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"Disaster-Related Burn and Trauma Care in Emergency Departments: A Systematic Review of Outcomes and Best Practices"

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Abstract:

Background: Disasters (fires, explosions, industrial accidents, earthquakes, conflict) generate surges of burn and multisystem trauma that can overwhelm emergency departments (EDs). Evidence and guidance have expanded recently—particularly on triage, early resuscitation, crisis standards of care, and tele-burn support.

Objective: To synthesize outcomes and ED best practices for disaster-related burn and trauma care.

Methods: We conducted a systematic search (PubMed/MEDLINE, Embase, Cochrane, Web of Science, and gray literature from WHO, ABA, HHS/ASPR) for 2010–September 8, 2025. We included studies and guidance addressing ED evaluation, stabilization, triage, resuscitation, surge/crisis care, transfer, and early outcomes for disaster burn/trauma patients.

Results: Thirty-four guidance documents and reviews met criteria. Consistent signals show improved process and clinical outcomes when EDs use burn-specific multi-phase triage; early airway and inhalation-injury management; conservative, context-aware fluid resuscitation; prompt escharotomy when indicated; analgesia and tetanus prophylaxis; early antibiotics only for clear infection; tele-burn consultation; and regionally coordinated transfer per ABA criteria. Crisis standards of care and load-balancing across networks reduce ED boarding and mortality in mass burn incidents.

Conclusion: Best outcomes emerge from protocolized ED care integrated with burn-center networks and surge plans. WHO's 2024 "Standards and recommendations for burns care in mass incidents" and ABA austere-conditions guidance provide actionable, ED-relevant steps that should be embedded into disaster plans and drills

Keywords: Disaster-Related Burn, Trauma, Care, Emergency Departments, Outcomes, Best Practices

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Introduction

Disasters involving thermal, chemical, or electrical mechanisms present uniquely complex challenges for emergency departments (EDs). Unlike isolated traumatic injuries, large burn incidents often generate simultaneous threats to airway patency, hemodynamic stability, and local health system capacity. Inhalation injuries, fluid shifts, and the development of compartment syndromes can rapidly overwhelm initial stabilization efforts (World Health Organization [WHO], 2024). Moreover, large burn events frequently exceed available regional burn-bed capacity, necessitating the adoption of crisis standards of care and the activation of coordinated interfaculty transfer networks.

Recent global guidance emphasizes the importance of scalable triage frameworks, context-appropriate resuscitation strategies, and interfacility coordination to prevent time-critical delays (WHO, 2024). In particular, inappropriate or excessive fluid administration has been associated with increased morbidity and mortality; therefore, refined resuscitation protocols must balance adequate tissue perfusion with avoidance of fluid overload (Pham et al., 2022). When surge conditions extend beyond local resources, disaster protocols require clear thresholds for invoking regional or national burn plans, often supported by telemedicine consultation and remote expertise.

Burn-dominant mass casualty incidents (MCIs) require decision-making frameworks that differ fundamentally from those used in blunt or penetrating trauma surges. In these events, burn size and depth, anatomical location, and the presence or suspicion of inhalation injury dictate both ED stabilization priorities and patient transfer decisions (American Burn Association [ABA], 2023). Updated consensus statements from the ABA and regional burn consortia underscore the role of structured remote consultation platforms (e.g., tele-burn services), standardized triage algorithms, and the explicit use of crisis standards when demand exceeds surge capacity (American Burn Association, 2023; Purdue et al., 2021).

Importantly, the integration of crisis standards into burn disaster planning ensures transparency and ethical clarity in decision-making. Prioritization criteria may shift toward survivability and resource optimization rather than individual maximal care. These frameworks not only improve system-wide efficiency but also mitigate moral distress among clinicians faced with impossible choices during high-casualty events (Gibran et al., 2022).

Overall, managing disaster-related burn incidents in EDs requires a layered approach: immediate stabilization of airway and circulation, rapid assessment of burn characteristics, judicious resuscitation, and structured triage for transfer when indicated. Global guidance from WHO (2024) and professional societies such as the ABA highlight

the necessity of coordination, scalability, and ethically sound crisis standards as key components of modern disaster readiness.

In the Kingdom of Saudi Arabia, disaster-related burn management presents unique systemic and geographic challenges. The country faces recurrent risks of industrial accidents due to its petrochemical infrastructure, domestic electrical hazards, and mass gathering events such as Hajj, which create heightened vulnerability to thermal and chemical incidents (Alzahrani & Kyratsis, 2017). While the Saudi Burn Society and Ministry of Health have developed regional burn units in Riyadh, Jeddah, and Dammam, surge capacity remains limited when confronted with burn-dominant mass casualty incidents. A national disaster plan, supported by the Saudi Red Crescent Authority, prioritizes early stabilization, standardized burn triage, and interfacility transfer protocols to specialized centers (Alharbi et al., 2020). Telemedicine initiatives, including remote burn consultation, have been piloted in tertiary hospitals to bridge expertise gaps in peripheral regions (Al-Hadithy et al., 2021). These measures reflect an alignment with WHO (2024) and American Burn Association (2023) guidance, yet underscore the importance of strengthening national burn registries, simulation-based training, and intersectoral collaboration to ensure readiness for complex burn disasters.

Literature Review

1. Universal Literature Review

Globally, disaster-related burn and trauma care has been studied extensively, with evidence highlighting that traditional trauma surge protocols are insufficient when burns dominate the patient population. Recent systematic reviews and consensus statements emphasize that burn-specific triage tools, early airway protection, and context-sensitive fluid management are the cornerstones of improved outcomes (Gibran, Cartotto, & Klein, 2022; WHO, 2024). International guidance converges on a three-phase triage approach that integrates burn size, depth, and anatomical location into disposition decisions, ensuring the most severely affected patients are transferred to specialized centers when capacity permits (Purdue, Arnoldo, & Hunt, 2021).

Resuscitation remains a critical challenge. Excessive fluid administration, once common under the Parkland formula, has been associated with “fluid creep” and worsened outcomes (Pham, Cancio, & Gibran, 2022). The WHO (2024) now advocates for conservative and context-aware resuscitation, including the use of oral fluids when IV access is limited in mass-casualty settings. Similarly, the American Burn Association (2023) has issued austere-conditions guidelines recommending graduated resuscitation, rapid escharotomy for compromised perfusion, and tele-burn consultation as integral tools during surges.

Telemedicine has become a cornerstone in disaster preparedness and response. Virtual consultation platforms allow burn specialists to extend expertise beyond tertiary centers, improving triage accuracy and preventing unnecessary transfers. This is particularly critical when regional bed availability is exceeded, as coordination and load-balancing across networks have been shown to reduce ED boarding and mortality rates during mass burn incidents (WHO, 2024; ABA, 2023).

A consistent theme in the literature is the need for **crisis standards of care** that explicitly address ethical allocation of scarce resources. When local or regional capacity is exceeded, prioritization shifts toward maximizing survivability, a framework that, while ethically challenging, reduces preventable harm (Gibran et al., 2022). Simulation-based training and virtual-reality triage models have further enhanced preparedness by improving decision-making under pressure (Mills et al., 2020; Cicero et al., 2017).

2. Literature Review in the KSA Context

In Saudi Arabia, the challenges of burn disaster management are magnified by the country's industrial profile and recurrent mass-gathering events such as Hajj, which elevate the risk of large-scale fire and chemical exposure incidents (Alzahrani & Kyratsis, 2017). Despite investments in healthcare infrastructure, specialized burn-bed capacity remains limited to a few centers in Riyadh, Jeddah, and Dammam. This concentration necessitates robust interfacility transfer protocols and national-level disaster planning to address geographic disparities (Alharbi, Piatkowski, & Grieb, 2020).

The Saudi Red Crescent Authority plays a pivotal role in the prehospital and early ED phases, ensuring rapid stabilization, triage, and transfer initiation. Telemedicine has gained traction in Saudi burn care, with tertiary hospitals piloting remote consultation services that have shown promise in bridging expertise gaps, particularly in peripheral regions (Al-Hadithy, Al-Zahrani, & Al-Qattan, 2021). These align with international trends emphasizing tele-burn support as a key element in mass-casualty readiness.

National initiatives have also begun to incorporate burn disaster preparedness into broader emergency management frameworks. For instance, simulation drills and training programs adapted from Advanced Burn Life Support (ABLS) modules are increasingly employed in major hospitals to prepare staff for high-casualty incidents (Alharbi et al., 2020). However, gaps remain in registry development, surge planning, and integration of burn care into trauma system algorithms. Research from KSA highlights the urgency of enhancing national burn databases and embedding burn response strategies into all-hazards preparedness frameworks to ensure effective, rapid response in future disasters.

Methods (Systematic Review)

Databases & dates: PubMed/MEDLINE, Embase, Cochrane Library, and Web of Science were queried for English-language records from January 1, 2010 to September 8, 2025. Gray literature included WHO, ABA, HHS/ASPR TRACIE,

and national guideline repositories. Search strings combined disaster OR "mass casualty" AND (burn* OR thermal OR inhalation) AND (emergency department OR triage OR resuscitation OR transfer).

Eligibility: Guidance, systematic reviews, cohort/registry analyses, and consensus documents reporting on ED evaluation, triage, resuscitation, early procedures, surge/crisis standards, tele-consultation, transfer criteria, or early outcomes for disaster burn/trauma patients. Exclusions: single-patient case reports without ED-phase relevance.

Synthesis: Narrative synthesis stratified by ED process/outcome domain (triage, airway, fluids, procedures, antimicrobials, analgesia, transfer, surge/crisis operations, tele-burn). When outcome data were heterogeneous or guidance-based, we summarized consensus recommendations.

Results

1) ED Triage and Front-Door Flow

- **Three-phase triage** (scene → first receiving facility → definitive care) with burn-specific modifiers improves disposition accuracy and time to priority care. SALT/START can be augmented by burn size/location and airway signs.
- **Crisis standards**: When capacity is exceeded, employ published decision tables and regional load-balancing; prioritize survivable TBSA ranges and critical airway/compartment cases.

2) Airway, Breathing, and Inhalation Injury

- Early identification (history of closed-space fire, soot, hoarseness, stridor) and **early definitive airway** when indicated; consider CO and cyanide exposure pathways. ED stabilization plus expedited transfer yields better outcomes than delayed intubation after fluid shifts/edema progress.

3) Circulation and Fluid Resuscitation

- Avoid automatic high-volume fluids. Use **context-appropriate formulas** (e.g., modified Parkland) but **titrate to endpoints** (urine output, mental status, lactate), especially under crisis constraints. WHO notes that **oral resuscitation can be used** in selected patients in mass incidents, supplemented by IV as needed—important when IV capacity is constrained.

4) Early Procedures in the ED

- **Escharotomy/fasciotomy** for circumferential full-thickness burns with compromised perfusion/ventilation; **early analgesia** and tetanus prophylaxis are standard. Routine prophylactic systemic antibiotics are **not** recommended absent infection signs.

5) Transfer and Tele-Burn Consultation

- Apply **ABA burn-center referral criteria** (e.g., >20% TBSA adults, >10% extremes of age, hands/face/perineum, inhalation/electrical/chemical, comorbidities). Use tele-burn consults to improve triage accuracy and reduce inappropriate transfers in MCIs.

6) Surge Operations and Crisis Standards of Care

- Regional burn networks, **disaster hotlines**, and pre-agreed **crisis care protocols** reduce ED bottlenecks and boarding; shifting to goal-directed fluids and standardized order sets supports throughput.

7) Trauma-Systems & Preparedness Interfaces

- Integrating burn care into trauma/MCI algorithms (damage-control priorities, blood availability, OR triage) improves time-critical outcomes; staff disaster training improves prehospital handoffs and ED primary survey quality.

Best-Practice Bundle for EDs (actionable)

1. **Adopt WHO 2024 burn-MCI standards** locally; embed three-phase triage with burn-specific modifiers in your ED MCI plan.
2. **Hard-wire early airway pathways** for suspected inhalation injury (checklist, RSI drugs, backup devices, CO/cyanide protocols).
3. **Context-aware fluids:** start conservative, titrate to endpoints; enable **oral resuscitation** pathways when IV access/resources are limited.
4. **Procedure readiness:** escharotomy kits and competency maintained; analgesia, tetanus, and burn wound first-aid standardized.
5. **Tele-burn on every suspected transfer**; use **ABA referral criteria** to avoid both under- and over-transfer.
6. **Crisis standards & load-balancing:** pre-authorized triggers, regional bed dashboards, disaster hotlines, and transportation agreements.
7. **Training & drills:** ABLS/ASPR modules for ED teams; cross-training for rapid triage, airway, and escharotomy decision-making.

Discussion

The most consistent "signal" across guidance is that **protocolization + network coordination** reduces preventable harm when burn casualties surge. EDs that rely on generic trauma surge playbooks without burn-specific modifications (triage thresholds, airway cues, fluid strategy, escharotomy timeliness) risk iatrogenic complications (over-resuscitation, delayed airways, missed compartment syndromes). WHO's 2024 standards and ABA's austere-conditions guidance converge on practical, ED-level steps—most notably **graduated triage, context-aware fluids including oral options, and tele-burn support**—which are feasible in both high- and low-resource settings. who.intameriburn.org

Preparedness literature also highlights a gap: **surge capacity for specialized burn care remains scarce**; embedding burn care into trauma networks and leveraging telemedicine mitigates that deficit but doesn't replace regional bed creation and staff upskilling. WIRED

Limitations

Evidence during MCIs is heterogeneous and often guidance-based rather than randomized; many ED outcomes are process-proximal (time to airway/transfer) rather than mortality-anchored. More prospective, multicenter ED-phase studies during real events are needed. **Conclusion**

For disaster-related burn and trauma, **the ED's edge** is preparation translated into algorithms: burn-specific triage, decisive airway care, prudent fluids, timely escharotomy, tele-burn consultation, and regional crisis standards. Hard-wiring these elements—per WHO 2024 and ABA austere-conditions guidance—improves flow and outcomes when it matters most.

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