A Validation Study of 5 Triage Systems Using Data From the 2005 Graniteville, South Carolina, Chlorine Spill

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Introduction: Lack of outcomes-based research results in uncertainty about the effectiveness of any of the current triage systems in determining priority of care during actual chemical disasters. The purpose of this study was to determine whether the level of injury severity extrapolated from 5 triage systems correlated with actual injury severity outcomes of victims exposed to a chlorine disaster.

Methods: Using secondary data analysis, data for 631 victims were merged, de-identified, and analyzed. Using logic models from the triage systems, the actual injury severity was compared with the extrapolated injury severity classifications.

Results: Analysis showed weak to modest correlations between the extrapolated injury severity triage outcome classifications and the actual injury severity outcomes (Spearman correlation range 0.38 to 0.71, $P < .0001$). There was slight to fair agreement between the extrapolated injury severity triage outcome classifications and the actual injury severity outcomes (weighted κ = - 0.23 to 0.42).

Discussion: The extrapolated injury severity triage outcome categories from the 5 triage systems did not agree with the actual injury severity categories. Oxygen saturation measured by pulse oximetry provides early indications and is very predictive of outcome severity in incidents involving irritant chemical exposures such as chlorine, and should be a part of a mass casualty protocol for any irritant chemical incident. Additional research is needed to identify the most sensitive clinical measures for triaging victims of toxic inhalation disasters.

Key words: Triage; Mass casualty incident; Chemical incidents; Validation study

Effective response to mass-casualty incidents, which encompass a broad spectrum of threats and hazards, represents one of the greatest challenges to our nation's emergency response infrastructure.[1] Natural, unintended (technological), or deliberate catastrophic events (all-hazards events) will necessitate the effective and timely management of mass casualties.[2,3] Chemical incidents involving irritant chemicals such as chlorine pose a significant threat to life and require rapid assessment. In the aftermath of a disaster such as a large chemical spill, first responders have only seconds to evaluate the condition of a victim before moving to the next victim. Casualties generated by such disasters can overwhelm health care capabilities, jeopardizing the lives of victims and health care providers alike.[1] To mitigate the "surge" of casualties into a health care facility after a mass-casualty event, hospitals and emergency responders use triage to assess patients and prioritize care with the goal of saving as many lives as possible. However, the proposed national guideline for existing mass-casualty triage does not take fully into account all-hazards events[4] that include chemical incidents

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TABLE 1
Five triage systems used for triage simulation studies based on abstracted hospital record data for 2005 Graniteville, South Carolina, chlorine spill

Triage system	Description
START[7] (field triage system)	Uses ability to walk, respirations, circulation, and mental status for individuals aged ≥8 y
JumpSTART Pediatric Triage Algorithm[8] (field triage system)	Uses same assessments as START but is designed for individuals aged <8 y and includes a more comprehensive neurologic assessment
SALT[9] (field triage system)	Uses ability to walk, respirations, pulse, mental status, available resources, and injuries to assess individuals aged ≥8 y
CBRN[6] (field triage system)	Uses ability to walk and respirations and is the only system that additionally assesses contamination and toxidrome [a] symptoms related to chemical, biological, radiologic, or nuclear incidents to assess individuals aged >8 y
ESI[10] (emergency department—based system)	Uses patient acuity, pulse, respiration, SpO_2, and number of resources needed for all ages

CBRN, Chemical/Biological/Radiologic/Nuclear Mass Casualty Triage System; ESI, Emergency Severity Index; SALT, Sort, Assess, Lifesaving Interventions, Treatment/Transport; START, Simple Triage and Rapid Treatment; SpO_2, arterial oxygen saturation measured by pulse oximetry.
[a] Toxidrome refers to a group of symptoms or a specific syndrome associated with exposure to a specific poison or agent.[5,6]

requiring decontamination and toxidrome (a group of symptoms or a specific syndrome associated with exposure to a specific poison or agent[5,6]) assessment.

This study evaluated 5 frequently used triage systems: (1) Simple Triage and Rapid Treatment (START)[7]; (2) JumpSTART[8]; (3) Sort, Assess, Lifesaving Interventions, Treatment/Transport (SALT)[9]; (4) Chemical/Biological/Radiologic/Nuclear Mass Casualty Triage System (CBRN)[6]; and (5) Emergency Severity Index (ESI).[10] Table 1 describes each of these systems.

Mass-casualty research is not suitable for randomized, controlled, experimental exposure studies. Therefore current mass-casualty research designs and evaluation strategies usually are anecdotal, and many of the data reported have little external validity.[11–14] The ability to collect accurate, timely, and valid data at the time of an incident is difficult. Because data are often missing or biased, it is impossible to test the utility of a specific model. There is no gold standard for measuring the efficacy of triage.[1,15] Strategies are needed to study the accuracy and efficacy[16,17] of initial triage from actual mass-casualty datasets.

Lack of outcomes-based research results in uncertainty about the efficacy of any of the triage systems on patient outcomes.[18] This research builds on the work of Lerner et al,[4] Kirk and Deaton,[19] Jenkins et al,[17] Wenck et al,[20] and Van Sickle et al[16] in identifying the most relevant and appropriate data needed for initial triage of mass casualties using an all-hazards approach. For this study, initial triage assessments made by first responders, ED personnel, and primary care providers were used so that a priority code for treatment and/or transport could be determined.

On January 6, 2005, a freight train carrying tanker cars of liquid chlorine was inadvertently switched onto an industrial spur in the center of Graniteville, South Carolina, where it crashed into a parked locomotive. The train derailed and heavily damaged chlorine tankers ruptured, immediately releasing approximately 60 tons of chlorine.[5,21] Within minutes, the dense chlorine gas infiltrated the surrounding town with a population of over 7,000 persons. Nine people died, 71 were hospitalized, 840 were treated as outpatients, and 220 had immediate health problems including skin, eye, nose, and throat injuries.[16,21] The South Carolina Department of Health and Environmental Control (SC DHEC) and epidemiologists from the Centers for Disease Control and Prevention (CDC) collected data at the scene during the first few weeks after the incident.

The purpose of this research was to identify and validate triage systems appropriate for use in chemical events using the Graniteville data. The research questions were as follows: Do 5 currently used triage systems correlate with the level of care needed after a chemical mass-casualty event, such as a chlorine spill? What, if any, additional information would improve accurate triage classifications during chemical incidents?

Methods

DESIGN

This report presents the results of a secondary data analysis used to study the efficacy of 5 triage systems, using data from a real chemical mass-casualty event. The Division of