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Comparative Analysis of Multiple-Casualty Incident Triage Algorithms

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Study objective: We sought to retrospectively measure the accuracy of multiple-casualty incident (MCI) triage algorithms and their component physiologic variables in predicting adult patients with critical injury.

Methods: We performed a retrospective review of 1,144 consecutive adult patients transported by ambulance and admitted to 2 trauma centers. Association between first-recorded out-of-hospital physiologic variables and a resource-based definition of severe injury appropriate to the MCI context was determined. The association between severe injury and Triage Sieve, Simple Triage and Rapid Treatment, modified Simple Triage and Rapid Treatment, and CareFlight Triage was determined in the patient population.

Results: Of the physiologic variables, the Motor Component of the Glasgow Coma Scale had the strongest association with severe injury, followed by systolic blood pressure. The differences between CareFlight Triage, Simple Triage and Rapid Treatment, and modified Simple Triage and Rapid Treatment were not dramatic, with sensitivities of 82% (95% confidence interval [CI] 75% to 88%), 85% (95% CI 78% to 90%), and 84% (95% CI 76% to 89%), respectively, and specificities of 96% (95% CI 94% to 97%), 86% (95% CI 84% to 88%), and 91% (95% CI 89% to 93%), respectively. Both forms of Triage Sieve were significantly poorer predictors of severe injury.

Conclusion: Of the physiologic variables used in the triage algorithms, the Motor Component of the Glasgow Coma Scale and systolic blood pressure had the strongest association with severe injury. CareFlight Triage, Simple Triage and Rapid Treatment, and modified Simple Triage and Rapid Treatment had similar sensitivities in predicting critical injury in designated trauma patients, but CareFlight Triage had better specificity. Because patients in a true mass casualty situation may not be completely comparable with designated trauma patients transported to emergency departments in routine circumstances, the

best triage instrument in this study may not be the best in an actual MCI. These findings must be validated prospectively before their accuracy can be confirmed.

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INTRODUCTION

The medical management of a major multiple-casualty incident (MCI) revolves around victim triage. Accurately identifying patients who will substantially benefit from early scene intervention or transport to definitive care may be the most important medical function at an MCI.[1] However, in the setting of a major MCI, these patients are typically in the minority, with most persons being either uninjured, mildly injured, or deceased.[2] Triage systems used in MCIs must therefore allow rapid identification of the critically injured without the need for detailed examinations of all involved persons.

Physiologic systems have been favored in the MCI setting because they aim to identify patients with current instability. Anatomic and mechanism of injury-based systems identify patients who have the potential to deteriorate; the triage priority is therefore based on potential, rather than actual, instability. This may result in a tendency to overtriage patients, thereby overwhelming the system.[3] Physiologic systems, however, provide a snapshot of the patient's stability at the instant of triage and are based on the assumption that triage will be an ongoing process with frequent reassessments. Patients who are initially physiologically stable but deteriorate will therefore be identified in subsequent triage rounds.

Several systems have been advocated as triage tools designed to enable the rapid identification of critically injured persons from large numbers of patients who do not have immediately life-threatening injuries in an MCI.

The Triage Sieve methodology[4] (Figure 1) has been widely advocated in the United Kingdom and has been adopted in parts of Australia. The physiologic variables used in Triage Sieve to stratify patients are respiratory rate and either capillary refill or heart rate, depending on the ambient weather and temperature conditions.

The Simple Triage and Rapid Treatment algorithm (Figure 2) is used widely in North America. Simple Triage and Rapid Treatment initially used the ability to obey commands, respiratory rate, and capillary refill to assign a triage category. Modifications were later recommended that substituted palpability of the radial pulse for capillary refill because data suggested it to be more reliable.[5]

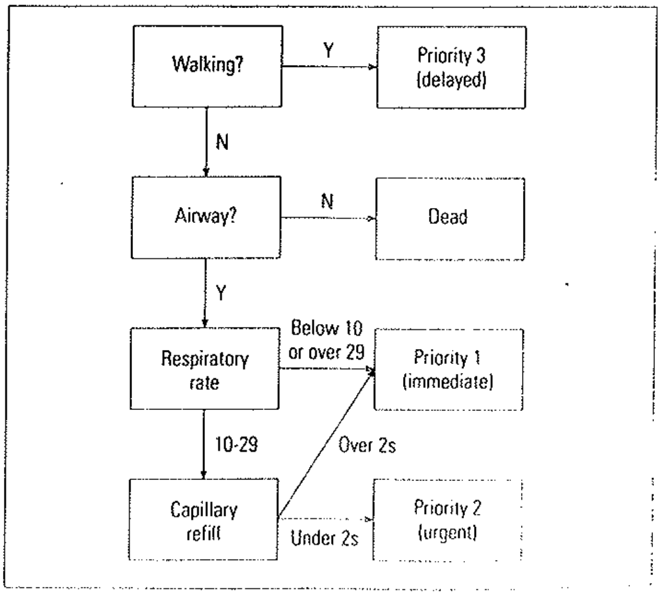
The CareFlight Triage (Figure 3) algorithm assesses the ability to obey commands, the presence of respirations, and the palpability of the radial pulse. It differs from modified Simple Triage and Rapid Treatment in that there is no respiratory rate assessment, and level of consciousness is assessed first.

There are no published reports or studies addressing the accuracy of these systems. The aim of this study was to retrospectively determine the association between the physiologic variables used in these triage systems, both in isolation and when combined together as an algorithm, with severe injury requiring immediate life-saving intervention or urgent transport.

MATERIALS AND METHODS

Consecutive trauma patients presenting to the emergency departments of 2 trauma centers in New South Wales, Australia, were retrospectively identified from the hospital trauma registries. All patients transported in the calendar year of 1994 were included. Patients from later years could

Figure 1.
Triage Sieve. A heart rate of 120 beats/min is substituted for capillary refill in cold conditions or poor lighting. © BMJ Publishing Group. Used with permission.



not be included because, starting in 1995, ambulances stopped collecting patient data on the basis of the Trauma Score and began using the Triage-Revised Trauma score. Because the new system did not use capillary refill, this information could no longer be collected. One hospital is a trauma service hospital providing tertiary trauma services equivalent to an American College of Surgeons Level I trauma center to an urban population of approximately 654,000 persons. The second hospital provides trauma services equivalent to an American College of Surgeons Level II trauma center to a catchment population of approximately 350,000 persons in a predominantly urban area but including a rural catchment. A system of designating trauma patients in the field operates in the catchment areas of both hospitals. Patients identified with physiologic or anatomic signs of severe injury or a high-risk mechanism of injury are transported directly to the trauma centers. All data abstraction was performed by one of the authors (AG), who was not blinded to the physiologic variables when determination of injury severity was made. All data were collected on a standardized data collection form.

Patient inclusion criteria were as follows: (1) a traumatic injury necessitating a stay of greater than 4 hours in the ED or admission to an inpatient unit; (2) patient transported directly from the incident scene; and (3) age 14 years or older. Patients of this age or older are treated as adults in the New South Wales trauma system and receive all their care through adult trauma centers.

Data collected from each case slip included demographic and physiologic data, plus mechanism-of-injury data. The ambulance service of New South Wales does not routinely collect data on whether the radial pulse is palpable. Therefore, for modified Simple Triage and Rapid Treatment and CareFlight Triage, persons with a systolic blood pressure of less than 80 mm Hg were assumed to not have a palpable radial pulse.[6]

Patients with critical injuries were defined as persons who required any of a set of life-saving interventions. These were derived from a modified version of the resource-based definition of severe injury introduced by Baxt and Upenieks.[7] Our modified criteria are as follows. First is a nonorthopedic operative procedure with positive operative findings within 6 hours of admission, including thoracotomies, laparotomies, pericardial windows, craniotomies, and burr-hole placement. Positive operative findings are defined as traumatic injuries that could have

Figure 2.
Modified Simple Triage and Rapid Treatment. The original algorithm used capillary refill time of greater than 2 seconds as the circulatory discriminator. © Newport Beach Fire Department and Hoag Memorial Hospital. Used with permission.

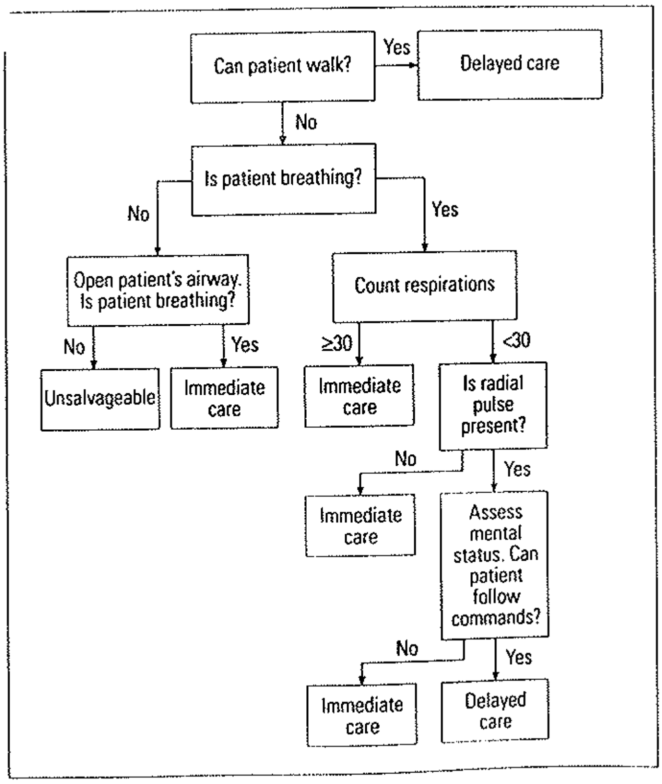
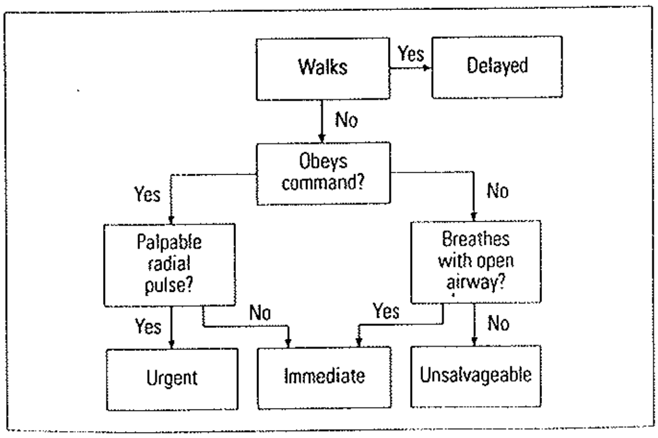


Figure 3.
CareFlight Triage. © CareFlight. Used with permission.



been life threatening if not treated. Second is fluid resuscitation, either out-of-hospital or in-hospital, of greater than 1,000 mL or transfusion to maintain a systolic blood pressure of more than 89 mm Hg (ie, a measured blood pressure of <90 mm Hg and requirement for >1,000 mL of fluid or transfusion to elevate the systolic blood pressure to >90 mm Hg). Third is invasive central nervous system monitoring, with a positive head computed tomographic scan or documented raised intracranial pressure. A positive computed tomographic scan is defined as significant extradural, subdural, or intraparenchymal hemorrhage. Fourth is requirement of a procedure to maintain a patent airway or requirement for assisted ventilation, either out-of-hospital or on arrival in the ED. Airway procedures or ventilatory assistance, which is indicated solely because of administration of sedative or anesthetic drugs, were excluded. Fifth is a requirement for decompression of a tension pneumothorax, either out-of-hospital or on arrival in the ED.

In contrast to the original Baxt and Upenieks[7] criteria, time to necessary surgery after injury was shortened from 48 hours to 6 hours. Patients who can tolerate a delay of greater than 6 hours to surgery should be considered as nonurgent cases in a major MCI setting. In addition, death as a sole indicator was removed. Patients whose injuries are so grave (ie, traumatic full arrests) that their prognosis is believed to be dismal should not be identified as critical in the setting of a large MCI. They are likely to consume large quantities of resources in a futile resuscitative effort.

Sensitivity and specificity were determined for the specific values of the physiologic variables used in the triage algorithms. Receiver operating characteristic curves were plotted for the physiologic variables that are either ordinal categoric or continuous variables. Areas under the curve were compared using the method of DeLong et al[8] to determine whether there were differences in the performance of physiologic variables. A logistic regression model was used to determine which of the physiologic variables (ie, respiratory rate ≥30 versus <30 breaths/min, Glasgow Coma Scale-Motor Response score ≤5 versus 6, systolic blood pressure <80 versus ≥80 mm Hg, capillary refill >2 versus ≤2 seconds, and heart rate >120 versus ≤120 beats/min) was associated with critical injury. A second logistic regression model was also developed as described previously but with respiratory rate (<10 or >29 versus 10 to 29 breaths/min). Goodness of fit was determined by using the Hosmer-Lemeshow test, and colinearity was assessed by means of correlation among independent factors and the variance inflate factor.[9] To validate the model, a jackknife technique was used rather than bootstrapping because the former method is considered to be the better test.[9]

Sensitivity, specificity, and odds ratios with 95% confidence intervals (CIs) were calculated to compare the test performance of each MCI triage algorithm against the modified resource-based definition of critical injury. Patients who were identified as "immediate" by the triage algorithms were considered to have been identified as critically injured. All of the triage algorithms use the ability to walk as a discriminator for minor or no injury. It is not possible to determine the association between the ability to walk and the absence of severe injury within our emergency medical services (EMS) system because patients with a high-risk mechanism of injury are actively immobilized by out-of-hospital providers. All patients transported by ambulance were assumed to not be able to walk.

Statistical analysis was performed with Statistical Package for the Social Sciences (SPSS) Version 10.0 (SPSS Inc., Chicago, IL) and SAS Version 8.01 (SAS, Cary, NC). The study was approved by the institutional Human Ethics and Research Committee.

RESULTS

There were 1,192 patients who met the study inclusion criteria. Forty-eight patients were excluded because the ambulance case sheets had not been filed in the patients' medical record or the data were incomplete, leaving 1,144 patients who were included in the data analysis. Sixty-five percent of the sample were men, 35% were women, and there were 38 (3.4%) deaths. The median age of the sample population was 33 years (interquartile range, 21 to 53 years). Mechanism of injury is presented in Table 1. One hundred thirty-five (11.8%) patients met the modified Baxt and Upenieks[7] criteria for critical injury, with requirement for airway management being the most common reason (Table 1). Over half the patients were classified as having a critical injury on one criterion only. Forty-one patients were assumed to not have a palpable radial pulse because of a systolic blood pressure of less than 80 mm Hg.

Table 2 details the sensitivity and specificity of the physiologic variables at the values used in the MCI triage tools. Figure 4 shows the receiver operating characteristic plots for heart rate, systolic blood pressure, respiratory rate, and Glasgow Coma Scale-Motor Response score. There was adequate goodness of fit of the logistic regression model (χ^2=1.47, P=.23). The correlation between independent variables was low (the highest at 0.30), and the variance inflate factor did not indicate multicolinearity. There were no outliers, as assessed by using the Cook test, with a value greater than 1.0.[9] Therefore, the logistic models were adequate. Table 3 demonstrates that the strongest predictors of critical injury were the ability to obey commands and systolic blood pressure in both logistic regression models, which was confirmed with jackknife statistics. The sensitivity, specificity, and odds ratio for the MCI triage algorithms are shown in Table 4.

DISCUSSION

The physiologic predictors with the strongest association with critical injury were the Motor Component of the Glasgow Coma Scale and systolic blood pressure in this population of designated adult trauma patients. This finding is similar to the findings of other studies that examined the relationship between physiologic variables and severe injury,[10,11] particularly the utility of a measure of level of consciousness.[12-14] The odds ratios were high for the Motor Component of the Glasgow Coma Scale and systolic blood pressure and may suggest the presence of sparse data in the logistic regression model. However, we believe that the models are stable after validation with the jackknife technique and checking for multicolinearity.

Table 1.
Mechanism of injury and criteria for critical injury in the patient sample.

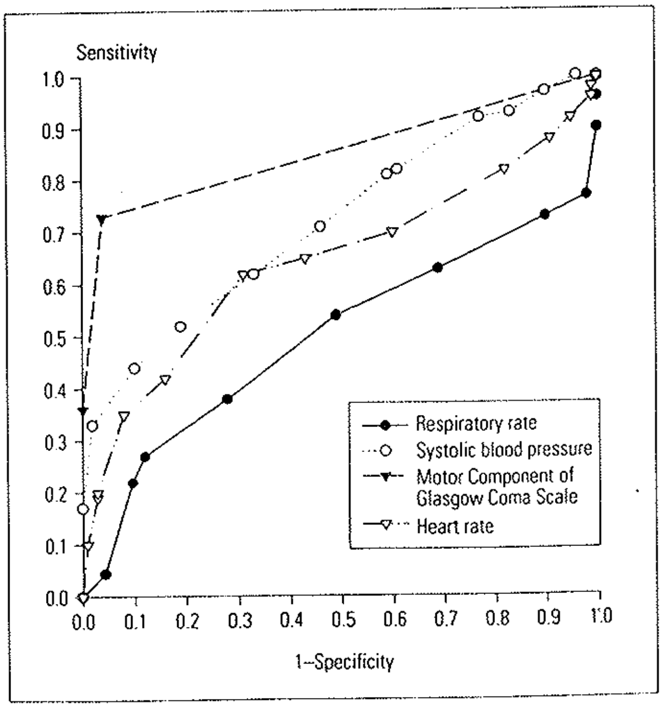
Mechanism of Injury	%
Motor vehicle crash occupant	39.1
Fall <5 m	21.3
Pedestrians and pedal cyclists	10.1
Motorcycle crash	6.6
Sports related	4.3
Blunt assault	4.3
Industrial accident	3.6
Stabbing	2.6
Fall >5 m	2.4
Burns	1.8
Gunshot wound	0.1
Other	3.7

Criteria	Frequency (%)	Frequency of Criterion as Sole Indicator of Critical Injury (%)
Operative intervention required	49 (36.3)	19 (14)
Fluid resuscitation required	51 (37.8)	18 (13.3)
Significant head injury	42 (31.1)	2 (1.5)
Required airway management	82 (60.7)	31 (23)
Required decompression of a tension pneumothorax	1 (0.7)	0 (0)
Any combination of 4 criteria above	2 (1.5)	
Any combination of 3 criteria above	21 (15.6)	
Any combination of 2 criteria above	42 (31.1)	
One criterion above	70 (51.9)	

Table 2.
Predictive value of the physiologic variables at the values used in the MCI triage algorithms.

Variable	Sensitivity, %	Specificity, %
Respiratory rate >29 breaths/min	14.8	95.3
Respiratory rate <10 or >29 breaths/min	25.2	95.3
Glasgow Coma Scale-Motor Response score <6	72.6	96.2
Systolic blood pressure <80 mm Hg	30.4	99.2
Capillary refill >2 s	36.3	93.2
Heart rate >120 beats/min	33.3	91.8

Figure 4.
Receiver operating characteristic (ROC) plot for heart rate, respiratory rate, systolic blood pressure, and Glasgow Coma Scale-Motor Response score. Areas under the ROC plot were as follows: Glasgow Coma Scale-Motor Response score 0.85 (95% CI 0.81 to 0.90); heart rate 0.64 (95% CI 0.58 to 0.70); systolic blood pressure 0.72 (95% CI 0.67 to 0.77); and respiratory rate 0.50 (95% CI 0.43 to 0.56).



CareFlight Triage appeared to be the best of the MCI triage tools in predicting critical injury as a result of greater specificity. However, we cannot be certain that CareFlight Triage was superior to Simple Triage and Rapid Treatment and modified Simple Triage and Rapid Treatment because of the limitations of the study. We are confident that both forms of Triage Sieve were significantly poorer predictors of severe injury in comparison with the other algorithms. These findings would be anticipated from the demonstrated association in the present study between the physiologic variables used in the algorithms and severe injury.

A resource-based definition of severe injury was used in this study because it is a mismatch of resources and needs that makes the process of triage necessary, particularly in the context of a large MCI. Triage aims to ensure that only patients who are likely to benefit from use of resources will have resources expended on them in the early phases of an incident. If resources are initially inadequate to deal with the numbers of critically injured, survival of as many persons as possible mandates that only those most likely to benefit will receive them.

Patients transported by ambulance were assumed to be unable to walk in this study because all patients with high-risk mechanisms of injury are actively immobilized by our EMS system, and the data were therefore unavailable. It is possible, although not likely, that patients identified as immediate priorities in this study by the algorithms could have walked on request and therefore been triaged as delayed in a real MCI. This will alter the reported sensitivities and specificities. All the algorithms tested, however, use the ability to walk as the initial discriminator. There is anecdotal evidence that this is a useful approach where there are large numbers of patients and limited medical resources.[15]

There is considerable doubt about the utility of capillary refill as a measure of hypovolemia in adults.[16] Utility of palpability of the radial pulse and the correlation with a systolic blood pressure of 80 mm Hg, although widely accepted and taught,[6] is yet to be validated. Different sensitivities and specificities will result if this assumption is proved to be invalid.

In the field, CareFlight Triage is likely to be the most rapidly performed of the algorithms because the discriminators used to identify critical patients are qualitative. In those who cannot walk, priority is assigned by asking the patient a simple question, such as where they have pain, while simultaneously palpating for the presence of a radial pulse. This requires 10 to 15 seconds per patient because both tests can be performed simultaneously. Counting a respiratory rate alone will take similar time and may be difficult in heavily clothed persons or low-light conditions.

CareFlight Triage does not assess respiratory rate. This may possibly lead to failure to identify persons with isolated airway injuries. Mass exposure to chemicals or fires could potentially result in large numbers of persons with primarily respiratory symptoms who are otherwise physiologically normal.[17] There is evidence that this risk may be

Table 3.
Logistic regression of predictive value of physiologic factors for critical injury.

Predictors	Odds Ratio (95% CI)	Jackknife Adjusted Odds Ratio (95% CI)
Model 1		
Respiratory rate (≥30 versus <30 breaths/min)	2.24 (0 82 -6 11)	2 35 (0.99 - 5.61)
Glasgow Coma Scale-Motor Response score (≤5 versus 6)	75.49 (42.67 – 133.53)	72 81 (39.98 - 132.62)
Systolic blood pressure (<80 versus ≥80 mm Hg)	32 47 (11.38 -92 67)	31.73 (9 18 - 109 71)
Capillary refill (>2 versus ≤2 s)	3.56 (1.64 -7.71)	3.56 (1 31 -9.67)
Heart rate (>120 versus ≤120 beats/min)	2.63 (1 03 6 69)	2 53 (1 15 -5 60)
Model 2		
Respiratory rate (<10 or >29 versus 10-29 breaths/min)	2 61 (1 01 - 6 70)	2 64 (1 21 -5 76)
Glasgow Coma Scale-Motor Response score (≤5 versus 6)	73.69 (41 59 130 57)	68 68 (37 59 125 47)
Systolic blood pressure (<80 versus ≥80 mm Hg)	32 71 (11 36 94 24)	31 00 (8 74 110 01)
Capillary refill (>2 versus ≤2 s)	3 46 (1 58 7 56)	3 39 (1 22 9 44)
Heart rate (>120 versus ≤120 beats/min)	2 49 (0 97 6 40)	2 45 (1 10 5 48)

Table 4.
Sensitivity, specificity, and odds ratios for the MCI triage algorithms.

Triage Algorithm	Sensitivity, % (95% CI)	Specificity, % (95% CI)	Odds Ratio (95% CI)
Simple Triage and Rapid Treatment (capillary refill)	85 (78 90)	86 (84 88)	35 (21 - 61)
Modified Simple Triage and Rapid Treatment (palpable radial pulse)	84 (76 89)	91 (89 93)	52 (31 -90)
Triage Sieve (capillary refill)	45 (37 54)	89 (87 91)	7 (4 - 10)
Triage Sieve (heart rate)	45 (37 54)	88 (86 90)	6 (4 - 10)
CareFlight Triage	82 (75 88)	96 (94 97)	99 (56 - 176)

theoretical only.[17-22] The Advanced Trauma Life Support course[23] does not list an abnormal respiratory rate as either a reason to suspect inhalational injury or an indication for intubation. Further studies are required to determine whether additional criteria are needed to rapidly identify persons with severe inhalational injury or airway burns.

There are a number of limitations to this study. Clearly, the major limitation is that it is retrospective. The classic manner by which a clinical rule is validated should be composed of 3 steps: derivation, retrospective prevalidation, and prospective validation. This study represents a fulfillment of the first 2 steps. Before any of these approaches can be believed to be validated, they must be tested prospectively in a real-time setting, with similar results to those presented here being obtained.

In addition, the sample of patients examined represents the typical adult trauma patient population seen through an urban trauma center in Australia. The population studied consists of trauma system entries, a preselected population. There was further selection by inclusion of only the patients who had a stay of 4 hours or more or who were admitted to an inpatient unit because these are the patients recorded in the trauma registry. This selection process will lead to the exclusion of some patients ith minor injuries. Because patients in a true mass casualty situation may not be completely comparable with designated trauma patients transported to EDs in routine circumstances, the best triage instrument in this study may not be the best in an actual MCI. Additionally, only 2.7% of the injuries were penetrating, and 1.8% were burns. Reports of both mass shootings and mass burning incidents are frequent in the medical literature. Unlike the population of patients used in this study, who have a variety of mechanisms of injury, most persons in a large MCI are likely to have the same or similar injury mechanisms. Performance of triage algorithms may vary with injury mechanism.

Penetrating trauma creates challenges because early physiologic compensation may mask significant injury, particularly in young adults and children. Algorithms using physiologic variables alone may not initially identify persons with significant injuries who are yet to decompensate. However, the initial round of triage in a mass shooting incident should aim to identify those persons with current physiologic instability because these persons are the most likely to benefit from early intervention and particularly from rapid transport to surgical care. Use of a physiologic system would therefore seem reasonable.

Furthermore, the algorithms studied here may identify atients as immediate whose injuries are so severe that they should not be resuscitated in the context of a major MCI, making the false-positive rate of these algorithms higher than predicted in the present study. Decisions regarding which critical patients should have treatment withheld in favor of casualties with greater chances of survival are unlikely to be amenable to application of a simple algorithm. The decision not to treat certain patients is dependent on many factors other than just physiologic or anatomic signs of severe injury. Guidelines have been published that attempt to bring an evidence base to these decisions in the catastrophic disaster situation.[5] Such decisions can only be made after a more detailed secondary assessment with knowledge of the available resources. What constitutes a false-positive test result in this context will therefore vary from incident to incident. Decisions of this kind will not be necessary in many MCIs, and algorithms of this type are an appropriate rapid screening tool. The decision to withhold treatment, in cases in which it is required, should be made during the more detailed secondary triage round.

The current study examines the MCI triage algorithms in a population of exclusively adult patients. Major MCIs involving almost exclusively children have occurred,[24] as have incidents involving large numbers of children, who must be triaged along with an even larger number of adults.[25] Applying the triage algorithms used in adults to children is difficult because children have different normal physiologic ranges for variables, such as heart rate, blood pressure, and respiratory rate. There are a limited amount of published data on the out-of-hospital triage of injured children. The physiologic variable that appears to be of the greatest benefit is a measure of level of consciousness,[26,27] which is similar to the findings for adults in the present study. The level of consciousness may be a more accurate predictor of major injury in children than adults.[28] However, further studies are needed to determine the accuracy of the MCI algorithms in pediatric populations.

In summary, of the physiologic variables used in the algorithms, the Motor Component of the Glasgow Coma Scale and systolic blood pressure had the strongest association with severe injury. Differences between the accuracy of CareFlight Triage, Simple Triage and Rapid Treatment, and modified Simple Triage and Rapid Treatment were not dramatic, although CareFlight Triage appeared to have greater specificity. Because patients in a true mass casualty situation may not be completely comparable with designated trauma patients transported to EDs in routine circumstances, the best triage instrument in this study may not be the best in an actual MCI. These findings must be validated prospectively and in other patient populations before their accuracy can be confirmed.

Author contributions: AG conceived the study and all authors were involved in study design. AG performed the data abstraction. AG and KH managed the data, including quality control. AL provided statistical advice on study design and analyzed the data. AG drafted the manuscript and all authors contributed substantially to its revision. AG, KH, and CHS take responsibility for the paper as a whole.

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REFERENCES

1. Waeckerle JF. Disaster planning and response. *N Engl J Med.* 1991;324:815-821.

2. Sklar DP. Disaster planning and organisation: casualty patterns in disasters. *J World Assoc Emerg Disaster Med.* 1987;3:49-51.

3. Hodgetts TJ. Triage. *Prehosp Immediate Care.* 1997;1:104-111.

4. Hodgetts TJ, Mackaway-Jones K, eds. *Major Incident Medical Management and Support, the Practical Approach.* Plymouth, MA: BMJ Publishing Group; 1995.

5. Benson DD, Keonig KL, Schultz CH. Disaster triage: START then SAVE—a new method of dynamic triage for victims of a catastrophic earthquake. *Prehosp Disaster Med.* 1996;11:117-124.

6. Prehospital Trauma Life Support Committee of the National Association of Emergency Medical Technicians in Cooperation with the Committee on Trauma of the American College of Surgeons. *Prehospital Trauma Life Support: Basic and Advanced.* 3rd ed. St. Louis, MO: Mosby; 1994:175.

7. Baxt WG, Upenieks V. The lack of full correlation between the Injury Severity Score and the resource needs of injured patients. *Ann Emerg Med.* 1990;19:1396-1400.

8. DeLong ER, DeLong DM, Clark-Pearson DL. Comparing the areas under two or more correlated receiver operating characteristic curves: a nonparametric approach. *Biometrics.* 1988;44:837-845.

9. Katz MH. *Multivariable Analysis: A Practical Guide for Clinicians.* New York, NY: Cambridge University Press; 1999.

10. Baxt WG, Jones G, Fortlage D. The trauma triage rule: a new, resource-based approach to the prehospital identification of major trauma victims. *Ann Emerg Med.* 1990;19:1401-1406.

11. Fries GR, McCalla G, Levitt MA, et al. A prospective comparison of paramedic judgement and the trauma triage rule in the prehospital setting. *Ann Emerg Med.* 1994;25:885-889.

12. Rhodes M, Perline R, Aronson J, et al. Field triage for on-scene helicopter transport. *J Trauma.* 1986;26:963-969.

13. Meredith W, Rutledge R, Hansen AR, et al. Field triage of trauma patients based upon the ability to follow commands: a study in 29,573 injured patients. *J Trauma.* 1995;38:129-135.

14. Ross SE, Leipold C, Terregino C, et al. Efficacy of the Glasgow Coma Score in trauma triage. *J Trauma.* 1998;45:42-44

15. Towne LE. China Eastern MD-11 mass casualty—expect the unexpected, a case report. *Aviat Space Environ Med.* 1995;66:998-1000.

16. McGee S, Abernathy WB, Simel DL. Is this patient hypovolemic? *JAMA.* 1999;281:1022-1029.

17. Baxter PJ, Davies PC, Murray V. Medical planning for toxic releases into the community: the example of chlorine gas. *Br J Ind Med.* 1989;46:277-285.

18. Thanabalasingham T, Beckett MW, Murray V. Hospital response to chemical incident: report on casualties of an ethyldichlorosilane spill. *BMJ.* 1991;302:101-102.

19. Okumura T, Takasu N, Ishimatsu S, et al. Report on 640 victims of the Tokyo subway sarin attack. *Ann Emerg Med.* 1995;28:129-135

20. O'Hickey SP, Pickering CAC, Jones PE, et al. Manchester air disaster. *BMJ.* 1987;294:1663-1667

21. Hart RJ, Lee JO, Boyles DJ, et al. The Summerland disaster. *BMJ.* 1975;1:256-259.

22. Sadler C. The St Valentine's Day disaster. *Nurs Mirror.* 1982;19:14-16

23. Committee on Trauma of the American College of Surgeons. *Advanced Trauma Life Support.* Chicago, IL: American College of Surgeons; 1997

24. Wass AR, Williams MJ, Gibson MF. A review of the management of a major incident involving predominantly paediatric casualties. *Injury.* 1994;25:371-374.

25. Van Amerogen RH, Fine JS, Tunik MG, et al. The Avianca plane crash: an emergency medical system's response to pediatric survivors of the disaster. *Pediatrics.* 1993;92:105-110.

26. Moront ML, Gotschall CS, Eichelberger MR. Helicopter transport of injured children: system effectiveness and triage criteria. *J Pediatr Surg.* 1996;31:1183-1188.

27. Phillips S, Rond PC, Kelly SM, et al. The need for pediatric-specific triage criteria: results from the Florida trauma triage study. *Pediatr Emerg Care.* 1996;12:394-399.

28. Engum SA, Mitchell MK, Scherer LR, et al. Prehospital triage of the injured pediatric patient. *J Pediatr Surg.* 2000;35:82-87.