
A pilot study examining the speed and accuracy of triage for simulated disaster patients in an ED setting: Comparison of a computerized version of CTAS and START methods	Canada (2021)	Compare triage nurse's time to triage and accuracy	Simulation-based study comparing START and CTAS in an ED setting	Nine vignettes with a mixture of six MCI and three non-MCI patients	CTAS and START	Triage nurses completed START triage faster than CTAS with similar level of accuracy between the two methods achieved	The use of either CTAS or START in the ED during MCI may be reasonable but choosing one method over another is not justified from this investigation
Simple triage and rapid treatment protocol for ED mass casualty incidents: A Taiwan experience	Taiwan (2019)	Assess the effectiveness of START protocol in ED	Retrospective analysis of MCI cases	47 patients	START	100% sensitivity for immediate and deceased categories and acceptable for predicting ED disposition	Retrospective, selection bias
The Berlin Hospital triage algorithm for the mass casualty incident	Germany (2020)	Validate and investigate the effect of the triage algorithm	Prospective observational study training exercises	15 mass disaster drills with 556 actors. The highest number of actors per drill was 181	Berlin screening algorithm	The triage algorithm showed a specificity of 97% and sensitivity of 75% for immediate life threatening	Done using simulated casualties
Developing a context-bound model for Hospital Triage in Disasters and Mass Casualty Incidents in the Health System of Iran	Iran (2023)	Develop a context-bound model of hospital triage in disasters and MCI in the health system of Iran	Mixed-methods study developing a context-specific triage model for Iran	Not applicable	Custom context-bound model (walking, airway, circulation, mental status)	Integrated global triage principles (e.g., START, SALT, Jump START, MPTT) while adapting to Iran's local conditions, resources, and disaster diversity	Has not been applied yet
Developing a hospital disaster preparedness plan for mass casualty incidents lessons learned from the downtown Beirut bombing	Lebanon (2017)	Description of experience in dealing with MCIs	Summary of debriefings	16 casualties within the first 30 min after the blast. 22 within the 1st h (total of 32)	Modified care flight	Prevent overloading of high acuity areas with low acuity patients	Might not be applicable for other hospital settings
Beirut port blast 2020: New Lessons learned in mass casualty incident management in the ED	Lebanon (2023)	Describe the hospital response to the Beirut port blast and outline lessons learned from managing a large-scale mass casualty incident	Descriptive analysis of the ED's response during the Beirut Port	360	Modified care flight	Effective elements included prompt activation of the disaster plan, crowd control and use of surge areas, and simplified triage using the modified care flight system	Lack of sensitivity and specificity metrics from triage tools

CTAS: Canadian Triage Acuity Scale, START: Simple triage and rapid treatment, SALT: Sort, Assess, lifesaving interventions, treatment/transport, MPTT: Modified Physiological Triage Tool, MCIs: Mass casualty incidents, ED: Emergency department

highlighting their strengths and identifying the gaps for future research. We identified five studies with varying objectives and methodologies. Research on the effectiveness of triage tools in hospital-based MCI response remains limited. None of the identified tools have been assessed through live activation, and while multiple hospitals have developed their own triage systems, these have neither been tested in simulations nor implemented in the real-world scenarios. The only study that applied a hospital-based triage tool did not assess its validity. This review highlights the need for further research on effective triage tools for hospital-based patient prioritization during MCI responses.

Various triage systems were analyzed across the studies. START was used in both retrospective and simulation-based settings. This system is designed for rapid MCI field triage, categorizing patients within 30–60 s based on four color-coded tags: Green (minor injuries/walking wounded), yellow (delayed care required), red (immediate care needed), and black (deceased or expectant). Triage decisions are based on key indicators, including the ability to walk, respiratory status (presence and rate), perfusion (assessed via capillary refill or radial pulse), and the ability to follow simple commands.[5,13] While START's effectiveness has been well studied for field triage,[13] its use in hospital settings remains less explored. The two studies evaluating its performance in hospitals found that the tool demonstrated 100% sensitivity for identifying patients in the immediate and deceased categories.[14] In a simulation-based study, START was faster than CTAS in an ED setting, with both methods achieving similar accuracy.[15] However, CTAS required a longer time for triage completion, between 10 and 15 min.[16] While these findings suggest that START may be an effective triage tool for hospital use during MCI, these studies has several limitations: None of the studies tested the tool during a live activation, raising concerns regarding reproducibility of the results in a real life context; furthermore, the number of patients in the scenarios the tool was tested in was small compared to what hospitals can experience in live activations, limiting the generalizability of the findings to large-scale incidents.

Homegrown MCI triage systems for hospitals have been developed in both Iran and Germany to address the gap in knowledge/tools in this area. The Berlin Hospital Triage Algorithm is a structured tool designed for MCIs, prioritizing patients using anatomical and physiological criteria, such as vital signs, level of consciousness, respiratory distress, and bleeding severity, with diagnostic integration like focus assessment with sonography for trauma. Designed for hospital settings, it takes around 2 min per patient, efficiently identifying critically injured cases but becoming time-consuming for stable patients who must undergo full assessment.[17] Tested for 15 mass disaster drills, with up to 181 casualties in the largest exercise, it demonstrated a specificity of 97% and a sensitivity of 75% for identifying life-threatening conditions.[17] Its main limitations include procedural complexity, the need for prior training, and limited applicability to pediatric patients. In addition, the study's reliance on prospective observational exercises with simulated casualties restricts its generalizability to real-world MCIs.

In Iran, a context-bound triage system was developed through mixed-methods approach, integrating elements from multiple global models, including START, SALT, and Jump START, while adapting classifications to local healthcare infrastructure and disaster response needs.[18] This disaster-focused model prioritizes patients based on walking ability, airway and respiration, blood circulation, and mental status, considering clinical importance, simplicity, and speed. This process begins with mobility assessment, followed by airway evaluation, radial pulse check, and mental responsiveness assessment. While designed for rapid assessment, the study does not specify the time required per patient. Despite its tailored approach, the model remains untested in actual MCIs, raising concerns about its practical effectiveness. Although various settings have adopted localized triage systems, many lack empirical validation and have neither been tested for sensitivity nor speed, highlighting the need for further research and real-world testing to ensure their reliability in MCIs.

Use of the Modified Care Flight Triage System for hospital triage in MCI was reported on two manuscript that described the hospital response to two distinct bombing incidents.[9,19] The Modified Care Flight Triage System is a rapid, physiology-based tool designed for MCIs, prioritizing patients based on simple assessments of mobility, respiratory status, circulatory status, and neurological function. Adapted from the original Australian Care Flight system, the modified version uses color-coded categories to classify patients by urgency. This system was applied during two major live MCIs: A car bombing and the Beirut Port ammonium nitrate explosion, resulting in 32 and 360 casualties, respectively. While it remains the only triage tool reported in live activations, neither study provided metric-based performance data, such as sensitivity or specificity, to assess its effectiveness in identifying patients most likely to benefit from immediate care. These limitations highlight the need for further research to validate the system's reliability and optimize its use in real-world mass casualty scenarios.

Call for Future Research

MCIs are becoming increasingly frequent in both HIC and LLMICs. With advanced weaponry, large scale MCIs are becoming more common, especially in LLMICs, highlighting the need for effective hospital-based MCI triage tools to help prioritize patients most likely to benefit from immediate care.[20] While several studies have attempted to address this knowledge gap, most were limited by the small number of casualties included in the study. Furthermore, no study to date has assessed the performance of existing tools in live activations. Future research should focus on evaluating the effectiveness of MCI triage systems for hospital-based use in real MCI scenarios to determine their reliability, accuracy, and speed of use in these contexts.

Author contributions
All authors participated in the planning, writing, editing, and review of this manuscript.

Conflicts of interest
None Declared.

Funding
None.

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