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# A review of the literature on the validity of mass casualty triage systems with a focus on chemical exposures

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## INTRODUCTION

Our world is full of disasters that frequently result in mass casualties. On average, a disaster occurs in the world each day.[1] Disasters can be natural or technological,[1] unintended or deliberate incidents that bring together a multidisciplinary work force under extreme conditions to determine the priority of care for victims. Disasters produce an imbalance between medical needs and available resources due to the large number of casualties. The large number of casualties necessitates triage strategies to mitigate the imbalance. Thus, the primary goal of triage is to identify patients who have the greatest chance for survival with healthcare intervention and to optimally use limited resources. Triage of casualties must be performed accurately and efficiently if providers are to do the greatest good for the greatest number during times of mass casualty incidents (MCI).

Mass casualty research is not suitable for randomized, controlled, experimental studies due to the nature of the incidents. Therefore, current research designs and evaluation strategies usually are anecdotal and much of the data reported has little external validity because no common factors seem able to be identified for generalization to other incidents. Essentially, no two MCI are exactly alike.[2,3] Sundnes and Birnbaum[4] discussed the impediments that influence the conduct of such research and evaluation, namely, lack of uniformly accepted standardized definitions, incomplete and inaccurate documentation, and lack of an accepted set of indicators for specific aspects of MCI.[4–6]

To reduce death and disability, it is essential that MCI victims receive life-sustaining care within a few minutes of injury.[7,8] When casualties overwhelm available resources the ability of healthcare providers to do the greatest good for the greatest number is predicated on the validity, reliability, and effectiveness of the triage data collected. Incorrectly performed triage can underestimate the need of critically injured patients for immediate care, resulting in preventable deaths or deformities (under-triage) or can overestimate the extent of minor

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injuries, resulting in mortality or disability of patients with more severe injuries (over-triage).[9–16]

## Mass Casualty Triage

MCI may include a range of functions in addition to mass casualty triage such as: rescue from a potentially dangerous environment; decontamination if appropriate; rapid stabilization; and transport to the appropriate definitive treatment facility.[17–22] MCI bring together emergency responders with a wide skill mix from cross-jurisdictional agencies who may never have worked together before, who use different triage systems, and who are often thrust into unfamiliar roles and tasks.[23] Environmental contextual factors such as the nature of the MCI (natural, technological, unintended or deliberate incident), duration, setting, and size also influence the ability of the responders to care for victims.[24] The multiplicity of triage systems used both within and outside the United States causes confusion.[25] The skill mix and characteristics of the responders and their unfamiliarity with roles, triage systems and tasks influence their ability to gather and process data rapidly, which influences their triage efficiency and healthcare outcomes.[78] The outcomes of care are dependent upon the ability of first responders to work cooperatively across jurisdictional lines to accurately and efficiently prioritize victims for care given the resources available.

The ability to identify and treat patients that have the greatest chance for survival with healthcare intervention requires data for decision support that: (1) incorporates chemical, radiological and biological injuries that may require decontamination prior to treatment;[2–29] (2) uses valid data points for rapid patient assessment;[26] (3) prioritizes patients accurately and efficiently;[10–13,](4) includes data appropriate for all ages, including children;[11,13,30,31] and (5) considers the most judicious appropriation of limited resources. Successful mass casualty triage depends on clear, accurate, complete, timely, valid, reliable and relevant data[4,26,32] that use common terms understood by all first responders.[4,18] Desirable features of a mass casualty triage system include simplicity, accuracy, reproducibility, rapidity and strong inter-rater reliability.[3,33] The validity, reliability, sensitivity and specificity of the triage system determine victim outcomes.[34–37] The science of disaster medical research is often observational or anecdotal and more descriptive than analytical as randomized, controlled, and experimental trials cannot be done.[5,11,14,15,22,26,30–43]



## MCI Involving Chemicals

MCI that include chemical exposures may cause immediate respiratory symptoms or evidence of a toxidrome with no apparent traumatic injuries. Many chemical materials such as chlorine and phosgene have a latency period resulting in rapid deterioration of victims after initial triage.[27,29,44–47] Current triage systems do not take this latency period into account. Patients with exposures to some hazardous materials may initially triage into a delayed category for treatment and then quickly deteriorate with respiratory distress.[44–47] Such delayed triage classification may exclude chemically-exposed victims from the immediate care required for survival.



Chlorine and phosgene are both industrial chemicals and war gases, and potential weapons of mass destruction. Chlorine is one of the most commonly produced chemicals in the

United States and the most commonly manufactured chemical used as a chemical weapon of mass destruction.[48,49] Chlorine gas spills in towns or cities are not unusual.[50] Since 1940, 27 such environmental public health disasters from chlorine have poisoned communities or put large populations at risk. Smaller spills injuring only a few individuals are much more prevalent.[51] According to national data, there were over 6,000 calls to US poison control centers for chlorine gas injuries each year from 2000–2004[52–56] During these same years, there were over 2,000 people treated for chlorine gas injury. These are only the cases reported to the poison control centers; therefore, these national statistics clearly underestimate the true prevalence of chlorine gas exposures each year. Kleindorfer et al.[57] investigated toxic exposure event epidemiology through the 16-state Hazardous Substance Emergency Events Surveillance (HSEES) system sponsored by the Centers for Disease Control and Prevention (CDC). They found that there were 534 chlorine gas disasters between 1994 and 2001, the second most common type of irritant gas event behind anhydrous ammonia. Chlorine disasters were more likely to have human casualties and evacuations than any other type of chemical exposure event. Chlorine gas is the most common cause of household and industrial exposure to irritant gases resulting in lung injury.[60] The Department of Homeland Security has estimated that if a large urban chlorine gas storage tank were attacked then 17,500 would die, 10,000 would suffer severe injuries, and 100,000 would require hospitalization.[61] Even the best prepared city would not be capable of coping with such a mass casualty incident. Small chlorine gas events are common, and large events occur with relative frequency. Effective triage systems need to be available to mitigate the surge from incidents such as large chlorine releases to ensure those most likely to survive are identified and prioritized for healthcare interventions.

## Characteristics of Current Triage Systems

Triage describes the process used to classify and prioritize victims according to predetermined severity algorithms to ensure the greatest survivability within a context of limited resources. Triage decisions rely on rapid assessments (taking less than a minute) for every patient, determining a priority category for each patient, and visibly identifying the categories (tags attached to each patient) for rescuers who will treat and/or transport the patients. Data used for triage decisions include physiologic indicators, injury mechanisms, resources needed, and/or trauma scores.[62] Triage systems use common data points such as mental status, ability to walk, respirations, and pulse to sort patients into priority care categories. Patients who can walk, are dead or non-salvageable are immediately identified and do not receive immediate care. The remaining patients are assessed for immediate or delayed treatment and transport to a medical treatment facility with the optimal use of limited sources.

The various versions and combinations of the most frequently used systems throughout the United States include:

- Simple Triage and Rapid Treatment (START)[17,63–68] which uses four basic assessments: ability to walk, respirations, circulation, and mental status to assess individuals > 8 years of age.

- JumpSTART Pediatric Triage Algorithm,[66,69,70] which uses the same assessments as START with pediatric (individuals < 8 years of age) vital sign parameters plus the A (alert) V (verbal) P (pain) U (unresponsive) assessment.
- Emergency Severity Index (ESI)[71–75] is used for individuals of all ages in emergency rooms/departments by experienced triage providers to evaluate both patient acuity (pulse, respiration and $SaO_2$) and resources needed.
- Sort, Assess, Life Saving Interventions, Treatment and/or Transport (SALT)[34,66,76] which uses similar assessments to START (ability to move, respirations, pulse, and mental status) but also considers resources and presence of hemorrhage for individuals > 8 years of age.
- Proposed Chemical/Biological/Radiological/Nuclear-capable Mass Casualty Triage System (CBRN)[77] is the only system that takes into consideration contamination and toxidrome symptoms related to chemical, biological radiological, or nuclear incidents. The ability to walk and respirations are also used to assess and assign a triage category to individuals > 8 years of age.
- Sacco Triage Method (STM)[3,66,78] is designed for use with communication and technology support and uses specially designed proprietary Sacco software to assign victims to transport and hospitals by a score based on a simple age adjusted physiological score (i.e. respiratory rate, pulse, best motor response) that is computed routinely on every trauma patient and that is correlated to survival probability and deterioration.
- Triage Sieve[26,64,66,79] which uses the same physiological assessments as START but different baseline assessments for respiratory and pulse to assign triage categories to individuals > 8 years of age.
- Pediatric Triage Tape (PTT)[26,66,80] is the child’s version of Triage Sieve that uses physiological measures proportional to a child’s height that is proportional to weight and age. This assures appropriate age assessment. A tape is placed next to the child from the head and then an algorithm next to the child’s feet is used to triage the child. Assessments are based on respiration, pulse and ability to walk.

Table 1 summarizes the triage systems by assessments and triage categories.

Initial triage is dependent largely on local or regional protocols, with little consistency or interoperability between jurisdictions.[66] The majority of systems for MCI response rely on paper triage tags that are attached to the patients.[18] Currently, the amount and type of data collected are not consistent or standardized,[4] and definitions are not universal. The triage of children[81] and victims of chemical, radiological or biological agents have been shown to require different strategies and methods.[27] Only three of the triage systems (JumpSTART, ESI and PTT) specifically address the unique needs of children and only one (CBRN) addresses incidents that involve biological, chemical or nuclear materials. Triage criteria show variations, including physiological “cut-off” values.[16,82] The use of different categories or cut-off values, varying types of data and inconsistently applied definitions results in great variability in acuity designations among triage tools[27] and can increase morbidity and mortality when patients are misclassified for treatment and transport. These inconsistencies highlight the need for a national standardized approach to mass casualty triage.[66] This article is a systematic review of the literature to ascertain the validity of triage system algorithms when used during a mass casualty incident, particularly those involving chemical exposures, to accurately predict likelihood of survival, using actual patient outcomes.

## METHODS

The following search terms were used for a systematic review of the literature: disaster, algorithms, all hazards, mass casualty, triage systems, mass casualty disaster, algorithms, triage tools, triage validation, mass casualty disasters and evidence based medicine. Inclusion criteria were peer reviewed studies in English from 1970 to July 24, 2012 that included combinations of these search terms as found when querying the following databases: CINAHL Plus, MEDLINE (EBSCO), PubMed-MEDLINE, Annual Reviews, Health Reference Center- Academic, Web of Science (ISI Citation), Ovid MEDLINE, and The Cochrane Library for all relevant articles (Table 2). In addition, the references cited in the retrieved articles were also reviewed and included if they met the above search criteria. Articles from 1970–2000 provide a valuable historical perspective and continue to be cited in the literature today as the foundation for the science of mass casualty research.

There is considerable uncertainty in the literature regarding exact definitions for mass casualty triage systems or tools. We used key search terms and Medical Subject Headings (MeSH) identified in the literature and key manuscripts. Each term was searched independently and then terms were combined to focus on validation studies of any MCI. Duplicate articles were eliminated.

## RESULTS

There is extensive research published on MCI, but few studies address the validation of triage tools or systems used for MCI.[26] Two researchers reviewed the 42 articles that met the inclusion criteria and excluded 23 articles that did not pertain specifically to triage during MCI or the validation of triage tools or systems using actual patient outcomes and data, simulation, literature reviews, consensus groups or mathematical models. The 19 remaining articles are summarized in Table 3. Only 3 studies included assessments of incidents involving chemicals,[44,45,77] and none included use of radiological, or biological material. An additional finding of interest was that none of the articles discussed the evaluation of triage using evolving informatics technology.[23,83,84]

Only four articles were identified that discussed the use of actual mass casualty outcome data to describe or analyze the efficacy of the triage system employed.[44,45,68,85,86] Kahn et al.[68] described the efficacy of the START triage system used in a train crash. Burstein's[86] article is a commentary on this research. Peral Gutierrez de Ceballos et al.[85] described outcomes from terrorist bomb explosion injuries in Madrid, Spain. Two articles by VanSickle et al,[44] and Wenck et al,[45] describe the outcomes from a MCI chemical (chlorine) incident. One final article used a randomized sample of trauma victims to evaluate the

START system but this review did not involve mass casualty patients.[67] The remaining 14 articles used simulation, mathematical models, a literature search or consensus groups to describe the efficacy of various triage systems.[19,26,35,66,77,87–94] No studies were identified that used actual outcome data to validate triage systems for radiological or nuclear incidents. The development of prototype handheld field triage instruments that include a radio frequency device (RFD) capability to track patients, equipment and responders as well as the ability to document care and triage status were discussed in several studies;[36,37,95,96] however, none has been validated under MCI conditions. Several studies also discuss the design and use of computerized disaster information systems[97–99] but none has been tested under an actual MCI.

The few available studies show problems with inaccurate assessment and over-triage using the START triage system.[3,7,68,85,90,91,94] Five articles describe the improvement of STM over START but also discuss problems with inaccurate assessment.[3,35,77,91,92] STM is the only proprietary triage system. The CBRN system is only mentioned in one study by Cone[77] and showed significant under-triage in an airport disaster drill. There are very limited studies that address the reliability and validity of the remaining major triage systems/tools: JumpSTART, PTT, Triage Sieve, and SAVE. The ESI is primarily used in acute care facilities, not for field triage.[3,26]

## DISCUSSION

Of the 43 articles which we reviewed, only six articles were identified that discussed the use of actual outcome data to describe or analyze triage outcomes.[44,45,56,67,68,86] Of the 8 most frequently used mass casualty triage systems none has been scientifically validated or tested under chemical, radiological or nuclear mass casualty conditions.[3] Several studies discuss unique needs related to the integration of disaster informatics system technology into the planning and response to MCI.[10,100] No consensus currently exists on standardized indicators or definitions for specific aspects of disaster triage response.[2,6] No universally accepted measure(s) currently exists against which to validate a specific approach to compare various triage systems.[66]

The CDC[32,101] and the Institute of Medicine (IOM)[102] published guidelines for public health research needs. These research priorities relate to the need for the evaluation of the specific components of trauma systems that contribute to improved outcomes for the acutely injured and for effectiveness criteria and metrics for public health preparedness. The Agency for Healthcare Research and Quality (AHRQ)[103] also recommended action steps to improve response to a medical disaster through the support of a research agenda specific to health and medical care standards for mass casualty disasters.

In any MCI the focus during triage is always saving as many victims as possible, and paperwork or reporting requirements are secondary.[104] However, without data or reports from real triage events it is impossible to evaluate triage efficacy with the goal of continuous quality improvement. Therefore, new technologies and approaches to conducting triage are needed to allow for the automated collection of mass casualty triage data. Such advances in triage would allow for the triage focus to properly remain on the assessment of victims while concurrently collecting information needed to advance the quality of triage processes and outcomes.

## CONCLUSIONS

According to Devereaux, much of the work to date to validate the efficacy of triage tools for MCI relies on expert opinion and she therefore postulates the need for further research in the domains of science, process, ethics, and law.[105] The decision-making necessary to save lives during a mass casualty incident requires a paradigm shift from the typical emergency response. Current literature does not provide needed evidence on the validity of triage systems for mass casualty incidents and in particular those involving chemicals. At present, there is no evidence-based literature to define what constitutes the best medical response by medical personnel within a disaster setting.[106] Well designed studies using actual patient data are needed to validate the reliability, sensitivity and specificity of triage systems used for all mass casualty incidents, especially those involving chemicals.

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**Table 1**

Triage Systems by Assessments and Triage Categories

| ASSES SMENTS | START | JumpSTART | ESI | CBRN | SALT | STM | Triage Sieve | PTT |
|---|---|---|---|---|---|---|---|---|
| **Age** | **> 8 Years of Age** | **< 8 Years of Age** | **All Ages** | **> 8 Years of Age** | **> 8 Years of Age** | **> 8 Years of Age** | **> 8 Years of Age** | **< 8 Years of Age** |
| **Walk/Motor response** | X | X | X | X | | X | X | X |
| **Respirations** | X | X | X | X | X | X | X | X |
| **Pulse/Capillary Refill** | X | X | X | | X | X | X | X |
| **Respiratory Distress** | | | X | X | X | | | |
| **Follow Directions** | X | X | X | | X | | | |
| **$O_2$Saturation** | | | X | | | | | |
| **Pain** | | X | X | | | | | |
| **Presence of Hemorrhage** | | | | | X | | | |
| **# of Resources** | | | X | | X | X | | |
| **Toxidrome** | | | | X | | | | |
| **Decontamination**[**] | | | | X | | | | |
| **Ambulance Access** | | | | | | X | | |
| **Ground & Air Transport** | | | | | | X | | |
| **Treatment Facilities** | | | | | | X | | |
| **TRIAGE CATEGORIES** | BLACK[*]<br>RED<br>YELLOW<br>GREEN | BLACK[*]<br>RED<br>YELLOW<br>GREEN | LEVELS 0 TO 5 | LEVELS T1 TO T4 | BLACK/GREY[*]<br>RED<br>YELLOW<br>GREEN | EXPECTANT<br>CRITICAL<br>SALVAGEABLE<br>DELAYED<br>MINOR | DEAD<br>IMMEDIATE<br>URGENT<br>DELAYED | DEAD<br>IMMEDIATE<br>URGENT<br>DELAYED |

[*] Deceased/Expectant: **(BLACK)**
Immediate: **(RED)**
Delayed: **(YELLOW)**
Ambulatory: **(GREEN)**

[**] Used only by CBRN to determine the need for decontamination prior to beginning the triage assessment to prevent exposures to emergency personnel

## Table 2

Summary of All Search Term Hits by Public Health Index For Literature Review From January 1970 to July 2012

| | Public Health Search Indices | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Search Terms** | **CINAHL** | **MEDLINE (EBSCO)** | **PubMed Plus MEDLINE** | **Annual Reviews** | **Health Reference Center-Academic** | **Web of Science (ISI)** | **Ovid MEDLINE** | **The Cochrane Library** |
| Disaster | 10239 | 15871 | 55768 | 34966 | 11152 | 15325 | 35835 | 6671 |
| Algorithms | 10049 | 132280 | 133708 | 106158 | 14972 | 100000 | 218858 | 10 |
| All Hazards | 3518 | 14717 | 0 | 4342 | 1472 | 41949 | 74682 | 14 |
| Mass Casualty | 757 | 1059 | 1071 | 408 | 181 | 588 | 3108 | 14 |
| Triage Systems | 521 | 1106 | 1118 | 290 | 176 | 499 | 469 | 6671 |
| Mass Casualty Disaster | 435 | 625 | 814 | 103 | 52 | 225 | 129 | 2 |
| Triage Tools | 334 | 178 | 181 | 50 | 36 | 118 | 228 | 13 |
| Mass Casualty *and* Triage Tools | 209 | 329 | 334 | 46 | 46 | 158 | 41 | 1 |
| Triage Validation | 157 | 274 | 278 | 66 | 40 | 239 | 3 | 1 |
| Mass Casualty *and* Triage Systems | 29 | 71 | 72 | 10 | 4 | 21 | 66 | 2 |
| Mass Casualty *and* Triage Validation | 2 | | 2 | | | 3 | 1 | * |
| Mass Casualty *and* Algorithms | 12 | 7 | 8 | 3 | 3 | 5 | 168 | 1 |
| Mass Casualty *and* All Hazards | | 13 | 9 | 5 | 3 | 7 | 267 | * |
| Mass Casualty *and* Algorithms *and* Triage Systems | | 4 | | | | | 16 | * |
| Mass Casualty Disaster *and* Triage Systems | 16 | 4 | 13 | 5 | 2 | 13 | 1 | * |

| Search Terms | Public Health Search Indices | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | CINAHL | MEDLINE (EBSCO) | PubMed Plus MEDLINE | Annual Reviews | Health Reference Center-Academic | Web of Science (ISI) | Ovid MEDLINE | The Cochrane Library |
| Mass Casualty Disaster *and* Triage tools | | 6 | 2 | 2 | | 2 | 2 | * |
| Mass Casualty Disaster *and* Triage Validation | 1 | 1 | 1 | | | | * | * |
| Mass Casualty Disaster *and* Algorithms | 2 | 10 | 13 | * | 1 | 3 | 15 | * |
| Mass Casualty Disaster *and* All Hazards | 6 | 3 | * | * | * | 7 | 7 | * |
| Mass Casualty Disaster *and* Evidence Based Medicine | * | 5 | 6 | 16 | * | 1 | 2 | * |
| Mass Casualty Disaster *and* Algorithms *and* All Hazards | * | * | * | * | * | * | 1 | * |

*No literature found

**Table 3**

Key Articles Discussing Mass Casualty Disasters and Triage Validation

| Author(s) | Study Design | Disaster Type | Sample | Results |
|---|---|---|---|---|
| Olchin & Krutz, 2012[50] | ***Literature review*** | All hazards | NA | Evidence-based pre-hospital guidelines for care of mass casualty victims |
| American Academy of Pediatrics et al., 2011[51] | ***Literature review and expert panel consensus*** | All hazards | NA | Developed uniform criteria for mass casualty triage to include: general considerations, global sorting, lifesaving interventions, and assignment of triage categories for pediatric victims |
| Lerner et al., 2011[52] | ***Consensus workgroup*** | All hazards | Workgroup of experts representing national stakeholder organizations | Model Uniform Core Criteria for Mass Casualty Triage were developed to be a national guideline for mass casualty triage to ensure interoperability and standardization when responding to a mass casualty incident. The Core Criteria consist of 4 categories: general considerations, global sorting, lifesaving interventions, and individual assessment of triage category. |
| Lerner et al., 2010[53] | ***Simulated mass casualty incident using SALT*** | Bomb blast | 28 to 30 victims, including 10 to 11 moulaged manikins triaged by 73 trainees | Of 217 victim observations initial triage showed:<br>81% correct<br>8% over-triaged<br>11% under-triaged. |
| Navin et al., 2010[54] | ***Simulated parallel disaster exercises***<br>Critique of Simple Triage and Rapid Treatment (START) framework and validation of Sacco Triage Method (STM) | Building collapse | EMT-I and EMT-Ps with a minimum of 2 years of experience used a 99-victim simulated building collapse to determine the accuracy of patient assessment, the timeliness in clearing the scene, the prioritization of patients and attitudinal responses. | START performed poorly<br>STM outperformed START<br>Time to clear the scene:<br>STM (53 minutes) and START (63 minutes)<br>STM:<br>12 of 13 most serious patients left the scene in the first 6 ambulances<br>START:<br>2 of 13 most serious transported in the first 13 ambulances<br>3 most serious transported by bus nearly an hour later<br>Surveyed providers:<br>Preferred START to STM falsely believing it to be more accurate, faster, and better able to identify the most serious patients |
| Neal et al., 2010[55] | ***Delphi method consensus study*** | All Hazards | Convenience sample of six prehospital casualty care experts for Delphi expert panel | Develop the PLUS Casualty Triage method to incorporate triage criteria specific to each selected injury mechanism or condition : to identify under-triage of seriously injured casualties |
| Kahn et al., 2009[27] | ***Secondary data analysis*** of START | Train crash | 148 records reviewed | 2 of 22 red-tagged patients – immediate life-threatening condition<br>62 of 120 patients – minor injuries over-triaged as red or yellow |
| Navin et al, 2009[56] | ***Mathematical models applied to simulations*** used to correlate patient scores to survival probability using logistic and validated through measures of discrimination | Combat causalities with blunt, penetrating and blast overpressurelike trauma | 99,369 military-age victims<br>1,266 patients | In 18 simulations, the projected survivors with STM ranged from 61% to 429% as compared to START'S maximum performance and increases more than 18 fold in |

| Author(s) | Study Design | Disaster Type | Sample | Results |
|---|---|---|---|---|
| | and calibration. Deterioration estimates determined through the Delphi method panel of experts<br>Simulations enable outcome comparisons of STM and START<br>***Retrospective analysis*** of combat causalities were also included | | | comparison to START'S worst case performance.<br>Independent retrospective analysis of the Navy/Marine Corps Combat Trauma<br>Registry showed that of the 1,266 patients with STM scores of 12 (i.e., normal physiology)<br>28% tagged green<br>22% tagged red<br>25% tagged yellow<br>25% not tagged |
| Van Sickle et al., 2009[45] | ***Analysis*** of the medical records and autopsy reports to describe the clinical presentation, hospital course and pathology from victim hospitalized or deceased as a result of a CL exposure | Chlorine leak casualties from a train derailment | 80 | Pulse oximetry and arterial blood gas analysis provided early indications of outcome severity.<br>Hypoxia on room air and PO2/FIO2 ratio predicted severity of outcome. |
| Cone et al., 2008[37] | ***Airport disaster drill to test CBRN system*** | Plane crash with release of organophosphate material | 56 patient scenarios | Significant under-triage rate (10.7%)<br>System can be applied rapidly by trained paramedics Needs refinement |
| Jenkins et al., 2008[40] | ***Literature review*** to determine the evidence-based approach of existing triage tools | All Hazards | Triage Tools Evaluated:<br>Care Flight Triage<br>JumpSTART<br>Pediatric Triage Tape<br>Triage Sieve<br>SAVE<br>START<br>STM | Major tools are not developed on evidence-based science. Limited studies address their reliability and validity. |
| Lerner et al., 2008[25] | ***Literature review consensus committee comparison*** of commonly used triage systems and development of a National mass casualty triage guidelines | All Hazards | 9 existing mass casualty triage systems | No nationally agreed upon guidelines.<br>Proposed SALT as the national triage guideline. |
| Gebhart et al., 2007[26] | ***Secondary data analysis*** of trauma victims, not mass casualty victims | Trauma | 357 trauma patient records randomly selected using a trauma database at a Level II trauma center | 75.77% survived with a respiratoryrate <30, palpable radial pulse, and intact mental status.<br>Data analysis suggest efficacy of START. |
| Hupert et al., 2007[57] | ***Simulation model of trauma system response*** | Not specified | Hypothetical population of critically and noncritically injured patients | Examined the relationship between over-triage and critical mortality after a mass casualty incident (MCI) using a simulation model of trauma system response. Over-triage has a positive, negative, or variable association with critical mortality depending on its etiology. In all of the modeled scenarios, the ratio of critical patients to treatment capability has a greater impact on critical mortality than over-triage level or time-dependent mortality assumption. |
| Wenck et al., 2007[46] | ***A rapid assessment of the health impact*** to determine morbidity caused by a chlorine leak and evaluate the effect of the mass-casualty event on health-care facilities. | train derailment | 597 victims examined in emergency facilities | Several (exact number of patients not specified) patients experienced a delayed onset of pulmonary edema hours after the exposure. Emergency department physicians should be aware of this possibility and use caution in sending patients with substantial chlorine exposure |

| Author(s) | Study Design | Disaster Type | Sample | Results |
|---|---|---|---|---|
| | | | | home after a short period of observation. |
| Lerner, 2006[16] | ***Literature review*** | Traumatic injuries | 80 articles reviewed | Determined the sensitivity and specificity of the American College of Surgeon's field triage criteria (physiologic, anatomic, mechanism of injury, and age and comorbidity). Concluded there is not sufficient research evidence to support the overall ACS field triage criteria. |
| Sacco et al., 2005[18] | ***Mathematical models applied to simulation*** used logistic function-generated survival probability estimates from score based on respiratory rate, pulse rate, and motor response.<br>Deterioration estimates determined through the Delphi method panel of experts.<br>Simulations enable outcome comparisons of STM and START | Blunt trauma | 76,459 blunt-injured patients from the Pennsylvania Trauma Outcome Study | STM resulted in greater expected survivorship than START in all simulations. |
| Navin et al., 2005[60] | ***Tabletop exercises*** using START | Not specified | 180 EMS providers 45 victims | START protocols not scalable. Strategy for a 20-victim incident is not the same as for a 200- or 2,000-victim incident.<br>Numbers of victims tagged with each color varied widely within and across regions:<br>red-tagged top priority for transport and treatment ranged from 4 to 44 out of 45 victims. |
| Peral Gutierrez de Ceballos et al., 2004[58] | ***Analysis*** of terrorist bomb explosion injuries in Madrid, Spain | Bomb injuries | 2000 causalities | Of 312 patients taken to the hospital:<br>91 were hospitalized<br>62 had only superficial bruises or emotional shock. |

Triage Tools/Systems:

CBRN: Chemical, Biological, Radiological/Nuclear

SAVE: Secondary Assessment of Victim Endpoint

JumpSTART

Pediatric Triage Tape tools

SALT: Sort, Assess, Lifesaving Interventions, Treatment/Transport

START: Simple Triage and Rapid Treatment

STM: Sacco Triage Method

Triage Sieve