Mass-Casualty Triage: Time for an Evidence-Based Approach

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Abbreviations:
EMS = emergency medical services
MCI = mass-casualty incident
NISS = New Injury Severity Score
PTT = Pediatric Triage Tape
SAVE = Secondary Assessment of Victim Endpoint
STM = Sacco Treatment Method
START = Simple Treatment and Rapid Transport

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Abstract

Mass-casualty triage has developed from a wartime necessity to a civilian tool to ensure that constrained medical resources are directed at achieving the greatest good for the most number of people. Several primary and secondary triage tools have been developed, including Simple Treatment and Rapid Transport (START), JumpSTART, Care Flight Triage, Triage Sieve, Sacco Triage Method, Secondary Assessment of Victim Endpoint (SAVE), and Pediatric Triage Tape. Evidence to support the use of one triage algorithm over another is limited, and the development of effective triage protocols is an important research priority. The most widely recognized mass-casualty triage algorithms in use today are not evidence-based, and no studies directly address these issues in the mass-casualty setting. Furthermore, no studies have evaluated existing mass-casualty triage algorithms regarding ease of use, reliability, and validity when biological, chemical, or radiological agents are introduced. Currently, the lack of a standardized mass-casualty triage system that is well validated, reliable, and uniformly accepted, remains an important gap. Future research directed at triage is recognized as a necessity, and the development of a practical, universal, triage algorithm that incorporates requirements for decontamination or special precautions for infectious agents would facilitate a more organized mass-casualty medical response.

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Introduction

During a mass-casualty incident (MCI), such as a disaster due to natural hazards or bioterrorism attack, triage algorithms may be used to guide the allocation of limited healthcare resources. Because of potential resource limitations, mass-casualty triage for civilian populations is aimed at ensuring that medical resources are directed at achieving the greatest good for the greatest number of people.[1] Accordingly, mass-casualty triage does not always direct care to the most critically injured, but rather to those deemed most likely to survive with emergent aid. Triage personnel are charged with separating those who will benefit from immediate intervention(s) from those who will not, and further identifying others who likely will die despite early intervention. Although the use of triage techniques began in the military, several mass-casualty triage algorithms have been developed for use in the civilian setting. Each seeks to categorize patients by severity of injury and optimize outcomes during times of severe resource constraints. The purpose of this paper is to describe the development of mass-casualty triage and those algorithms that have been developed for civilian populations, review the data regarding their reliability and validity, and discuss the need for empirically derived and validated algorithms.

History

Triage is derived from the French word *trier*, meaning "to sort", and refers to the process of sorting patients based on their severity of injury or illness. During wartime, determining which victims may benefit from rapid transport

	Ability to Walk	Ability to Breathe	Perfusion/Pulse	Ability to Follow Commands	Motor Response
START	X	Respirations	Radial Pulse	X	
Triage Sieve	X	Respirations	Capillary Refill		
Care Flight Triage	X	Yes/No	Radial Pulse	X	
STM		X	X		X

Table 1—Physiological parameters assessed in adult primary mass-casualty incident (MCI) (START = Simple Treatment and Rapid Transport; STM = Sacco Treatment Method)

and/or treatment and which soldiers could return to the battlefield has been a high priority, particularly under conditions in which available resources are constrained. The earliest use of triage for the sorting of patients was employed by Baron Dominique Jean Larrey (1766–1842), a chief surgeon in Napoleon's army. Recognizing the importance of early surgical intervention, Larrey was the first military surgeon to develop a system that evacuated wounded soldiers from the battlefield and based the immediacy of surgical treatment on severity of their injuries, rather than on military rank.[2]

During the American Revolution, John Morgan, Director General of Hospitals, reportedly strode through the camps sorting out those with minor injuries from those severely wounded and/or debilitated.[3] Then, the patients were carried back to general hospitals created to receive them. During World War I, the concept of triage was reintroduced to the US military by the Allied Forces. Triage or dressing stations operated as receiving and forwarding stations. At these stations, the sick and wounded were classified according to the nature of their injuries and severity of illness. Military field care was refined further during World War II with the utilization of tiered triage, during which casualties initially were attended to on the frontlines. The use of triage subsequently helped determine which of the casualties were transferred to successively higher levels of care. During World War II, patient triage was regarded as the single most important factor contributing to the survival of US soldiers with abdominal wounds.[4] During the Korean War, the application of a four-tiered triage system (i.e., minimal, delayed, immediate, and expectant) led to a striking improvement in casualty survival.[5] While the primary goal of military triage has been the evaluation and classification of casualties for purposes of treatment and evacuation, military triage also may have included decisions based upon advancing mission objectives rather than strict medical criteria.[6]

Mass-Casualty Triage Instruments

Mass-casualty triage instruments developed for use in civilian populations may be broadly classified into two types: (1) primary; and (2) secondary triage. Primary mass-casualty triage instruments, such as Simple Treatment and Rapid Transport (START),[7] the Triage Sieve,[8] Care Flight Triage,[9] and the Sacco Triage Method (STM),[10] prioritize patients in the field for evacuation and transport to definitive medical care. Secondary triage instruments such as Secondary Assessment of Victim Endpoint (SAVE) Triage[11] and Triage Sort,[8] establish the order in which patients receive care at the hospital or, in the setting of delayed transportation, at the scene.

All of the primary mass-casualty triage instruments except for the STM are algorithms that classify patients into one of four categories: (1) deceased or expectant (black); (2) immediate (red); (3) delayed (yellow); or (4) ambulatory (green). *Decreased or expectant* are patients who are presumed dead or have serious injuries and are not expected to survive. *Immediate* means that the patient is critically injured and requires immediate intervention(s), whereas *delayed* includes injured victims that are less severely injured than are those classified as immediate. The *ambulatory* category consists of patients that can walk and are judged the least severely injured. The physiologic parameters measured in each adult triage algorithm are summarized in Table 1. Note that while each algorithm uses four STM categories for classification, the names of the categories vary. In contrast to these ordinal algorithms, the STM is an interval-based classification system that assigns a survivorship score to each patient and uses a mathematical model to order the patients for transport and treatment based on available resources.

START and JumpSTART Triage Algorithms

In 1983, researchers at Hoag Hospital, in conjunction with the Newport Beach, California Fire Department, developed the START Triage System. The goal of START is to prioritize patients based on objective physiological and observational data gathered by first responders during a MCI (Figure 1).[7] The START algorithm assigns treatment priority based on the ability of the patient to walk, airway patency, breathing rate, presence of radial pulse or capillary refill longer than or less than two seconds, and ability to follow simple commands. For START, patients are prioritized into one of four categories: (1) deceased or expectant; (2) immediate; (3) delayed; or (4) minor (i.e., ambulatory). The START algorithm has been adopted by many emergency medical services (EMS) systems in the United States as a tool for providers to characterize the acuity of patients in the prehospital setting. It also has been utilized during disasters such as the 1989 Northridge earthquake, the 1992 and 2001 attacks of the New York World Trade Center, and the 1995 Oklahoma City bombing.[12,13]

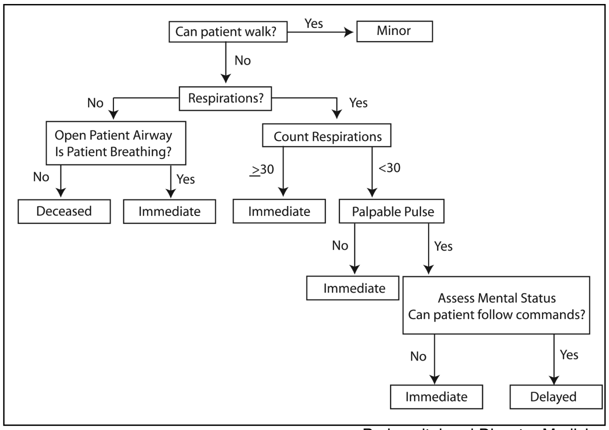

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Figure 1—Modified Simple Treatment and Rapid Transport (START) algorithm
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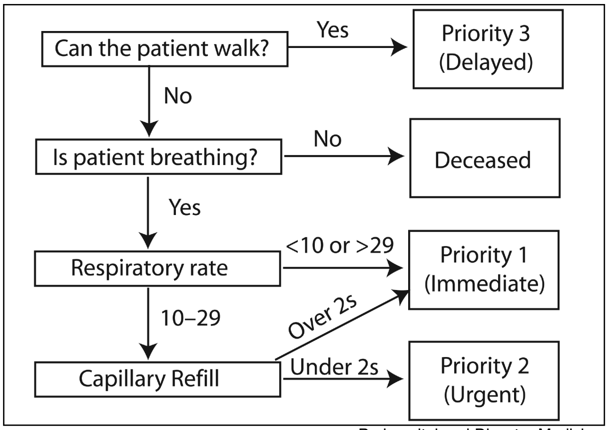

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Figure 2—Triage Sieve algorithm.
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Recognizing that the normal physiological parameters of children differ from adults and that prehospital providers often have less experience with injured children, Romig developed a pediatric version of START, known as JumpSTART. JumpSTART is designed to be used in conjunction with START during MCIs involving children 1–8 years of age. The JumpSTART algorithm uses the same color-coded triage categories as START and provides a similar chart containing pediatric physiological parameters to guide prioritization of pediatric patients. An additional pathway component directs responders to give pediatric patients who are not breathing, but still have a peripheral pulse, five rescue breaths in an attempt to stimulate spontaneous breathing.[14] To date, no current literature describing the use of JumpSTART in an actual MCI has been published.

Triage Sieve Algorithm and Pediatric Triage Tape
In 1995, Hodgetts and Mackway-Jones published the Triage Sieve (Figure 2) as a component of the Major Incident Medical Management and Support (MIMMS) course for healthcare providers.[8] The Triage Sieve assigns priority based on the assessments of ability to walk, airway patency, breathing rate, and pulse rate.[15] Triage Sieve is used to assess breathing and pulse differently than in START. The Triage Sieve defines abnormal breathing as <10 breaths or >30 breaths/minute (min),[8] whereas the START considers >30 breaths/minute to be abnormal.[7] The Triage Sieve categorizes patients with a pulse rate >120/min as "immediate" (a physiological parameter that has been shown to be correlated with the presence of shock).[8] The Triage Sieve has received support from prehospital providers in the United Kingdom and parts of Australia. Documented use of Triage Sieve has included the categorization of 122 injured patients at the scene of a train wreck in Balochistan, Pakistan by Malik *et al*.[16]

Hodgetts *et al* also developed a pediatric version of the Triage Sieve, known as the Pediatric Triage Tape (PTT).[17] Although the physiological parameters included in the PTT are the same as in the parent algorithm, the normal values associated with the parameters vary according to the child's height (length). A child's length is proportional to its weight, which is proportional to its age. The PTT is a waterproof, non-tear tape that relates the child's height/length to normal physiological variables so that their physiologic status can be assessed using age-appropriate norms. No published reports exist describing the use of PTT during an actual MCI.

Care Flight Triage Algorithm
In 2001, Nocera and Garner developed the Care Flight Triage algorithm (Figure 3) with the intent of providing responders in Australia with a primary MCI triage tool to standardize disaster response in the country. Care Flight Triage relies only on qualitative observations and requires no quantitative vital sign measurements.[9] This algorithm assesses the ability to obey commands, the presence of respirations, and the palpability of the radial pulse. It differs from START in that there is no respiratory rate assessment, and the level of consciousness is assessed first. The authors of Care Flight Triage state that it may be performed within 15 seconds and that it is appropriate for triaging children as well as adults. The use of Care Flight Triage has been reported in the evacuation of patients following the nightclub bombings in Bali in 2002.[18]

Sacco Triage Method
In addition to the above triage algorithms, Sacco *et al* developed the STM for prioritizing patients during a MCI.[10] According to available resources, the STM is not an algorithm—it is a mathematical model that orders the treatment of patients based on their probability of survival, potential for deterioration, and available resources. To develop this model, Sacco and colleagues first estimated the probability of survival for a set of physiological scores that on ventilatory rate, pulse rate, and best motor response. The survivorship scores were derived empirically from a statewide trauma registry database containing records from >76,000 blunt trauma patients. Second, the probability of

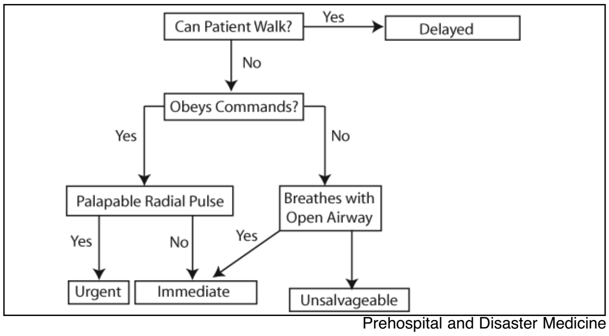

Figure 3—Care Flight Triage Algorithm
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deterioration was estimated by expert consensus for patients who remained at the scene for different periods of time. Based on the physiological score and the probability of deterioration, STM relies on a mathematical model that involves linear programming to determine the order in which victims are to be transported and treated given the resources at hand.[10]

Currently, the STM is the only empirically derived triage method, and it also is the only system that changes the prioritization of patients in a real-time manner based on available resources. Using STM also requires software support, personnel for data entry, communication to incident command or central dispatch, and resource availability information. Resource constraints and the requirement for software and hardware support may limit the usability of the STM. In addition, the proprietary nature of the system makes it less accessible to economically disadvantaged areas. There are no published reports using the STM or addressing its real-world applicability.[10]

Secondary Triage Instruments

Because of the evolving nature of some injuries and the deterioration that can occur if treatment is delayed, two secondary triage instruments, SAVE Triage[11] and Triage Sort[8] have been developed to provide prehospital personnel with more detailed guidelines for assigning treatment priorities. The SAVE Triage instrument is designed for MCIs in which providers with limited medical resources reach patients at the disaster site but evacuation to definitive care will be prolonged. It provides detailed guidelines to aid in prioritization of patients for treatment at the disaster scene once they have been assigned an initial treatment priority using the START algorithm. Triage Sort also is a secondary triage algorithm—it is designed to be used in conjunction with Triage Sieve during incidents in which there are many patients to prioritize for evacuation and treatment, but where resources have not been overwhelmed. Triage Sort categorizes patients based on a combined weighted score using the Glasgow Coma Scale, ventilatory rate, and systolic blood pressure.[8]

Current Research on Mass Casualty Triage Instruments

Although a number of factors must be considered when selecting the most appropriate instrument to use during a MCI, one of the critical factors is the instrument's reliability and validity, which is the most critical characteristic of any instrument. The triage algorithms mentioned above and the current research describing them are summarized in Table 2. Reliability means that the instrument is used to assess something in a reproducible way. Intra-rater reliability occurs when the instrument results in identical triage categories if the same evaluator rates the same patient twice (usually the two ratings are conducted within a short period of time at two different time points, at which the patient's condition is not expected to change). Inter-rater reliability occurs when the instrument also yields identical triage categories of the same patient from at least two different raters. None of the mass-casualty triage algorithms have been tested for intra- or inter-rater reliability.

The construct validity of an instrument relates to its ability to assess what it is intended to assess.[19] Although the validity of the secondary triage instruments has not been investigated, a few studies have examined the construct validity of the primary mass-casualty triage instruments. Garner *et al* used trauma registry data from 1,144 adult trauma patients to retrospectively assign each one a triage level according to START, Triage Sieve, and Care Flight Triage, and compared the ability of the use of the instruments to discriminate between patients with a critical injury (defined as a patient requiring a life-saving intervention).[9] The discriminant validity of Care Flight Triage and START was significantly better than TriageSieve in this retrospective analysis.

Sacco *et al* compared the predictive validity of STM and START by estimating the use of the instruments to maximize the number of survivors using computer simulations that varied in terms of resources available and the number of patients that could be transported. The authors found that the use of the STM provided higher numbers of expected survivors than did the use of the START in all of the simulations, and that the difference between the results of using the two instruments increased as resources became more constrained.[10]

Finally, Wallis and Carley prospectively evaluated the discriminant validity of Care Flight Triage, JumpSTART, START, and the PTT for triaging children aged ≤12 years who were presented to a trauma unit within 12 hours of receiving an acute injury. From among 3,461 patients, the investigators evaluated the ability of the different triage algorithms to classify patients with serious injuries using different criteria such as the Injury Severity Score, the New Injury Severity Score (NISS), or requiring a life-saving intervention. The patterns were similar given the three criteria used. For example, when serious injury was defined as those with a NISS above 15, the sensitivity of placing them in the highest triage category (immediate) was calculated. Care Flight Triage had the highest sensitivity for NISS above 15 for placing patients in the highest triage category at 31.5% (95% Confidence Interval (CI) 29%–34%), followed by PTT at 26.1% (95% CI 23%–29%), START at 22.3% (95% CI 16%–31%), and JumpSTART at 2.4% (1%–5%).[20,21] Specificities were 99% for CareFlight, 98.9% for PTT, 97.8% for JumpSTART, and 77.3% for START.[20]

Triage Instrument	Time to Administer	Geographic Use	Reliability	Validity	Applicable to all Hazards
START	60 sec[43]	North America	No studies	Discriminant validity; predictive validity	No
Triage Sieve	Not reported	UK/Australia	No studies	Discriminant validity	No
Care Flight	15 sec[34]	Australia	No studies	Discriminant validity	No
STM	45 sec[40]	North America	No studies	Predictive validity	No
JumpSTART	Not reported	North America	No studies	Discriminant validity	No
PTT	Not reported	UK/Australia	No studies	Discriminant validity	No

Table 2—Comparison of primary mass-casualty incident (MCI) Triage Instruments (PTT = Pediatric Triage Tape; START = Simple Treatment and Rapid Transport; STM = Sacco Treatment Method)

Call for Research and an Internationally Accepted Algorithm

A recent emergency medicine consensus conference on surge capacity identified the determination of the effectiveness of the use of triage protocols as one of the most important research priorities related to high-consequence events.[22] The studies described above include validity data relative to use of the mass-casualty triage algorithms available. The most frequently tested triage algorithms are the START and Care Flight Triage; however, neither of these studies was evaluated in real-world conditions.[9,20] Again, no studies have directly addressed the reliability of the use of triage algorithms. The reliability and validity of all of the triage algorithms requires further testing before any should be accepted universally.

In addition, the validity also has not been assessed when the use of biological, chemical, or radiological toxins are introduced. None of the instruments are applicable to all hazards, and most triage algorithms have been designed for use only in the treatment of injuries. These algorithms assess physiological criteria that are based upon trauma criteria that may not be appropriate in situations created by the use of chemical or biological hazards.[11] Exposure to chemical, radiological, or infectious agents could alter standard mass-casualty triage decisions. While generally it is accepted that patients with life-threatening conditions should be treated prior to decontamination and patients without life-threatening conditions should be decontaminated before being treated, the degree to which such exposure complicates triage may vary widely. In addition, the recognition that infectious agents may be involved, especially those requiring respiratory isolation, may raise an entirely different set of triage considerations.

During a MCI, many different local, national, and international agencies likely will work together in the initial rescue phase. It is important that these agencies are able to effectively communicate information, especially critical information such as the triage priority of rescued patients. A standardized triage system with well-defined categories and instructions would alleviate this type of confusion. The lack of a standard mass-casualty triage system that is uniformly accepted, validated, and reliable remains as a gap. The creation of a common triage algorithm along with additional information for triage of patients in various settings could facilitate a rapid and organized medical response during a MCI. A common triage classification system for enhanced disaster response coordination could offer medical providers specific tools to care for patients more effectively.

Conclusions

When a MCI occurs, rapid assessment and treatment of the victims is the utmost priority. There is no denying the important role that triage can play during a MCI, especially when resources are constrained. A number of MCI triage instruments have been developed largely based on physiological parameters associated with clinical instability. The most widely recognized mass-casualty triage algorithms available were not developed using evidence-based methods. Limited studies address reliability and validity and no studies directly address these issues in the mass-casualty setting. Furthermore, none have evaluated existing mass-casualty triage algorithms regarding ease of use, reliability, and validity when biological, chemical, or radiological agents are introduced. Future research directed at all-hazard mass-casualty triage is required to ensure adequate preparedness and international cooperation in disasters. The development of a practical universal triage algorithm that incorporates requirements for decontamination or special precautions for infectious agents would facilitate a more highly organized mass-casualty medical response.

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