Comparative Effectiveness Review
Number 205

Physiologic Predictors of Severe Injury: Systematic Review

Agency for Healthcare Research and Quality

Effective Health Care Program

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Key Messages

Purpose of Review

To summarize evaluations of physiologic measures that can be used by emergency medical services personnel to identify patients at high risk of serious injury and inform decisions about the level of trauma care needed.

Key Messages

- Studies examined individual measures and combinations for trauma triage, including systolic blood pressure, heart rate, shock index, lactate, base deficit, respiratory rate, oxygen saturation, and need for airway support.
- Included measures have:
    - Low sensitivities, so normal values on the physiologic measure (a negative test) cannot be used with confidence to determine that patients are not seriously injured.
    - High specificities, meaning abnormal values on the physiologic measure (positive test) are unlikely in patients not seriously injured.
- Combinations of physiologic measures with measures of consciousness may perform better than physiologic measures alone, but feasibility and reliability of performance in the field are significant challenges.
- Measures perform less well in children and older people. Changes in cut-points for these age groups may improve performance but have not yet been rigorously evaluated.
- Research is needed on the feasibility of combination measures and how precisely physiologic parameters are measured, including use of technology.
- Researchers should use standard definitions of serious injury to permit comparisons across studies and measures.

This report is based on research conducted by the Pacific Northwest Evidence-based Practice Center (EPC) under contract to the Agency for Healthcare Research and Quality (AHRQ), Rockville, MD (Contract No. 290-2015-00009-I). The findings and conclusions in this document are those of the authors, who are responsible for its contents; the findings and conclusions do not necessarily represent the views of AHRQ. Therefore, no statement in this report should be construed as an official position of AHRQ or of the U.S. Department of Health and Human Services.

None of the investigators have any affiliations or financial involvement that conflicts with the material presented in this report.

The information in this report is intended to help health care decisionmakers—patients and clinicians, health system leaders, and policymakers, among others—make well-informed decisions and thereby improve the quality of health care services. This report is not intended to be a substitute for the application of clinical judgment. Anyone who makes decisions concerning the provision of clinical care should consider this report in the same way as any medical reference and in conjunction with all other pertinent information, i.e., in the context of available resources and circumstances presented by individual patients.

AHRQ or U.S. Department of Health and Human Services endorsement of any derivative products that may be developed from this report, such as clinical practice guidelines, other quality enhancement tools, or reimbursement or coverage policies, may not be stated or implied.

This report may periodically be assessed for the currency of conclusions. If an assessment is done, the resulting surveillance report describing the methodology and findings will be found on the Effective Health Care Program Web site at www.effectivehealthcare.ahrq.gov. Search on the title of the report.

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Preface

The Agency for Healthcare Research and Quality (AHRQ), through its Evidence-based Practice Centers (EPCs), sponsors the development of evidence reports and technology assessments to assist public- and private-sector organizations in their efforts to improve the quality of health care in the United States. The National Highway Traffic Safety Administration requested this report from the EPC Program at AHRQ to support revision of the Field Triage Guidelines. AHRQ assigned this report to the Pacific Northwest Evidence-based Practice Center (Contract No. 290-2015-00009-I).

The reports and assessments provide organizations with comprehensive, evidence-based information on common medical conditions and new health care technologies and strategies. They also identify research gaps in the selected scientific area, identify methodological and scientific weaknesses, suggest research needs, and move the field forward through an unbiased, evidence-based assessment of the available literature. The EPCs systematically review the relevant scientific literature on topics assigned to them by AHRQ and conduct additional analyses when appropriate prior to developing their reports and assessments.

To bring the broadest range of experts into the development of evidence reports and health technology assessments, AHRQ encourages the EPCs to form partnerships and enter into collaborations with other medical and research organizations. The EPCs work with these partner organizations to ensure that the evidence reports and technology assessments they produce will become building blocks for health care quality improvement projects throughout the Nation. The reports undergo peer review and public comment prior to their release as a final report.

AHRQ expects that the EPC evidence reports and technology assessments, when appropriate, will inform individual health plans, providers, and purchasers as well as the health care system as a whole by providing important information to help improve health care quality.

If you have comments on this evidence report, they may be sent by mail to the Task Order Officer named below at: Agency for Healthcare Research and Quality, 5600 Fishers Lane, Rockville, MD 20857, or by email to epc@ahrq.hhs.gov.

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Technical Expert Panel

In designing the study questions and methodology at the outset of this report, the EPC consulted several technical and content experts. Broad expertise and perspectives were sought. Divergent and conflicted opinions are common and perceived as healthy scientific discourse that results in a thoughtful, relevant systematic review. Therefore, in the end, study questions, design, methodologic approaches, and/or conclusions do not necessarily represent the views of individual technical and content experts.

Technical Experts must disclose any financial conflicts of interest greater than $5,000 and any other relevant business or professional conflicts of interest. Because of their unique clinical or content expertise, individuals with potential conflicts may be retained. The TOO and the EPC work to balance, manage, or mitigate any potential conflicts of interest identified.

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Prior to publication of the final evidence report, the EPC sought input from independent Peer Reviewers without financial conflicts of interest. However, the conclusions and synthesis of the scientific literature presented in this report do not necessarily represent the views of individual reviewers.

Peer Reviewers must disclose any financial conflicts of interest greater than $5,000 and any other relevant business or professional conflicts of interest. Because of their unique clinical or content expertise, individuals with potential nonfinancial conflicts may be retained. The TOO and the EPC work to balance, manage, or mitigate any potential nonfinancial conflicts of interest identified.

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Physiologic Predictors of Severe Injury: Systematic Review

Structured Abstract

Objectives. To systematically identify and summarize evaluations of measures of circulatory and respiratory compromise, focusing on measures that can be used in field assessment by emergency medical services to inform decisions about the level of trauma care needed. We identified research on the ability of different measures to predict whether a patient was seriously injured and thus required transport to the highest level of trauma care available.

Data sources. We searched Ovid MEDLINE®, CINAHL®, and the Cochrane databases from 1996 through August 2017. Reference lists of included articles were reviewed for additional relevant citations.

Review methods. We included studies of individual measures and measures that combined circulatory, respiratory, and level of consciousness assessment. Evaluations included diagnostic accuracy (sensitivity and specificity) and area under the receiver operating characteristic curve (AUROC). We used data provided to calculate values that were not reported and pooled estimates across studies when feasible.

Results. We identified and included 138 articles reporting results of 134 studies. Circulatory compromise measures evaluated in these studies included systolic blood pressure, heart rate, shock index, lactate, base deficit, and heart rate variability or complexity. The respiratory measures evaluated included respiration rate, oxygen saturation, partial pressure of carbon dioxide, and need for airway support. Many different combination measures were identified, but most were evaluated in only one or two studies. Pooled AUROCs from out-of-hospital data were 0.67 for systolic blood pressure (moderate strength of evidence); 0.67 for heart rate, 0.72 for shock index, 0.77 for lactate, 0.70 for respiratory rate, and 0.89 for Revised Trauma Score combination measure (all low strength of evidence); and were considered poor to fair. The only AUROC that reached a level considered excellent was for the Glasgow Coma Scale, age, and arterial pressure (GAP) combination measure (AUROC, 0.96; estimate based on emergency department data). All of the measures had low sensitivities and comparatively high specificities (e.g., sensitivities ranging from 13% to 74% and specificities ranging from 62% to 96% for out-of-hospital pooled estimates).

Conclusions. Physiologic measures usable in triaging trauma patients have been evaluated in multiple studies; however, their predictive utilities are moderate and far from ideal. Overall, the measures have low sensitivities, high specificities, and AUROCs in the poor-to-fair range. Combination measures that include assessments of consciousness seem to perform better, but whether they are feasible and valuable for out-of-hospital use needs to be determined. Modification of triage measures for children or older adults is needed, given that the measures perform worse in these age groups; however, research has not yet conclusively identified modifications that result in better performance.

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Evidence Summary

Background

Unintentional injury is the fourth leading cause of death in the United States, the leading cause for people 1 to 44 years of age,[1] and the reason for millions of emergency department (ED) visits.[2] Trauma is the primary reason emergency medical services (EMS) transport people to the hospital.[3] Out-of-hospital care includes the early interventions and life support needed to prevent immediate deterioration and to secure vital functions after injury.

In the United States, out-of-hospital trauma care is delivered predominately by EMS personnel. EMS personnel can include individuals with different levels of training and certification, including emergency medical responder, emergency medical technician (EMT), advanced EMT, and paramedic.[4] EMS personnel assess patients in environments that are often chaotic and sometimes dangerous. Some out-of-hospital care decisions can be made based on observable characteristics of the injury (e.g., a crush injury or amputation), but other injuries require additional assessment. Triage guidelines and protocols include the assessment of circulatory and respiratory compromise as essential components of the triage process to identify high-risk trauma patients and inform transport destination decisions.

In the current guidelines,[5] field triage of injured patients consists of four steps designed to identify different levels of risk and match patient risk to hospital transport decisions. The first step is to assess variables such as level of consciousness, circulation, and respiration. This assessment is combined with the results of the second step, an assessment of the anatomy of the injury. The combined results of steps 1 and 2 are used to identify the most seriously injured patients who "should be transported preferentially to the highest level of care within the defined trauma system."[5] The initial triage criteria in the current guidelines are physiologic status and level of consciousness. Measures, monitors, and tools are needed to facilitate assessment of physiologic status because, unlike the anatomy of the injury, physiologic status cannot be directly observed. Thresholds indicating need for major level trauma care have been operationalized in the triage guidelines as Glasgow Coma Scale (GCS) ≤13, systolic blood pressure (SBP) <90 mmHg, and respiratory rate <10 or >29 breaths per minute (>20 in infants aged less than 1 year) or need for ventilatory support.[5] If steps 1 and 2 do not specify the patient as requiring transport to a major trauma center, steps 3 and 4 consider the mechanism of injury and additional factors such as age and comorbidities.

The purpose of this systematic review is to identify and summarize the research evidence evaluating measures of circulatory and respiratory compromise, focusing on measures that can be used in the field to triage trauma patients.

This review is designed to help inform decisions about what measures should be recommended in field triage guidelines and promoted for use in EMS practice. This is one of a series of reviews conducted for this purpose. A similar review compared the total GCS to the single item of the motor component for use in out-of-hospital assessment.[6] The ultimate goal is to promote the efficient and effective use of trauma care resources in order to achieve good outcomes for patients.

Methods

Detailed methods are available in the full report and the posted protocol (http://effectivehealthcare.ahrq.gov/index.cfm).

This review focuses on measures that assess the physiologic status (i.e., circulatory or respiratory compromise) of a trauma patient and that can be used in the field by EMS personnel. The purpose of the measures is to identify patients at high risk of serious injury so this information can be used to inform decisions about whether an injured patient needs immediate transport to the highest-level trauma center available.

The scope is limited to considering how well the physiologic measures predict serious injury in trauma patients evaluated by EMS personnel. The assumption is that being able to identify seriously injured patients will inform triage and transport decisions, and these decisions will impact care for the injury, which will affect outcomes. These assumed relationships and the ultimate patient outcomes are important, but not part of the review.

We included measures in the review that can be obtained by standard medical equipment or devices specially designed for field assessment or monitoring. We included ED studies and their data because conducting studies in the field is difficult and the body of evidence based on out-of-hospital data is limited for some measures. However, the data were analyzed and the results are presented separately for out-of-hospital and ED data.

The Key Questions for the review were:

Key Question 1: For patients with known or suspected trauma who are treated out-of-hospital by EMS personnel, what is the predictive utility of **measures of circulatory compromise** or derivative measures (e.g., the shock index) for predicting serious injury requiring transport to the highest level trauma center available?

> 1a. How does the predictive utility of the studied measures of circulatory compromise vary across age groups (e.g., children or the elderly)? Specifically, what values for the different age ranges are supported by the evidence?

Key Question 2: For patients with known or suspected trauma who are treated out-of-hospital by EMS personnel, what is the predictive utility of **measures of respiratory compromise** for predicting serious injury requiring transport to the highest level trauma center available?

> 2a. How does the predictive utility of the studied measures of respiratory compromise vary across age groups (e.g., children or the elderly)? Specifically, what values for the different age ranges are supported by the evidence?

Key Question 3: For patients with known or suspected trauma who are treated out-of-hospital by EMS personnel, what is the evidence that scales combining **(a) measures of respiratory and circulatory compromise or (b) measures of respiratory and/or circulatory compromise together with measurement of altered levels of consciousness** (as defined by Glasgow Coma Scale or its components) can predict the need for transport to a trauma center?

3a. How does the predictive utility of combinations of measures vary across age groups (e.g., children or the elderly)? Specifically, what values for the different age ranges are supported by the evidence?

The scope and Key Questions for this topic were initially developed by the Agency for Healthcare Research and Quality in conjunction with the sponsoring partner agency, the National Highway Transportation Safety Administration.

To identify studies we searched Ovid MEDLINE®, CINAHL®, and the Cochrane Databases from 1996 through August 2017. We included studies of individual measures and measures that combined circulatory, respiratory, and level of consciousness assessment. For studies that met inclusion criteria, the key characteristics and results were abstracted into evidence tables that provide the basis for the description and synthesis of this body of literature. Studies were evaluated for risk of bias using the Quality in Prognosis Studies (QUIPS) tool.[7] The complete evidence tables and the risk of bias ratings for each included study are available in Appendixes D and F of the full report.

The end points or outcomes of interest were the predictive utility of the measures. We included different approaches to assessing predictive utility: (1) measures of diagnostic accuracy (e.g., sensitivity and specificity,) and (2) discrimination (e.g., area under the receiver operating characteristic curve [AUROC]). Studies that provided only descriptive information, unadjusted risk estimates, or assessments of continuous variables (e.g., correlations or tests of differences in means) were excluded unless data were provided that could be used to calculate included outcomes. For this review our focus was on the predictive utility for identifying patients at high risk of being seriously injured. We defined seriously injured broadly and used a range of indicators of serious injury, including resource use (e.g., blood transfusion, intensive care unit [ICU] admission, and life-saving interventions), measures of anatomic injury severity measures (e.g., the Injury Severity Score [ISS]), and mortality, or combinations of any of these).

We conducted quantitative synthesis (i.e., meta-analysis) of diagnostic measures when there were adequate data from included studies. In cases with few studies, lack of data, or when data were only available as adjusted risk estimates from multivariate analyses, the range of the results and qualitative summaries were provided.

For meta-analyses we used a bivariate logistic mixed effects model[8] to analyze sensitivity and specificity, incorporating the correlation between sensitivity and specificity. We assumed random effects across studies for sensitivity and specificity, and heterogeneity among the studies was measured based on the random effect variance. We also assessed statistical heterogeneity using the standard χ^2 test and I^2 statistic. We calculated positive likelihood ratio (LR+) and negative likelihood ratio (LR-) using the summarized sensitivity and specificity.[9,10] Analyses were stratified by different cutoff points when necessary to generate clinically meaningful combined estimates. Similarly, we performed random effects meta-analysis to calculate the

combined AUROC using the profile likelihood method, which incorporates the uncertainty related to estimating between-study heterogeneity into account.

All analyses were conducted using Stata/IC 13.1 (StataCorp LP, College Station, TX), except for the bivariate logistic mixed effects model, for which SAS 9.4 (SAS Institute Inc., Cary, NC) was used.

The review team and Technical Expert Panel included experts who have conducted and published research in this field. In order to avoid bias, or the appearance of bias, we took the following steps: (1) authors were not involved in any decisions about including or excluding their own work, (2) to the extent it was feasible, reviewers were blinded to authors during title and abstract review so that the other team members/reviewers were not biased in favor of colleagues, (3) for full-text review, no one was assigned to review research they contributed to, and (4) team members and experts did not rate the risk of bias or abstract data from studies to which they contributed.

Results

We identified and included 138 articles reporting results of 134 studies: 90 evaluated measures of circulatory compromise, 39 respiratory compromise, and 64 included combination measures. Over two-thirds (96) of the studies were retrospective and the remainder (42) were prospective. A total of 25 studies used data from multi-site registries, 65 studies used administrative or registry data from a single site, and 48 studies engaged in primary data collection for the study. Three-quarters (103) of the studies were assessed as moderate risk of bias and the others were rated low risk of bias (10) or high risk of bias (25 studies). The concerns about bias were primarily related to three domains: study participation (e.g., concerns about sampling or recruitment), attrition (e.g., lost to followup), and lack of control for confounding factors that were not adequately addressed in the study design.

Studies used different indicators for serious injury, and often assessed more than one indicator. We grouped the indicators into three categories: (1) resource utilization, which includes lists of life-saving interventions, surgery, transfusion, ICU admission, or the published consensus-base criterion standard;[11] (2) ratings of anatomic injury severity such as the ISS or types of injury or diagnosis such as traumatic brain injury; and (3) mortality. Resource utilization was the most common indicator (110 studies). A similar number of studies reported on the relationship between the measures and mortality (95 studies), while injury severity or type was less common (19 studies).

Tables A, B, and C consolidate the key estimates of the predictive utility of each identified measure. Sensitivity, specificity, and AUROC values for out-of-hospital and ED measurements are provided. When we were able to pool data, the pooled estimates are given in bold; when data were not pooled, the range of values from the included studies are given in italics. Additional information, such as the number of patients in the included studies and 95% confidence intervals for the estimates, are available in the figures and tables in the full report.

Table A. Key Question 1 results: overview of predictive utility of circulatory measures for serious injury* by setting

Measure	Out-of-Hospital: Sensitivity (SOE) Specificity (SOE) Number of Studies	Emergency Department: Sensitivity (SOE) Specificity (SOE) Number of Studies	Out-of-Hospital: AUROC (SOE) Number of Studies	Emergency Department: AUROC (SOE) Number of Studies
Systolic Blood Pressure	SBP <90 mmHg Sen: **19%** (SOE: Low) Sp: **95%** (SOE: Moderate) 17 studies[12-28] SBP higher thresholds (<100, 110, or 120 mmHg) Sen: **35%** (SOE: Low) Sp: **88%** (SOE: Low) 6 studies[12,13,19,29-31]	SBP <90 mmHg Sen: **18%** (SOE: Low) Sp: **97%** (SOE: Moderate) 9 studies (in 10 articles)[12,21,29,30,32-37] SBP higher thresholds (<100, 110, or 120 mmHg) Sen: **35%** (SOE: Low) Sp: **89%** (SOE: Moderate) 4 studies[12,38-40]	**0.67** (SOE: Moderate) 9 studies[16,28,41-47]	**0.64** (SOE: Moderate) 12 studies (in 13 articles)[32,35,36,38,43,48-55]
Heart Rate	HR >110 bpm Sen: **28%** (SOE: Low) Sp: **85%** (SOE: Low) 4 studies[19,28,30,31]	HR >110 bpm Sen: **29%** (SOE: Moderate) Sp: **93%** (SOE: Moderate) 5 studies[33,37,40,51,56]	**0.67** (SOE: Low) 5 studies[28,42,44-46]	**0.66** (SOE: Moderate) 9 studies (in 10 articles)[32,35,36,38,49,51-53,55,57]
Shock Index	SI >0.9 or >1 Sen: **37%** (SOE: Low) Sp: **85%** (SOE: Low) 5 studies[47,54,58-60]	SI >0.9 or >1 Sen: **40%** (SOE: Low) Sp: **93%** (SOE: Moderate) 11 studies (in 12 articles)[35,36,38,59-67]	**0.72** (SOE: Low) 7 studies[16,28,41,45,47,58,68]	**0.71** (SOE: Moderate) 11 studies (in 12 articles)[35,36,38,40,49,53,55,62,63,65,69,70]
Lactate	Lactate >2 or 2.5 mmol/L Sen: **74%** (SOE: Low) Sp**: 62%** (SOE: Moderate) 3 studies[16,71,72] Lactate >4 mmol/L Sen: **23%** (SOE: Insufficient) Sp: **93%** (SOE: Insufficient) 1 study[71]	Lactate >2 or 2.5 mmol/L Sen: **74%** (SOE: Low) Sp: **52%** (SOE: Low) 9 studies (in 10 articles)[35,36,43,73-79] Lactate >4 mmol/L Sen: **50%** (SOE: Low) Sp: **86%** (SOE: Moderate) 9 studies[39,43,58,61,73,75,77,80,81]	**0.77** (SOE: Low) 2 studies[16,72]	**0.68** (SOE: Moderate) 14 studies (in 15 articles)[35,36,43,58,73,74,76,78-80,82-86]

Measure	Out-of-Hospital: Sensitivity (SOE) Specificity (SOE) Number of Studies	Emergency Department: Sensitivity (SOE) Specificity (SOE) Number of Studies	Out-of-Hospital: AUROC (SOE) Number of Studies	Emergency Department: AUROC (SOE) Number of Studies
Base Deficit	None	Sen: *19 to 59%* (SOE: Low) Sp: *59 to 98%* (SOE: Moderate) 9 studies (in 10 articles)[32,35-37,61,75,80,83,87]	None	*0.67 to 0.90* (SOE: Moderate) 12 studies (in 13 articles)[32,35,36,49,52,65,73,77,80,82,83,85,86]
Heart Rate Variability/Heart Rate Complexity	Sen: *80 to 90%* (SOE: Low) Sp: *67 to 100%* (SOE: Low) 2 studies[44,88]	None	*0.60 to 0.95* (SOE: Low) 7 studies[44,46,88-92]	*0.67 to 0.68* (SOE: Insufficient) 1 study[93]

AUROC = area under the receiver operating characteristic curve; bpm = beats per minute; HR = heart rate; SBP = systolic blood pressure; Sen = sensitivity; SI = shock index; SOE = strength of evidence; Sp = specificity

Note: Bold font = data from pooled estimates; italic font = range from unpooled studies

*Serious injury includes resource use (e.g., blood transfusion, intensive care unit [ICU] admission, and life-saving interventions) and injury severity measures (e.g., the Injury Severity Score [ISS], mortality, or combinations of any of these)

Table B. Key Question 2 results: overview of predictive utility of respiratory measures for serious injury* by setting

Measure	Out-of-Hospital: Sensitivity (SOE) Specificity (SOE) Number of Studies	Emergency Department: Sensitivity (SOE) Specificity (SOE) Number of Studies	Out-of-Hospital: AUROC (SOE) Number of Studies	Emergency Department: AUROC (SOE) Number of Studies
Respiratory Rate	RR <10 or >29 Sen**: 13%** (SOE: Low) Sp: **96%** (SOE: Low) 6 studies[14,20,23-25,94]	RR <10 or >29 Sen: **27%** (SOE: Moderate) Sp: **95%** (SOE: Moderate) 4 studies[33,34,38,51]	**0.70** (SOE: Low) 3 studies[46,95,96]	**0.61** (SOE: Moderate) 3 studies[38,48,51]
O_2 Saturation	Sen: *13 to 99%* (SOE: Low) Sp: *85 to 99%* (SOE: Low) 3 studies[17,27,28]	Sen: *25 to 100%* (SOE: Low) Sp: *39 to 94%* (SOE: Low) 2 studies[32,97]	*0.53 to 0.76* (SOE: Low) 3 studies[27,28,96]	*0.61 to 0.76* (SOE: Low) 2 studies[32,53]

Measure	Out-of-Hospital: Sensitivity (SOE) Specificity (SOE) Number of Studies	Emergency Department: Sensitivity (SOE) Specificity (SOE) Number of Studies	Out-of-Hospital: AUROC (SOE) Number of Studies	Emergency Department: AUROC (SOE) Number of Studies
Airway Support	Sen: *8 to 53%* (SOE: Low) Sp: *61 to 100%* (SOE: Low) 4 studies (in 5 articles)[17,24,92,98,99]	Sen: *32 to 57%* (SOE: Low) Sp: *85 to 96%* (SOE: Low) 3 studies[34,93,100]	None	None

AUROC = area under the receiver operating characteristic curve; O2 = oxygen; RR = respiratory rate; Sen = sensitivity; SOE = strength of evidence; Sp = specificity

Note: Bold font = data from pooled estimates; italic font = range from unpooled studies

*Serious injury includes resource use (e.g., blood transfusion, intensive care unit [ICU] admission, and life-saving interventions) and injury severity measures (e.g., the Injury Severity Score [ISS], mortality, or combinations of any of these)

Table C. Key Question 3 results: overview of predictive utility of combination of circulatory, respiratory, and level of consciousness measures for serious injury* by setting

Measure	Out-of-Hospital: Sensitivity (SOE) Specificity (SOE) Number of Studies	Emergency Department: Sensitivity (SOE) Specificity (SOE) Number of Studies	Out-of-Hospital: AUROC (SOE) Number of Studies	Emergency Department: AUROC (SOE) Number of Studies
Revised Trauma Score and Revised Trauma Score for Triage	RTS <7.5, T-RTS <12 Sen: *95 to 96%* (SOE: Insufficient) Sp: *38 to 42%* (SOE: Insufficient) 1 study (in 2 articles)[98,99]	RTS <5.68 or <5.97, T-RTS <8 or <12 Sen: *19 to 84%* (SOE: Low) Sp: *64 to 100%* (SOE: Low) 6 studies[28,34,48,61,101,102]	**0.57** for Resource use (SOE: Low) **0.89** for Mortality (SOE: Low) 3 studies (in 4 articles)[28,45,98,99]	**0.88** for Mortality (SOE: Low) 7 studies[48,69,70,83,101,103,104]
Glasgow Coma Scale, Age, and Arterial Pressure (GAP)	None	Sen: *75 to 98%* (SOE: Low) Sp: *57 to 91%* (SOE: Low) 2 studies[101,105]	None	**0.96** for both Mortality and Early Mortality (SOE: Moderate) 3 studies[101,103,105]

AUROC = area under the receiver operating characteristic curve; RTS = Revised Trauma Score; Sen = sensitivity; SOE = strength of evidence; Sp = specificity; T-RTS = Revised Trauma Score for Triage

Note: Bold font = data from pooled estimates; italic font = range from unpooled studies

*Serious injury includes resource use (e.g., blood transfusion, intensive care unit [ICU] admission, and life-saving interventions) and injury severity measures (e.g., the Injury Severity Score [ISS], mortality, or combinations of any of these)

Our analysis of individual measures of circulatory and respiratory compromise (Key Question 1 and Key Question 2) included pooled analyses of SBP, shock index (SI), heart rate (HR), lactate, and respiratory rate (RR), and qualitative summaries of studies of heart rate variability/heart rate complexity, base deficit, and oxygen saturation. Other measures that were the subject of one or two studies were included but not synthesized.

Most of the strength of evidence assessments were "low" due to inconsistency in results across studies and imprecise estimates, though in some cases study limitations also contributed to the low rating. There were a few "moderate" ratings for measures where there were more studies and subjects and the results were consistent and the estimates more precise. There were no "high" strength of evidence ratings as we are not confident that the results will not change based on future studies of physiologic measures that are larger, better, and purposefully designed to study trauma triage.

Across all the measures, the pooled AUROC values we calculated generally fell into the ranges considered poor (0.60 to 0.69) or fair (0.70 to 0.79). Focusing on data collected out-of-hospital, the lowest pooled AUROCs were for SBP (0.67) and HR (0.67). The AUROCs were in the fair range for SI (0.72), lactate (0.77), and RR (0.70). We also pooled data to estimate sensitivity and specificity results for blood pressure and lactate at different thresholds (<90 and <100 mmHg for blood pressure and >2.0 or >4.0 mmol/L for lactate). Using the higher threshold of <100 mmHg for SBP did increase sensitivity compared the lower threshold of <90 mmHg (from 19% at the lower threshold to 35% at the higher threshold for out-of-hospital studies, and from 18% to 35% for ED studies) with a moderate decrease in specificity (from 95% at the lower threshold to 88% at the higher threshold for out-of-hospital, and from 97% to 89% in ED). For lactate, defining abnormal with a more extreme value of >4.0 mmol/L decreased sensitivity and increased specificity. The changes were more extreme in the out-of-hospital data (sensitivity was 74% for lactate >2.0 mmol/L and 23% for >4.0 mmol/L; specificity increased from 62% to 93%) than in the ED data (sensitivity was 74% for lactate >2.0 mmol/L and 50% at >4.0 mmol/L; specificity increased from 52% to 86%). However, the out-of-hospital estimates are from fewer studies and patients and the estimates are less stable and less precise.

We identified numerous combination measures (Key Question 3); however, most were analyzed in only one or two articles. The exception was the Revised Trauma Score (RTS) and variations on this score. Given that the formula for RTS cannot be calculated quickly without a calculator or app, some studies suggested and evaluated revisions that simplified the calculation. The produced minor decreases in AUROCs (from 0.90 for the RTS to 0.88[99] for the simpler version, or from 0.75 to 0.74[98]). Another combination of potential interest is Glasgow Coma Scale, age, and arterial pressure (GAP), which combines the Glasgow Coma Scale (GCS) score, adds points if the patient is over 60 years of age (age is the A in GAP), and scores SBP as above or below 120 mmHg. Adding age means this is not purely a physiologic measure, but it is included as it is simple and there is small but growing evidence of its performance. While the data we reviewed is from a smaller number of studies than are available for other measures, and the measures were all collected in the ED, these initial indications are that the GAP performs well. Reported AUROCs were over 0.9 and sensitivities ranged from 75 to 98 percent and specificities from 57 to 91 percent across different indicators of serious injury.

We examined the utility of the measures or specific thresholds for pediatric and older trauma patients. The included studies that assessed measures in pediatric patients reported that the standard thresholds used for adults for SBP and base deficit resulted in low sensitivities in children. Lactate >2.0 resulted in higher sensitivities compared to the other measures, but the

values were still low. Performance of this measure varied across indicators of serious injury and in age subgroups in the one study with subgroup comparisons; however, larger studies are needed to confirm these variations. The results of evaluations of respiratory rate are inconsistent, with reported sensitivities ranging from 2 to 76 percent. Combination measures performed better, with better results for a trauma score developed specifically for pediatrics.

In older adults, studies reported consistently low sensitivities and AUROCs for SBP, lactate, base deficit, respiratory rate, and assisted ventilation. Shock index also performed less well in older patients.[106] Some variations of triage criteria modified for older adults by either changing thresholds or adding additional criteria (e.g., mechanism of injury) have demonstrated substantial increases in sensitivity (e.g., 76% to 92%[107]), but this magnitude of improvement is not consistent across indicators of serious injury and came with similar substantial decreases in specificity (e.g., 78% to 42%[107]).

Discussion

Implications and Applicability

For out-of-hospital clinical practice, our findings demonstrated that current circulatory and respiratory measures have low sensitivities but higher specificities. The evidence does not point to necessarily "better" cut-points for measures such as SBP, SI, and RR. In general, more liberal cut-points (e.g., SBP <110 mmHg vs. <90 mmHg) will raise sensitivity and lower specificity—an inevitable trade-off, but the magnitude of this trade-off may differ across tests.

However, based on the evidence we identified, no physiologic measures have high enough sensitivity that a negative result (e.g., normal physiologic value) could be confidently used to conclude that a patient is not at risk of being seriously injured, even with more liberal cut-points.

Our findings were based on a relatively large number of diverse studies. Having data from studies across a wide range of possible situations mirrored the reality of field triage and out-of-hospital assessment. While the diversity across the studies meant heterogeneity was high in the pooled estimates and the consistency across results was lower, the range was likely to reflect the variation that will be seen in trauma assessment and triage.

An approach to summarizing the data across studies and considering their impact is presented in Table D. This is a standard approach often used to present the implications of how well a screening test or triage tool performs. The pooled data are modeled to generate positive and negative likelihood ratios (LR+ and LR-). The positive likelihood ratio is Sensitivity/(1-Specificity) and the negative likelihood ratio is (1-Sensitivity)/Specificity. The likelihood ratios are then applied to different hypothetical pre-test probabilities and odds to produce post-test odds of the outcome (in this case serious injury) given a negative or positive test. The post-test probability if the test is negative (1-Negative Predictive Value) is also referred to as under-triage.

Table D. Post-test odds and probability of serious injury given pre-test assumptions

Physiological Predictor (Test)	Serious Injury Indicator (Outcome)	Pre-Test Probability (Hypo-thetical)	Pre-Test Odds	LR+	LR-	Post-Test Odds (if a patient has positive test)	Post-Test Probability (PPV) (if a patient has positive test)	Post-Test Odds (if a patient has negative test)	Post-Test Probability (1-NPV) (if a patient has negative test)
SBP < 90	Resource Use	10%	0.11	4.32	0.83	0.48	32%	0.09	8%
SBP < 90	Resource Use	20%	0.25	4.32	0.83	1.08	52%	0.21	17%
SBP < 100	Resource Use	10%	0.11	3.30	0.80	0.36	27%	0.09	8%
SBP < 100	Resource Use	20%	0.25	3.30	0.80	0.83	45%	0.20	17%
HR ≥ 110	Resource Use	10%	0.11	1.37	0.91	0.15	13%	0.10	9%
HR ≥ 110	Resource Use	20%	0.25	1.37	0.91	0.34	25%	0.23	19%
SI > 1	Resource Use	10%	0.11	3.13	0.71	0.34	26%	0.08	7%
SI > 1	Resource Use	20%	0.25	3.13	0.71	0.78	44%	0.18	15%
Lactate > 2*	Resource Use	10%	0.11	1.94	0.29	0.21	18%	0.03	3%
Lactate > 2*	Resource Use	20%	0.25	1.94	0.29	0.48	33%	0.07	7%
Lactate >4*	Resource Use	10%	0.11	2.34	0.59	0.26	21%	0.07	6%
Lactate >4*	Resource Use	20%	0.25	2.34	0.59	0.59	37%	0.15	13%
RR < 10 or > 29	Resource Use	10%	0.11	5.61	0.90	0.62	38%	0.10	9%
RR < 10 or > 29	Resource Use	20%	0.25	5.61	0.90	1.40	58%	0.23	18%

HR = heart rate; LR+ = positive likelihood ratio; LR- = negative likelihood ratio; NPV = negative predictive value; PPV = positive predictive value; RR = respiratory rate; SBP = systolic blood pressure; SI = shock index

*Lactate >4 is based on emergency department data; lactate >2 is out-of-hospital

Overall, our analysis demonstrated that physiologic measures have low sensitivity for identifying high-risk trauma patients (i.e., many patients will have normal physiology and prove to have serious injuries—there are higher numbers of false negatives), but have high specificity (i.e., patients with abnormal physiologic measures are likely to have resource needs, serious injuries, and are at higher mortality risk – there are few false positives). There was little evidence to suggest that one physiologic measure is significantly better than another (e.g., SBP versus SI versus lactate) because fewer studies compared these measures directly in head-to-head studies, the head-to-head studies were not amenable to pooling as they use different thresholds and outcomes, and the differences across our pooled estimate were small to moderate. However, combining different categories of physiologic measures (e.g., circulatory and level of consciousness) may increase predictive yield. Less extreme cut-points (e.g., lactate >2, SBP

<110) raised sensitivity and lowered specificity, demonstrating that sensitivity and specificity have an inverse relationship when selecting dichotomous cut-points in continuous measures.

Limitations

The major limitations of the evidence base are the limited number of head-to-head comparisons and generally low strength of evidence available. As this review illustrates, there are a number of potential physiologic measures that could be used in triage and a range of indicators of serious injury used in this body of research. Our approach to this diversity was to focus on combining information for the same measure across studies and then looking across the measures. If we had limited our examination to comparable head-to-head comparisons we would have had small numbers of studies in each of a larger number of pairwise comparisons. However, there is a risk in comparing measure across studies rather than relying on comparisons within studies. Measures in different studies may produce similar results but for different populations. For example, if estimates of the AUROC for SBP and HR are similar, based on different studies with different populations, we could erroneously conclude that they will perform similarly across all patients when in truth SBP has this discriminant level for one subtype of patients while HR is similar but in a different subtype of patients. In order to assess this risk, we examined the results of the available head-to-head studies from the smaller number of studies that included direct comparisons and this did not change our conclusions. An overview of selected comparisons and all the results from these studies are included in the text and Appendix of the full report.

The literature available for analysis was dominated by studies that effectively limited their population to trauma patients who are transported by EMS. Most of the studies were based on data from trauma registries. While the specifics for inclusion vary across registries and also across studies that use administrative records in a similar way, standard practice seems to be inclusion of data collected on transported and/or admitted patients. The implication is that patients assessed by EMS but not transported are either not included at all or included inconsistently.

Another characteristic of the data in these registries is that it is usually collected prospectively but analyzed retrospectively, thus blurring the distinction between retrospective and prospective study types. In many cases the data sources are difficult to determine based on the published reports. Analysis is also complicated by the fact that the registry studies usually have large samples, while more clearly prospective studies we identified were often exploratory with small samples. The distinction matters because in other situations we might be able to make assumptions about the potential for differences in bias in prospective and retrospective studies, but in this literature the direction of the potential bias was not clear.

A substantial limitation in the evidence base was the lack of population-based samples where physiologic measures were collected in the out-of-hospital setting and patients were tracked across all hospitals (i.e., not limited to patients transported to major trauma centers), across phases of care (e.g., ED, hospital #1, transfer, hospital #2), and using population-based sampling to reduce selection bias.

There was also limited detail about how the physiologic measure data were collected. Studies rarely reported details that could be important, such as what equipment was used, how and when the measurement was taken, and who was involved. Another important limitation of the research on this topic is the lack information on subpopulations, particularly children and older adults.

The evidence base also was inconsistent in how high-risk, seriously injured, trauma patients were defined, especially related to resource use. Studies tended to use a single indicator, such as need for a massive transfusion, rather than include multiple indicators, and even the definitions of given indicator varied across studies (e.g., what volume is considered massive and over what time period?). While the trauma research community has made efforts to come up with a comprehensive resource-based definition (i.e., the consensus-based criteria[11] and lists of life-saving interventions), such a uniform definition is not yet common in the trauma research. The result is that many studies may underestimate the utility of measures by requiring that they predict single or narrowly-defined indicators of severe injury.

There were also limitations to this review resulting from our decisions and processes. We included measurements in the ED as well as out-of-hospital measurements, but presented the ED and out-of-hospital results separately. We identified and included prognostic studies as they are similar but not identical to studies of predictive utility.

Future Research Needs

This review summarizes a sizable body of literature and it highlights several areas in which future research is needed.

One priority is for studies that compare, or at least document, differences in measurement (e.g., instrumentation, timing). This would allow the impact of these differences on the predictive utility of the measure to be considered.

Another priority is to encourage more research using the consensus-based criteria of the need for care in a major trauma center or a standardized list of life-saving interventions. If the indicators of high-risk patients were consistent, cleaner comparisons could be made both across studies and across measures. This would also permit an assessment of the utility of individual measures in a broader context.

Also, sampling patients in the out-of-hospital setting and tracking them through their hospital course and beyond, regardless of which hospital they were transported to, would help to reduce a large source of potential bias.

A key topic for additional research is the assessment of the utility of measures across age groups. While we did identify some studies that considered the use of physiologic measures for children and older adults, this is still a small subset of the literature and many questions remain. Age is often available or collected and if more researchers stratified analyses by age, even if age is not the focus of the study, a substantial amount of information would become available to inform decisions and improve care for children and older individuals.

Conclusions

While specifics vary across measures, settings, and populations, overall the predictive utilities of physiologic measures that are either currently used for trauma assessment and triage, or have been suggested, are moderate and not ideal. Measures of circulatory compromise (SBP, HR, SI, and lactate) and respiratory compromise (RR) have been evaluated in multiple studies, some with large numbers of patients. In general, these measures have low sensitivities, high specificities, and AUROCs in the fair-to-good range. Use of these measures should be guided by the understanding that when they are abnormal, that they are highly predictive of high-risk of serious injury in trauma patients, but that many patients with serious injuries will have normal physiologic measures. Combinations of these measures with assessments of consciousness seem to perform better, but how they would be implemented out-of-hospital needs to be determined,

and then they need to be tested under field conditions to confirm their effectiveness and utility. Modification of triage measures for children or older adults is needed, given that these measures perform worse in these age groups than in adults; yet, the research has not yet identified better performing variations or replacements.

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Introduction

Background

Burden of Trauma

In 2015, unintentional injury was the fourth leading cause of death in the United States, the leading cause for individuals 1 to 44 years of age, and in the top five for all age groups except people 65 years of age and older (seventh for this group).[1] In 2014, there were approximately 40 million emergency department (ED) visits for injuries (28.3% of all ED visits); of these, 3 million were due to trauma complications and unspecified injuries.[2] Trauma is also the most frequent reason for emergency medical services (EMS) emergency responses, accounting for over 25 percent of all encounters in the United States in 2010.[3]

Trauma Triage

Pathways of care for injured patients, which include people with intentional as well as unintentional injuries, are based on systems of care that address the various stages along the trauma chain of survival.[4] Out-of-hospital care includes the early interventions and life support needed to prevent immediate deterioration and secure vital functions as well as triaging (sorting) patients to appropriate sites for additional care.

In the United States, out-of-hospital trauma care is delivered predominately by EMS personnel. EMS personnel can include individuals with different levels of training and certification, including an emergency medical responder, emergency medical technician (EMT), advanced EMT, and a paramedic.[5] EMS personnel must assess patients in environments that are often chaotic and sometimes dangerous. While it is often clear that a patient is injured, a more nuanced assessment is frequently required to identify high-risk patients and inform the best course of action and transport decisions. EMS providers must quickly identify if there are immediate life-threatening conditions or serious injuries that require emergent interventions. The treatment of injured patients includes assessment of injuries and stabilization as well as deciding where to transport the patient. Triage (from French, “to sort”) is the process of deciding where the patient will be transported. While the assessment, treatment, and stabilization are direct care activities, when combined with the transport destination decision they are often referred to as field triage (Figure 1).

Figure 1. Emergency medical services field triage

An important aspect of this initial care for informing triage and transport decisions is accurately identifying those trauma patients who are likely to have a serious injury, require early

critical resources, or are at risk for death. Selecting the appropriate destination hospital, specifically whether or not a patient should be transported to a designated major trauma center, is a key decision affecting patient outcomes.[6,7] Under-triage, meaning transporting someone to a lower level of care than needed after trauma, is associated with a substantial increase in mortality.[8] Survival among patients with serious injuries is 25 percent higher when treated at a major trauma center compared with a nontrauma center.[9] However, major trauma centers are a costly and limited resource. Patients without serious injuries can be treated effectively outside of major trauma centers and at hospitals that may be closer, and studies suggest that accurate triage could reduce over-use and produce substantial cost savings.[10,11] Therefore, one of the goals of trauma systems is to efficiently concentrate patients with serious injuries in major trauma centers. Field trauma triage plays a critical role in this process.

Field triage criteria have been developed to help EMS personnel match patient needs with the appropriate level of care. The utility of these criteria is based on their ability to help identify high-risk trauma patients with serious injuries who have a high likelihood of mortality and other adverse clinical outcomes and who, therefore, needs higher levels of care.

In the current guidelines, field triage of injured patients consists of four steps designed to identify different levels of risk and match patient risk to hospital transport decisions. The first step is to assess variables such as level of consciousness, circulation, and respiration. This assessment is combined with the second step, an assessment of the anatomy of the injury, and the combined results of steps 1 and 2 are used to identify the most seriously injured patients who "should be transported preferentially to the highest level of care available within the defined trauma system." If steps 1 and 2 do not identify the patient as requiring transport to a major trauma center, step 3 considers the detailed mechanism of injury (i.e., falls, high-risk auto crash, or motorcycle crash) and the recommendation is that patients with these injuries should be transported to the "closest trauma center, which need not be the highest level." Step 4 adds consideration of several additional factors such as age, comorbidities (e.g., anticoagulation and bleeding disorders, end-stage renal disease, pregnancy >20 weeks), burns with or without trauma, and EMS judgment, and recommends that medical control be contacted with transport to a trauma center or specific resource hospital considered.[12]

The initial (step 1) triage criteria in the current guidelines are physiologic (blood pressure, respiratory rate [RR]) measures and level of consciousness. Measures, monitors, and tools are often needed to facilitate assessment of physiologic status because, unlike the anatomy of the injury, physiologic status cannot be directly observed. Thresholds indicating need for major level trauma care have been operationalized in the most recent trauma triage guideline as Glasgow Coma Scale (GCS) ≤13, systolic blood pressure (SBP) <90 mmHg, and respiratory rate (RR) <10 or >29 breaths per minute (>20 in infants aged less than 1 year), or a need for ventilatory support.[12]

Physiologic Measures in Field Triage

Blood pressure, RR, and GCS have been part of the field triage guidelines since their initial publication in 1987. Ventilatory support was added in 2011, and the threshold for GCS was changed from ≤14 to ≤13 since the initial publication.[13]

In 2007, the Institute of Medicine issued a report on the future of EMS, *Emergency Medical Services: At the Crossroads*, which pointed out evidence gaps in prehospital trauma care.[14] Over the past decade, the research base has grown: the number of studies used to support the trauma triage guidelines has increased 24-fold from approximately two per year in the 2006 guidelines

to about 48 per year in the 2011 guidelines.[12] Other developments, including point-of-care testing and advanced monitoring technology such as sensors, may impact the entire triage process. Despite these changes, the criteria have remained relatively stable since the initial version.[13] Recent prospective research suggests that the current Field Triage Decision Scheme fails to identify a substantial number of patients with serious injuries[15] and that there is opportunity to optimize the field triage criteria, particularly the physiologic measures. New continuous monitoring and communications technologies have been developed and present opportunities to collect, use, and transmit additional information in trauma care.[16-19] Additionally, testing and evaluation of these physiologic indicators of trauma have revealed that they may perform differently in different populations. For example, some measures may underestimate risk and therefore lead to undertriage of elderly trauma victims,[20,21] and some measures may require different cutoffs when assessing children.[22] These factors have led to proposals to consider new potential indicators such as complexity/variability of heart rate (HR), tissue O_2 saturation, mean arterial pressure, lactate, end-tidal CO_2, descriptors for respiratory effort, or derivatives such as the shock index (HR divided by SBP), as well as new age-specific thresholds.[23,24] Individual measures may also be combined into risk assessment instruments. For trauma care in the field, ideal measures and instruments need to be easy to use, accurate, and easy to interpret under a variety of field conditions by personnel with varying levels of training.

Determining the need for trauma center care among injured patients is important in evaluating and comparing different measures of physiologic compromise that can be used to inform triage decisions, but operationalizing the identification of high-risk trauma patients requiring care in major trauma centers is challenging. Indicators of the need for trauma care that have been used or proposed include in-hospital mortality, measures of resource use (e.g., a published consensus-based criterion,[15,25] lists of life-saving interventions,[16,17] or a need for a single intervention such as major nonorthopedic surgery), and anatomic injury severity (e.g., the Injury Severity Score [ISS]). However, none of these indicators is perfect and their advantages and disadvantages need to be considered when evaluating the evidence base for the predictive utility of the various physiologic measures.

Objective

The purpose of this systematic review is to identify and summarize the research evidence evaluating measures of circulatory and respiratory compromise, focusing on measures that can be easily used in the field to triage trauma patients. This review is designed to help inform decisions about what measures should be recommended in the next version of the field trauma triage guidelines and promoted for use in EMS practice. This is one of a series of reviews conducted for this purpose. A similar review compared the total GCS to the single item of the motor component for use in out of hospital assessment.[26] The ultimate goal is to promote the efficient and effective use of EMS and trauma care resources in order to achieve optimal outcomes for injured patients.

Key Questions and Scope

The scope of this review is limited to measures of circulatory or respiratory compromise in a trauma patient that can be used in the field by out-of-hospital providers to identify high-risk trauma patients requiring care in a major trauma center. The purpose of the measures is to identify patients likely to have serious injuries, require early critical resources, or at risk of death, and to use this information to inform decisions about whether an injured patient needs immediate

transport to the highest level trauma center available. We included measures in the review that can be readily obtained by standard medical equipment or devices designed specifically for field assessment or monitoring.

The Key Questions for this review are listed below. Key Questions 1, 2, and 3 differ only in that they address the utility of different categories of physiologic measures (i.e., circulatory, respiratory, or combinations) for predicting the likelihood that a patient has a serious injury. There are multiple ways to define serious injury and several indicators have been included in the review. These are listed in the PICOTS (populations, interventions, comparators, outcomes, timing, setting) section.

Key Question 1: For patients with known or suspected trauma who are treated out-of-hospital by EMS personnel, what is the predictive utility of **measures of circulatory compromise** or derivative measures (e.g., the shock index) for predicting serious injury requiring transport to the highest level trauma center available?

> 1a: How does the predictive utility of the studied measures of circulatory compromise vary across age groups (e.g., children or the elderly)? Specifically, what values for the different age ranges are supported by the evidence?

Key Question 2: For patients with known or suspected trauma who are treated out-of-hospital by EMS personnel, what is the predictive utility of **measures of respiratory compromise** for predicting serious injury requiring transport to the highest level trauma center available?

> 2a: How does the predictive utility of the studied measures of respiratory compromise vary across age groups (e.g., children or the elderly)? Specifically, what values for the different age ranges are supported by the evidence?

Key Question 3: For patients with known or suspected trauma who are treated out-of-hospital by EMS personnel, what is the evidence that scales combining **(a) measures of respiratory and circulatory compromise or (b) measures of respiratory and/or circulatory compromise together with measurement of altered levels of consciousness** (as defined by Glasgow Coma Scale or its components) can predict the need for transport to a trauma center?

> 3a. How does the predictive utility of combinations of measures vary across age groups (e.g., children or the elderly)? Specifically, what values for the different age ranges are supported by the evidence?

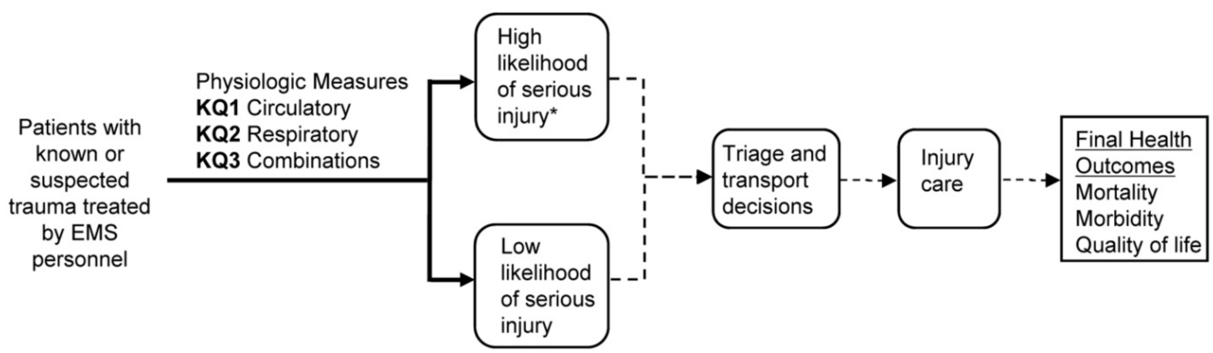
The scope and Key Questions for this topic were initially developed by the Agency for Healthcare Research and Quality in conjunction with the sponsoring partner agency, the National Highway Transportation Safety Administration. The questions were reorganized by the project team and revised after input from the Technical Expert Panel. There was no formal topic refinement process for this review.

We adapted the graphical analytic framework and PICOTS framework, tools designed for intervention studies, to this review. Combined, the analytic framework (Figure 2) and the PICOTS further delineated the scope and established our inclusion and exclusion criteria.

Analytic Framework

The analytic framework depicts the relationship among the major elements of the Key Questions as well as their expected relationships to intermediate and clinical outcomes, even though these relationships are not always included in the review. This review is limited to considering how well the physiologic measures predict serious injury in trauma patients evaluated by EMS personnel. These are the components connected with solid lines. The assumption is that being able to identify seriously injured patients will inform triage and transport decisions, and these decisions will impact care for the injury, which will affect outcomes. These relationships are represented with dashed lines as they are important assumptions, but not part of the review.

Figure 2. Analytic framework



EMS = emergency medical services; KQ = Key Question

Note: Solid lines = relationships within the scope; dashed lines = assumed relationships outside the scope of the review

*Defined by inpatient mortality, resource use (e.g., the published consensus-based criterion standard, need for life-saving interventions, major surgery), or injury severity score (ISS) >15

Methods

The procedures for conducting this review are based on the Agency for Healthcare Research and Quality (AHRQ) *Methods Guide for Systematic Reviews of Diagnostic Tests* in addition to the *Methods Guide for Effectiveness and Comparative Effectiveness Reviews*.[27,28] These methods have been adapted to this review of studies that evaluate physiologic measures of circulatory and respiratory compromise in term of predictive utility. In this section we summarize key elements of the methods that are necessary to understand the results. The protocol for this review, posted on the AHRQ Web site (http://effectivehealthcare.ahrq.gov/index.cfm), includes a detailed description of methods.

Search Strategy

We included studies with publication dates from 1996 to August 2017. This search start date was selected because trauma care has changed over time; only rudimentary measures and monitors existed prior to 1996 and only five States had fully implemented trauma systems in the early 1990s.[29] We searched MEDLINE®, CINAHL®, Embase®, and the Cochrane databases. The search strategies are provided in Appendix A. Notice was posted in the *Federal Register* requesting published and unpublished evidence relevant to the review; no submissions were received. Reference lists of included articles were reviewed for additional relevant citations.

Criteria for Inclusion/Exclusion of Studies in the Review

The criteria for inclusion and exclusion of studies were based on the Key Questions and the analytic framework. The PICOTS (Populations, Interventions, Comparators, Outcomes, Timing, Setting/Study Design) framework was used to delineate what we included and excluded, as described in Table 1.

- **Population** refers to the patients who are the subjects in the studies to be included.
- The **Intervention** is usually the treatment or health service of interest that is being evaluated in terms of its impact on the population. In this review, physiologic measures are being evaluated.
- The **Comparator** in this review is what was used to evaluate the physiologic measure's ability to identify patients who are at high risk of having a severe injury. Defining and operationalizing what "high risk" means is challenging for several reasons. The extent of injury at the time of field triage cannot be determined conclusively and we expect that clinical outcomes (e.g., death or disability) are affected by out-of-hospital and in-hospital treatment (i.e., a person can have a serious injury and recover). For this reason, we included several indicators that a patient was seriously injured.
- The end points or **Outcomes** of interest are the predictive utility of the measures. We included two different approaches to assessing predictive utility: (1) measures of diagnostic accuracy (e.g., sensitivity and specificity); and (2) discrimination (e.g., area under the receiver operating characteristic curve [AUROC]). Studies that provide only descriptive information, unadjusted risk estimates, or assessments of continuous variables (e.g., correlations or tests of differences in means) were excluded unless data were provided that could be used to calculate included outcomes.
- The **Timing** of the measurement is important for this review. We were primarily interested in data collected upon the arrival of emergency medical services personnel to the scene of injury, during treatment in the field, and during transport (collectively

referred to as out-of-hospital or in the field). Studies with measures taken upon arrival at an emergency department (ED) were considered in instances where there was insufficient out-of-hospital data.

- Relevant **Settings** are the locations of care, and in this review settings are closely related to timing, as we focused on out-of-hospital or early ED care.
- **Study Designs** are not formally part of PICOTS, but are important as the design determines a study's ability to address a question of interest. We included any study that evaluated a measure that met our inclusion criteria and produced an outcome of interest or provided data that allowed the outcome to be calculated.

Table 1. Inclusion and exclusion criteria

Adapted PICOTS	Included	Excluded
Populations (P)	• Patients of any age with known or suspected trauma • Require assessment of physiologic compromise by EMS out-of-hospital personnel	• Nontrauma conditions (e.g., burns, chemical exposure) or illnesses • Healthy people • Animal studies • Study population restricted to patients with: o Serious injuries only (sample limited major trauma patients automatically transported to a trauma center (ISS >15, GCS 8 or less) o Injuries that can be assessed or defined as serious based on direct observation (e.g., an amputation)
Interventions (I) (Measures)	**KQ 1:** Physiologic measures of circulatory compromise **KQ 2:** Physiologic measures of respiratory compromise or effort **KQ 3:** Measures of respiratory and/or circulatory compromise together with measurement of altered levels of consciousness compromise with or without measures of altered levels of consciousness (as defined by Glasgow Coma Scale or its components) Measures applicable to screening or triage out-of-hospital	• Measures not assessing a circulatory or respiratory compromise (e.g., temperature, coagulation musculoskeletal soundness, blood glucose) • Measures that would be included but are used to evaluate a treatment or monitor a patient after a treatment • Measures that could not be used out-of-hospital (e.g., a CT scan)
Comparators (C) (Indicators of serious injury)	• Resource use or interventions o The published consensus-based criterion standard o Lists of life-saving interventions o Surgery o Transfusion o ICU admission or length of stay • Ratings of injury severity such as ISS • Mortality	• No indicator of serious injury • Orthopedic surgery • Elective procedures
Outcomes (O)	• Measures of Predictive Utility o Standard measures of diagnostic accuracy (e.g., sensitivity, specificity, and predictive values) o AUROC	• Does not include a measure of predictive utility o Descriptive measures or continuous measure (e.g., correlations, differences in means) o Unadjusted risk estimates
Timing (T)	• Assessment at or near the time of injury during resuscitation and acute care	• Assessment to evaluate ongoing treatment or status several hours after injury • Transport from initial hospital to another

Adapted PICOTS	Included	Excluded
Setting (S)	• Out-of-hospital: upon the arrival of EMS personnel to the scene of injury, during treatment in the field, and during transport • ED: on arrival or during early treatment and resuscitation in ED • Civilian or military settings	• Inpatient hospital • Outpatient care • Countries with out-of-hospital care systems that differ from those in the United States
Study Design	• Randomized controlled trials • Observational studies: prospective or retrospective • Evaluations of a single measure • Head-to-head comparisons of two or more measures	• Nonsystematic reviews, commentaries, letters • Case reports, case series and modeling studies • Descriptions of the properties or performance of measures that do not include evaluation of predictive utility

AUROC = area under the receiver operating characteristic curve; CT = computerized tomography; ED = emergency department; EMS = emergency medical services; GCS = Glasgow Coma Scale; ICU = intensive care unit; ISS = Injury Severity Score; KQ = Key Question; PICOTS = Populations, Intervention, Outcomes, Comparators, Timing, Setting/Study Design

Study Selection

To ensure accuracy, all excluded abstracts were independently reviewed by at least two reviewers. To avoid bias or the appearance of bias, team members who conduct research and have published studies on this topic did not triage studies. All citations deemed appropriate for inclusion by at least one of the reviewers were retrieved for full-text review. Each full-text article was independently reviewed for eligibility by at least two investigators, including any articles suggested by peer reviewers. Any disagreements were resolved by discussion and consensus across the investigators to arrive at the final list of included studies (Appendix B). A record of studies excluded at the full-text level with reasons for exclusion was maintained and is provided as an appendix to this report (Appendix C).

Data Abstraction and Data Management

For studies that met inclusion criteria, the key characteristics and results were abstracted into evidence tables that provide the basis for the description and synthesis of this body of literature. The complete evidence tables are provided in Appendix D and selected data are included in the in-text tables in the Results sections of this report.

All abstracted study data were verified for accuracy and completeness by a second team member.

Assessment of Methodological Risk of Bias of Individual Studies

Predefined criteria were used to assess the risk of bias for individual studies by using clearly defined templates and criteria (Appendix E). Studies were evaluated using appropriate study design-specific criteria,[28] in this case the Quality in Prognosis Studies (QUIPS) tool.[30] Each study evaluated was independently reviewed for risk of bias by two team members. Any disagreements were resolved by consensus. Team members who were involved in the conduct of a study were not involved in risk of bias assessment for that study. The QUIPS tool includes domains on: study participation, study attrition, prognostic factor measurement, outcomes measurement, study funding, and statistical analysis and reporting. Studies were rated as “low risk of bias,” “medium risk of bias,” or “high risk of bias” (Appendix F).

Studies rated as low risk of bias are considered to have minimal risk of bias, and their results are generally considered valid. Low risk of bias studies included clear descriptions of the population, setting, and measures; sufficient description of how the measure was executed and instrumentation used; how the measure was interpreted; if specific threshold values were used; and how the risk of serious injury was evaluated.

Studies rated medium risk of bias are susceptible to some bias, though not enough to invalidate the results. These studies may not meet all of the criteria for a rating of low risk of bias, but no flaw is likely to cause major bias. The study may be missing information, making it difficult to assess limitations and potential problems. The medium risk of bias category is broad, and studies with this rating will vary in their strengths and weaknesses. The results of some medium risk of bias studies are likely to be valid, while others may be only possibly valid.

Studies rated high risk of bias have significant flaws that imply biases of various types that may invalidate the results. They have one or more serious or "fatal" flaw in design, analysis, or reporting; large amounts of missing information; or discrepancies in reporting.

We did not exclude studies rated high risk of bias a priori, but high risk of bias studies were considered to be less reliable than low or medium risk of bias studies when synthesizing the evidence, particularly when discrepancies between studies were present.

Data Analysis and Synthesis

We analyzed and reported results from studies using out-of-hospital and ED data separately when studies in both settings were available, as our interest is primarily in the out-of-hospital performance of measures. Also, rapid changes are possible as patients are resuscitated, transported, and treated on scene or en route. We included ED studies and their data because conducting studies in the field is difficult and the body of evidence based on out-of-hospital data is limited for some measures. When data by age group were available we presented this to address the sub Key Questions on the performance of the tests and different thresholds in various age groups.

Results were synthesized, either quantitatively or qualitatively, across studies of each identified physiologic measure, and qualitatively compared across measures. We consulted with the clinical experts on our review team, local experts, and TEP members to determine which serious injury indicators were clinically similar enough to allow grouping. As there are many different indicators of serious injury used in trauma research, we grouped them into four categories: resource use, injury severity, mortality, and composite indicators that included two or three of the above categories. Resource use included the provision of services such as life-saving interventions, emergent surgery, blood transfusion, or intensive care unit (ICU) admission. To avoid survival bias and fully account for resource use, early death, when reported together with other resource use, was also counted as a resource use indicator (i.e., the patient would have required interventions had they survived). Injury severity included assessment by tools such as the Injury Severity Score (ISS) or a diagnosis such as potentially severe head injury. Mortality included any death reported in the studies regardless of the timing of death (the timing of death was recorded in the evidence tables if it was reported in the article). If a study reported death within 24 hours alone as a serious injury indicator, it was counted as mortality, not resource use. We reported the results grouped by these categories in the same forest plot to allow assessment of consistency across categories, and also generated an overall estimate across the categories. When studies reported data for more than one indicator of serious injury, all data were included in the indicator-specific analysis, but only data from one indicator were included in the overall

estimate based on the following order: resource use, injury, mortality and composite. Therefore, each study were only included once when generating the overall estimate for a physiologic measure.

Results were also synthesized separately according to the predictive utility outcomes: (1) diagnostic accuracy (e.g., sensitivity and specificity), or (2) AUROC. We extracted all data that could be used to calculate diagnostic accuracy measures whether or not these diagnostic measures were reported in the included studies, and calculated sensitivity and specificity when necessary (noted as calculated in the in-text tables and the complete evidence tables in Appendix D). When positive and negative predictive values were reported in the studies, they were included in the evidence tables (Appendix D). We did not include these in the in-text tables as they are dependent on the prevalence, making comparisons across studies and populations problematic. AUROC values were reported as well as confidence intervals (CIs) when they were provided. We used AUROC both as an indicator of the level of performance of a measure and to compare performance across measures. We followed conventions that specify AUROCs of less than 0.70 as poor, 0.70-0.79 as fair, 0.80-0.89 as good, and 0.90-1 as excellent.[31] As in other work,[26] we defined a small difference in the AUROC as a difference of less than 0.05, moderate as a difference of 0.05 to 0.10, and large as a difference of greater than 0.10.

We conducted quantitative synthesis (i.e., meta-analysis) of diagnostic measures when there were adequate data from included studies. In cases with few studies, lack of data, or when data were only available as adjusted risk estimates from multivariate analyses (Appendix G), the range of the results and qualitative summaries were provided.

First the random effects DerSimonian-Laird model[32] was used to pool data and statistical heterogeneity was assessed using the standard χ^2 test and I^2 statistic. The I^2 statistic from these analyses are included in the plots. Given the high statistical heterogeneity and that the DerSimonain-Laird Model can result in confidence intervals that are too narrow when heterogeneity is high, we used alternative random effects models and reported the pooled estimates and confidence intervals from these alternative analyses in the forest plots and tables.

We used a bivariate logistic mixed effects model[33] to analyze sensitivity and specificity, taking the correlation between sensitivity and specificity into account. We assumed random effects across studies for sensitivity and specificity, and heterogeneity among the studies was measured based on the random effect variance. We calculated positive likelihood ratio (LR+) and negative likelihood ratio (LR-) using the summarized sensitivity and specificity.[34,35] Analyses were stratified by different cutoff points when necessary to generate clinically meaningful combined estimates. For example, we combined studies of lactate using a cutoff point of 2.0 mmol/L and separately using a cutoff point greater than 4.0 mmol/L. We also conducted sensitivity analyses by comparing results when outlying studies were included or excluded.

Similarly, we performed random effects meta-analysis to calculate the combined AUROC using the profile likelihood method, which incorporates the uncertainty related to estimating between-study heterogeneity. When a study only reported the point estimate of AUROC without providing a 95% CI or a standard error, we calculated the standard error if the study reported the number of patients with and without the serious injury indicator of interest;[36] otherwise the standard error was imputed using the average standard error from other studies with similar sample size.

All analyses were conducted using Stata/IC 13.1 (StataCorp LP, College Station, TX), except for the bivariate logistic mixed effects model, for which SAS 9.4 (SAS Institute Inc., Cary, NC) was used.

Grading the Strength of Evidence for Major Comparisons and Outcomes

The strength of evidence for each Key Question (Appendix H) was initially assessed by one researcher for the predictive utility of each identified measure paired with each indicator of the need for trauma care in accordance with the approaches described in the *Methods Guide for Effectiveness and Comparative Effectiveness Reviews*[28] and the guidance for diagnostic tests.[37] To ensure consistency and validity of the evaluation, the grades were reviewed by the entire team of investigators for:

- Study limitations: low, medium, or high level of risk of bias
- Consistency of results: consistent, inconsistent, or unknown/not applicable
- Directness of the evidence: direct or indirect
- Precision of the outcome estimates: precise or imprecise
- Reporting bias: suspected or undetected

The strength of evidence assessment criteria was adapted for this review. For example, while measures of predictive utility can be considered indirect measures because they are not clinical outcomes, we did not downgrade the evidence on this basis as these are appropriate outcomes given the objectives and Key Questions of this review.

The strength of evidence was assigned an overall grade of high, moderate, low, or insufficient, according to a four-level scale by evaluating and weighing the combined results of the above domains:

- High—We are very confident that the estimate of effect lies close to the true effect for this outcome and that the findings are stable (i.e., another study would not change the conclusions).
- Moderate—We are moderately confident that the estimate of effect lies close to the true effect for this outcome and that the findings are likely to be stable, but some doubt remains.
- Low—We have limited confidence that the estimate of effect lies close to the true effect for this outcome and additional evidence is needed before concluding either that the findings are stable or that the estimate of effect is close to the true effect.
- Insufficient—No evidence is available or the body of evidence has unacceptable deficiencies, precluding reaching a conclusion.

Assessing Applicability

Applicability is the extent to which the findings in published studies are likely to reflect the results when the measures are used to evaluate trauma patients in similar situations. Applicability was considered according to the approach described in the *Methods Guide for Effectiveness and Comparative Effectiveness Reviews*[28] and the guidance for systematic reviews of diagnostic tests.[38] We used the PICOTS framework to consider the applicability of the evidence base for each Key Question; for example, examining the characteristics of the patient populations (e.g., patient age and type of trauma) and triage situation, as well as how the measures of physiologic compromise are obtained and used (e.g., use of different monitors or threshold values). Variability or limitations of the body of evidence may restrict the ability of the users of this review to apply the results to other populations and settings.

Managing Bias and the Appearance of Bias

The review team and Technical Expert Panel include experts who have conducted and published research in this field. In order to avoid bias, or the appearance of bias, we took the following steps: (1) authors were not involved in any decisions about including or excluding their own work, (2) to the extent it was feasible, reviewers were blinded to authors during title and abstract review so that the other team members/reviewers were not biased in favor of colleagues, (3) for full-text review, no one was assigned to review research they contributed to, (4) team members and experts did not rate the risk of bias or abstract data from studies to which they contributed.

Peer Review and Public Commentary

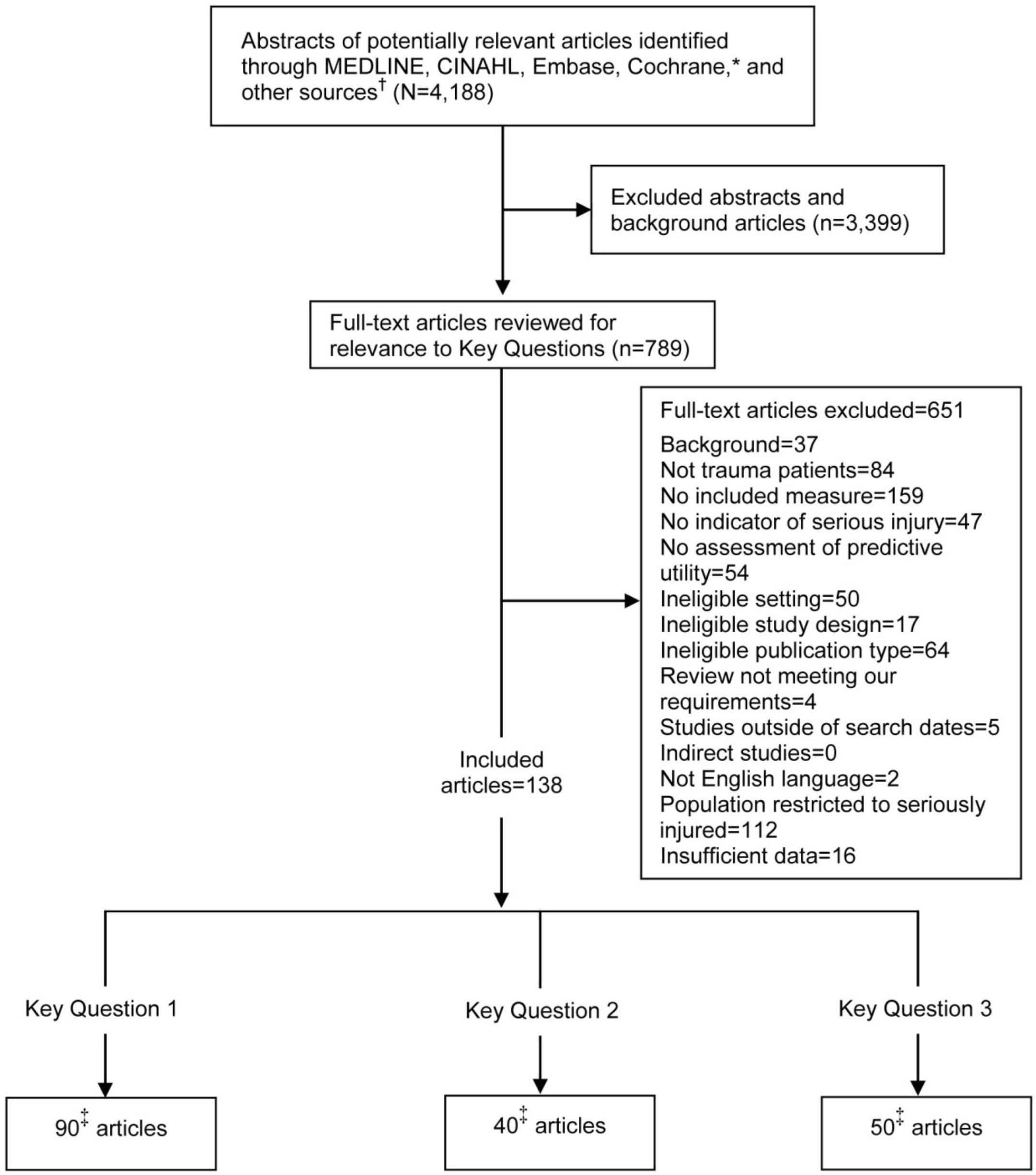
Experts were invited to provide external peer review of this systematic review; AHRQ and an associate editor also provided comments. We addressed relevant reviewer comments and revised the text as appropriate. In addition, the draft report was posted on the AHRQ Web site for 4 weeks to elicit public comment; no comments were received.

Results

Literature Search Yield

The search and selection of articles are summarized in Figure 3. Database searches yielded 4,188 potentially relevant citations. Dual review of titles and abstracts identified 789 articles that appeared to meet the inclusion criteria. The full text of these articles was reviewed, and we included 138 articles (Appendix B).

Figure 3. Literature flow diagram



*Cochrane databases include the Cochrane Central Register of Controlled Trials and the Cochrane Database of Systematic Reviews

†Other sources include reference list, experts, etc

‡Studies of multiple measures were used in more than one Key Question

Description of Included Studies

Table 2 summarizes selected characteristics of the 138 included articles. For some characteristics a publication may be included in multiple categories. For example, some studies included measurements collected both out-of-hospital as well as after the patient arrived at an emergency department (ED).

Despite the challenges of conducting studies in the field, half (71 out of 138) of the included articles assessed out-of-hospital data for the evaluated measures. Two-thirds (96) of the articles were retrospective and one-third (41) were prospective. Twenty-five studies used data from multi-site registries, 65 studies used administrative or registry data from one site, and 47 studies engaged in primary data collection for the study.

The majority of the studies (102) were evaluated as having a moderate risk of bias, with 10 studies rated low risk of bias and 25 rated high risk of bias. The concerns about bias were primarily related to three domains: study participation (e.g., concerns about sampling or recruitment), attrition (e.g., lost to followup), and lack of adequate control for confounding factors that were not adequately addressed in the design. Common limitations and potential sources of bias included: retrospective study design; trauma registry data (limited to patients presenting to trauma centers and meeting criteria for inclusion in a registry); loss to followup; selection exclusion of certain types of patients; and data were not always available for important variables believed to affect outcomes. The ratings for each domain as well as the overall ratings are provided in Appendix F.

Studies used different indicators for “serious injury” and often assessed more than one indicator. We grouped the indicators into three categories for clarity: (1) resource utilization, which included lists of life-saving interventions, surgery, transfusion, intensive care unit admission or a version of a published consensus-base criterion standard;[25] (2) ratings of injury severity such as the Injury Severity Score (ISS) or types of anatomic injury or diagnosis such as traumatic brain injury; and (3) mortality (most commonly in-hospital mortality). Resource utilization was the most common indicator (113 studies), though many studies reported on the relationship between the measures and mortality (98 studies), while injury severity or type was less common (19 studies). A detailed list of the measures studied is included in tables at the beginning of the results for each Key Question below.

The most common population for these studies consisted of adult patients treated in the United States. The majority of the studies (93 of 138) were conducted in the United States, with 18 studies conducted in Europe, 8 in Asia, 9 in the Middle East, 3 in Australia and New Zealand, 5 in Canada, 2 in South Africa, 1 in Colombia, and 2 in multiple countries (international). Most studies were of adult patients or patients of all age groups, with only 13 studies providing data separately on older patients and 10 providing data on children. Most of the studies were of civilian populations. We did not exclude military studies if they met our other inclusion criteria. Three of the included studies were conducted at military support hospitals: two U.S. hospitals in Iraq and one U.K. hospital in Afghanistan. These hospitals treated predominately military casualties but also cared for injured civilians. Not all studies explicitly stated how patients were transported, but the studies included some that were limited to patients transported by air (25 studies) or ground (10 studies) while others were mixed (17 studies). One-third of the studies (50) were funded by public entities, another third did not report funding (55), 20 reported no external support, and 5 reported partial or full private funding support.

Table 2. Overall key characteristics of included studies

Key Characteristics	Study Information	Number of Publications (N=138)	References
Setting*	Out-of-hospital	n=71	17,39-108
	Emergency department	n=86	39,42,44,48,50,51,57,60,74-79,81,82,87,92,94,99,103-105,108-170
	Not reported or unclear	n=5	171-175
Study Design	Prospective cohort	n=42	44,58,63-65,68,70,77-82,84,95,96,100,101,103,106,108-110,112-115,119,120,126,138,141,146,155,157-160,162,166,168,171
	Retrospective cohort	n=96	17,39-43,45-57,59-62,66,67,69,71-76,83,85-94,97-99,102,104,105,107,111,116-118,121-125,127-137,139,140,142-145,147-154,156,161,163-165,167,169,170,172-175
	Trials	n=0	None
Study Populations*	Adult	n=90	17,39,43-49,51,58,59,61-67,72,76,78,80-84,86,87,89-93,97-100,102,103,106,108-110,113-118,120,123-125,128,129,131,132,134-138,141-156,158-161,163,164,166-168,170,172
	Pediatric	n=10	57,77,88,101,111,140,157,171,173,175
	Elderly	n=13	46,72,87,89,90,116,117,123,136,146,151,163,170
	Military	n=3	U.S. military in Iraq: 115,118 U.K. military in Afghanistan: 166
	Civilian	n=129	17,39-41,43-48,50-70,72-75,77-114,116,117,119-165,168,169,171-175
	Not reported, unclear, or mixed population	n=34	40-42,50,52-56,60,68-71,73-75,79,87,94-96,104,105,107,119,121,126,127,130,133,162,165,169
Type of Data Source	Multi-site registry	n=26	39,45,46,48,57,61,62,65,66,71,72,88,93,102,116,125,127,134,136,138,142,145,151,164,169,172
	Administrative data/single site registry	n=65	17,40-42,47,49-56,59,60,67,69,74-76,83-87,89,90,92,98,99,104,105,107,111,117,118,120-124,126,128,129,131-133,137,139,140,143,144,149,152-154,156,163,165,167,170,171,173-175
	Primary data collection	n=47	43,44,58,63,64,68,70,73,77-82,91,94-97,100,101,103,106,108-110,112-115,119,130,135,141,146-148,150,155,157-162,166,168
Type of Indicator of Serious Injury*	Resource utilization	n=113	17,42,44-47,49-55,59-61,63-66,68-83,85-108,110,111,113-115,118-120,122-124,128,130,135,137-175
	Injury severity or type	n=19	43,45,46,57,58,66-68,72-74,78,124,127,130,137-140
	Mortality	n=98	17,39-41,48,51,56,60,62,63,65,66,68,72,74,75,77,84-110,112,114,116-118,121,122,125,126,129,131-139,141-175
Mode of Transport	Ground	n=10	65,94-97,109,110,115,136,158
	Air	n=25	17,40,41,47,49,52-56,58,59,63,64,69,70,73,80-83,86,101,106,107
	Ground and air	n=17	50,51,61,62,68,72,77,91,92,98,103,124,133,137,138,173,174
	Not reported	n=86	39,42-46,48,57,60,66,67,71,74-76,78,79,84,85,87-90,93,99,100,102,104,105,108,111-114,116-123,125-132,134,135,139-157,159-172,175
Geographic Location*	United States	n=93	17,39-42,45-47,49-60,63-66,68-70,72,73,75-90,92,98-101,103-105,107,108,111,113,114,117,119-123,126-129,131,135,137,141,142,146-152,157,159,160,162-165,168,170,171,173-175
	Europe (Germany, France, Norway, Sweden, The Netherlands, United Kingdom)	n=18	44,62,67,91,93-97,106,116,130,133,134,140,145,158,164

Key Characteristics	Study Information	Number of Publications (N=138)	References
	Asia (Japan, Hong Kong, Singapore, South Korea, Taiwan)	n=8	74,132,136,138,139,143,156,169
	Middle East (Afghanistan, Iraq, Turkey)	n=9	42,71,109,112,115,118,155,166,167
	Australia and New Zealand	n=3	61,124,161
	Canada	n=5	43,65,102,110,172
	Africa (South Africa)	n=2	48,125
	South America (Colombia)	n=1	144
	International (multiple countries)	n=2	153,154
Funding*	Public entity	n=50	17,40,41,48,49,52,53,55,56,58,63-65,68-70,72-74,77,79-84,88-90,97,98,100,102,103,107,108,111,118,128,133,139,141,153,154,159,160,162,168,172,175
	Foundation	n=2	89,90
	No external support	n=20	46,47,57,85,93,106,116,120,131,135,142,145,147,148,155,156,158,161,164,166
	Private	n=5	86,108,113-115
	Not reported, but declared no conflicts of interest	n=9	66,67,71,95,96,124,132,134,144
	Not reported	n=55	39,42-45,50,51,54,59-62,75,76,78,87,91,92,94,99,101,104,105,109,110,112,117,119,121-123,125-127,129,130,136-138,140,143,146,149-152,157,163,165,167,169-171,173,174

*The total number of publications is more than 138 for this characteristic as a publication may be in more than one category.

Detailed information from each study is included in the evidence tables in Appendix D, and the risk of bias assessments are in Appendix F. The following results sections summarize the available evidence for each Key Question and highlight additional characteristics when they add to the understanding of the results. Relevant study characteristics are also included in the discussion of the limitations and applicability of the findings of this review.

Overview

The 134 studies reported in 138 articles evaluated three major categories of physiologic measures: (1) the current physiologic measures included in many trauma triage guidelines (e.g., systolic blood pressure [SBP] and respiratory rate [RR]); (2) other physiologic measures and scores in current use for triage as well as prognosis; and (3) newly developed or improved proposed measurement strategies including specific thresholds. The diversity of measures as well as the variety of study designs makes synthesis challenging. The results are presented and summarized for each measure separately within sections organized by Key Question (i.e., circulatory, respiratory, and combinations).

Tables 3-5 consolidate the key estimates of the predictive utility of each measure. Sensitivity, specificity, and area under the receiver operating characteristic curve (AUROC) values for out-of-hospital and ED measurements are provided. The overall combined estimates are reported unless otherwise specified. When we were able to pool data, the pooled estimates are given in bold; when data were not pooled, the range of values from the included studies are provided in italics. Additional information, such as the number of patients in the included studies and 95% confidence intervals (CIs) for the estimates are included in the figures and tables that follow in the results sections, while the detailed extracted study information is included in the evidence tables in Appendix D.

Table 3. Key Question 1 results: overview of predictive utility of circulatory measures for serious injury* by setting

Measure	Out-of-Hospital: Sensitivity (SOE) Specificity (SOE) Number of Studies	Emergency Department: Sensitivity (SOE) Specificity (SOE) Number of Studies	Out-of-Hospital: AUROC (SOE) Number of Studies	Emergency Department: AUROC (SOE) Number of Studies
Systolic Blood Pressure	SBP <90 mmHg Sen: **19%** (SOE: Low) Sp: **95%** (SOE: Moderate) 17 studies[39,46,60,65,67,68,70,77-79,88,89,91,99,103,107,171] SBP higher thresholds (<100, 110, or 120 mmHg) Sen: **35%** (SOE: Low) Sp: **88%** (SOE: Low) 6 studies[39,46,70,75,76,80]	SBP <90 mmHg Sen: **18%** (SOE: Low) Sp: **97%** (SOE: Moderate) 9 studies (in 10 articles)[39,75,76,78,115,124,133,147,148,156] SBP higher thresholds (<100, 110, or 120 mmHg) Sen: **35%** (SOE: Low) Sp: **89%** (SOE: Moderate) 4 studies[39,116,119,137]	**0.67** (SOE: Moderate) 9 studies[52,55,59,62,65,93,104,106,107]	**0.64** (SOE: Moderate) 12 studies (in 13 articles)[61,104,110,115,116,125,127,147-149,159,165,170]
Heart Rate	HR >110 bpm Sen: **28%** (SOE: Low) Sp: **85%** (SOE: Low) 4 studies[70,76,80,107]	HR >110 bpm Sen: **29%** (SOE: Moderate) Sp: **93%** (SOE: Moderate) 5 studies[48,61,124,137,156]	**0.67** (SOE: Low) 5 studies[55,59,62,106,107]	**0.66** (SOE: Moderate) 9 studies (in 10 articles)[61,115,116,125,147-149,159,162,170]
Shock Index	SI >0.9 or >1 Sen: **37%** (SOE: Low) Sp: **85%** (SOE: Low) 5 studies[44,50,74,93,165]	SI >0.9 or >1 Sen: **40%** (SOE: Low) Sp: **93%** (SOE: Moderate) 11 studies (in 12 articles)[50,74,112,116,123,136,144,145,147,148,151,166]	**0.72** (SOE: Low) 7 studies[44,52,53,62,65,93,107]	**0.71** (SOE: Moderate) 11 studies (in 12 articles)[116,123,125,131,136,137,142,145,147,148,159,170]

Measure	Out-of-Hospital: Sensitivity (SOE) Specificity (SOE) Number of Studies	Emergency Department: Sensitivity (SOE) Specificity (SOE) Number of Studies	Out-of-Hospital: AUROC (SOE) Number of Studies	Emergency Department: AUROC (SOE) Number of Studies
Lactate	Lactate >2 or 2.5 mmol/L Sen: **74%** (SOE: Low) Sp**: 62%** (SOE: Moderate) 3 studies[47,65,101] Lactate >4 mmol/L Sen: **23%** (SOE: Insufficient) Sp: **93%** (SOE: Insufficient) 1 study[47]	Lactate >2 or 2.5 mmol/L Sen: **74%** (SOE: Low) Sp: **52%** (SOE: Low) 9 studies (in 10 articles)[104,117,128,143,146-148,157,158,161] Lactate >4 mmol/L Sen: **50%** (SOE: Low) Sp: **86%** (SOE: Moderate) 9 studies[44,104,112,117,119,120,126,143,157]	**0.77** (SOE: Low) 2 studies[65,101]	**0.68** (SOE: Moderate) 14 studies (in 15 articles)[44,97,104,113,114,117,120,128,146-148,150,152,158,161]
Base Deficit	None	Sen: *19 to 59%* (SOE: Low) Sp: *59 to 98%* (SOE: Moderate) 9 studies (in 10 articles)[97,112,115,120,122,143,147,148,156]	None	*0.67 to 0.90* (SOE: Moderate) 12 studies (in 13 articles)[97,113-115,117,120,125,145,147-150,157]
Heart Rate Variability/ Heart Rate Complexity	Sen: *80 to 90%* (SOE: Low) Sp: *67 to 100%* (SOE: Low) 2 studies[73,106]	None	*0.60 to 0.95* (SOE: Low) 7 studies[40,41,49,56,59,73,106]	*0.67 to 0.68* (SOE: Insufficient) 1 study[160]

AUROC = area under the receiver operating characteristic curve; bpm = beats per minute; HR = heart rate; SBP = systolic blood pressure; Sen = sensitivity; SI = shock index; SOE = strength of evidence; Sp = specificity

Bold font = data from pooled estimates (see corresponding figures); italic font = range from unpooled studies, details in corresponding results tables

*Serious injury includes resource use (e.g., blood transfusion, intensive care unit admission, and life-saving interventions) and injury severity measures (e.g., the Injury Severity Score , mortality, or combinations of any of these)

Table 4. Key Question 2 results: overview of predictive utility of respiratory measures for serious injury* by setting

Measure	Out-of-Hospital: Sensitivity (SOE) Specificity (SOE) Number of Studies	Emergency Department: Sensitivity (SOE) Specificity (SOE) Number of Studies	Out-of-Hospital: AUROC (SOE) Number of Studies	Emergency Department: AUROC (SOE) Number of Studies
Respiratory Rate	RR <10 or >29 Sen**: 13%** (SOE: Low) Sp: **96%** (SOE: Low) 6 studies[77,83,88,89,91,171]	RR <10 or >29 Sen: **27%** (SOE: Moderate) Sp: **95%** (SOE: Moderate) 4 studies[61,116,124,133]	**0.70** (SOE: Low) 3 studies[54,59,94]	**0.61** (SOE: Moderate) 3 studies[61,110,116]
O_2 Saturation	Sen: *13 to 99%* (SOE: Low) Sp: *85 to 99%* (SOE: Low) 3 studies[67,103,107]	Sen: *25 to 100%* (SOE: Low) Sp: *39 to 94%* (SOE: Low) 2 studies[115,135]	*0.53* to *0.76* (SOE: Low) 4 studies[64,94,103,107]	*0.61 to 0.76* (SOE: Low) 2 studies[115,159]
Airway Support	Sen: *8 to 53%* (SOE: Low) Sp: *61 to 100%* (SOE: Low) 4 studies (in 5 articles)[56,67,89,95,96]	Sen: *32 to 57%* (SOE: Low) Sp: *85 to 96%* (SOE: Low) 3 studies[57,133,160]	None	None

AUROC = area under the receiver operating characteristic curve; bpm = beats per minute; HR = heart rate; HRC = heart rate complexity; HRV = heart rate variability; O2 = oxygen; RR = respiratory rate; SBP = systolic blood pressure; Sen = sensitivity; SI = shock index; SOE = strength of evidence; Sp = specificity

Note: Bold font = data from pooled estimates (see corresponding figures); italic font = range from unpooled studies, details in corresponding results tables

*Serious injury includes resource use (e.g., blood transfusion, intensive care unit admission, and life-saving interventions) and injury severity measures (e.g., the Injury Severity Score, mortality, or combinations of any of these)

Table 5. Key Question 3 results: overview of predictive utility of combination of circulatory, respiratory, and level of consciousness measures for serious injury* by setting

Measure	Out-of-Hospital: Sensitivity (SOE) Specificity (SOE) Number of Studies	Emergency Department: Sensitivity (SOE) Specificity (SOE) Number of Studies	Out-of-Hospital: AUROC (SOE) Number of Studies	Emergency Department: AUROC (SOE) Number of Studies
Revised Trauma Score and Revised Trauma Score for Triage	RTS <7.5, T-RTS <12 Sen: *95 to 96%* (SOE: Insufficient) Sp: *38 to 42%* (SOE: Insufficient) 1 study (in 2 articles)[95,96]	RTS <5.68 or <5.97, T-RTS <8 or <12 Sen: *19 to 84%* (SOE: Low) Sp: *64 to 100%* (SOE: Low) 6 studies[107,109,110,112,130,133]	**0.57** for Resource use (SOE: Low) **0.89** for Mortality (SOE: Low) 3 studies (in 4 articles)[62,95,96,107]	**0.88** for Mortality (SOE: Low) 7 studies[97,109,110,131,138,142,169]
Glasgow Coma Scale	None	Sen: *75 to 98%* (SOE: Low) Sp: *57 to 91%* (SOE: Low) 2 studies[109,155]	None	**0.96** for both Mortality and Early Mortality (SOE: Moderate) 3 studies[109,138,155]

AUROC = area under the receiver operating characteristic curve; RTS = Revised Trauma Score; T-RTS = Revised Trauma Score for Triage; Sen = sensitivity; SOE = strength of evidence; Sp = specificity

Note: Bold font = pooled, see corresponding figures; italic font = range from unpooled studies, details in corresponding results tables

*Serious injury includes resource use (e.g., blood transfusion, intensive care unit admission, and life-saving interventions) and injury severity measures (e.g., the Injury Severity Score, mortality, or combinations of any of these)

Key Question 1: Measures of Circulatory Compromise

For Key Question 1, we included the results from 90 articles (from 89 studies). Six measures of circulatory compromise were evaluated in eight or more studies: SBP, heart rate (HR), shock index (SI), lactate, base deficit, and heart rate variability (HRV)/heart rate complexity (HRC). Few studies evaluated the remaining measures identified, which we grouped into three other categories. The measures, number of included articles with data on each measure, and corresponding references are provided in Table 6.

Table 6. Measures of circulatory compromise (Key Question 1) evaluated by included studies

Measure Evaluated	Number of Studies (articles)	References
Systolic blood pressure	49	39,46,48,51,52,54,55,59-62,65-68,70,75-80,83,88,89,91,93,99,103,104,106,107,110,115,116,119,124,125,127,133,137,147-149,156,159,165,170,171
Heart rate	16	54,55,59,61,62,70,76,80,83,103,106,107,116,124,137,156
Shock index	26 studies (28 articles)	44,50,52-54,62,65,66,74,87,93,105,107,108,112,116,123,125,136,137,142,144,145,147,148,151,159,166,170
Lactate	22 studies (23 articles)	47,63,65,101,104,112-114,117,119,120,128,143,146-150,152,157,158,161,165
Base deficit	15 studies (16 articles)	97,112-115,117,120,122,125,143,145,147-150,156
Heart rate variability and complexity	8	40,41,49,56,59,73,106,160
Other: Blood pressure related (diastolic blood pressure, mean arterial pressure, pulse pressure)	7	52-54,59,115,149,162
Other: Variations on shock index	3	53,93,136
Other: Miscellaneous (radial pulse character min pulse, Max pulse index, capillary refill, cardiac index, photoplethysmogram)	8	55,61,70,84,86,115,116,162

Systolic Blood Pressure

The most frequently evaluated measure of circulatory compromise in the identified literature is SBP. We identified 49 studies that evaluated the predictive utility of SBP. Current triage guidelines recommend that trauma patients with SBP <90 mmHg be considered at risk of serious injury. Many of the included studies evaluated the predictive utility of this threshold. Five studies were not included in the pooled estimates reported below.[48,51,54,66,83] These studies were not included in the pooled estimates because they did not provide data that could be used to calculate sensitivity and specificity;[48,66] their populations overlapped with larger studies;[54,83] or they reported change in pressure.[48]

We combined 17 studies of out-of-hospital SBP (cited in Table 7) and calculated a pooled sensitivity of 19 percent (95% confidence interval [CI] 12 to 29, I^2=98.8%) and a pooled specificity of 95 percent (95% CI 91 to 97, I^2= 99.2%) across all serious injury indicators for SBP <90 mmHg. In this analysis, all studies were included only once. Figures 4 and 5 provide the estimates stratified by type of serious injury indicator (resource use, injury type or severity, mortality, or composite indicators) and demonstrate that the estimates are similar for the different categories of indicators of serious injury. The pooled sensitivity and pooled specificity of out-of-hospital SBP <100 mmHg are indicated in Figures 6 and 7. Table 7 reports these values, as well as estimates from studies using SBP <90 mmHg measured in the ED, and studies that evaluated higher thresholds including 100, 110, and 120 mmHg, measured both in the field and in the ED. Plots for the ED analyses are included in Appendix I.

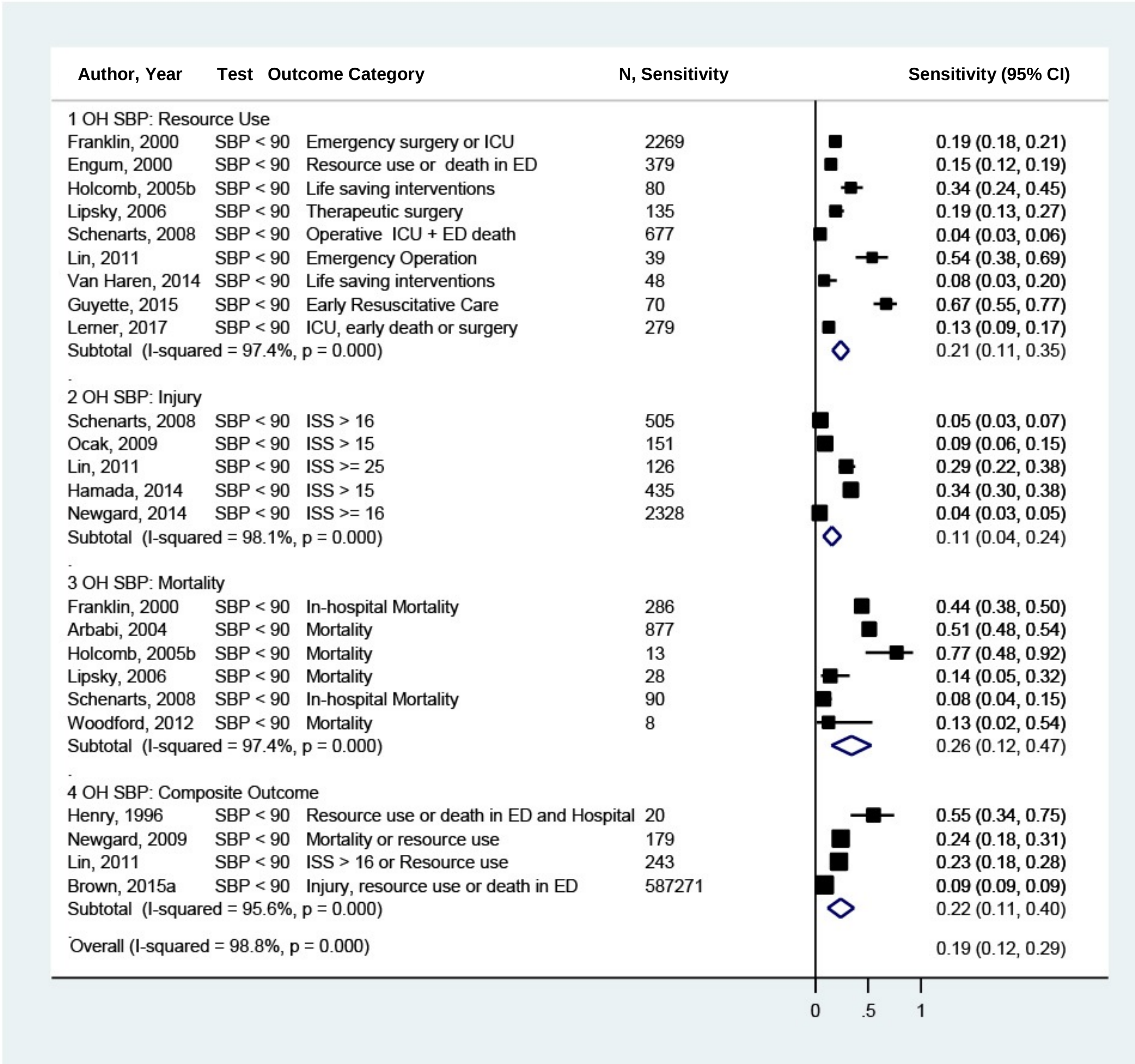
The pooled AUROC for out-of-hospital SBP was 0.67 (95% CI 0.58 to 0.75, I^2=90.1%; Figure 8) based on 9 studies[52,55,59,62,65,93,104,106,107] and 0.64 (95% CI 0.60 to 0.68, I^2=95.7%) for ED SBP based on 12 studies.[61,104,110,115,116,125,127,147-149,159,165,170] The low sensitivities and high specificities resulted in poor to fair discriminative ability; these results reflect the fact that low SBP is highly specific in identifying high-risk trauma patients (few false positives) but that patients with SBP above the thresholds can still be seriously injured (many false negatives—low sensitivity). Higher SBP thresholds yielded higher sensitivity and lower specificity.

Table 7. Pooled sensitivity and specificity of systolic blood pressure for identifying high-risk patients across all serious injury indicators

Measure, Setting	Number of Studies	Sensitivity (95% CI, I^2)	Specificity (95% CI, I^2)
SBP <90 mmHg, OH	17[39,46,60,65,67,68,70,77-79,88,89,91,99,103,107,171]	19% (12 to 29, 98.8%)	95% (91 to 97, 99.2%)
SBP <90 mmHg, ED	9[39,75,76,78,115,124,133,147,148,156]	18% (11 to 28, 99.1%)	97% (97 to 98, 93.5%)
SBP <100-120 mmHg, OH	6[39,46,69,75,76,80]	35% (19 to 54, 99.7%)	88% (73 to 95, 99.8%)
SBP <100-120 mmHg, ED	4[39,116,119,137]	35% (14 to 63, 98.7%)	89% (75 to 95, 99.5%)

CI = confidence interval; ED = emergency department; OH = out-of-hospital; SBP = systolic blood pressure

Figure 4. Pooled sensitivity of out-of-hospital blood pressure <90 mmHg

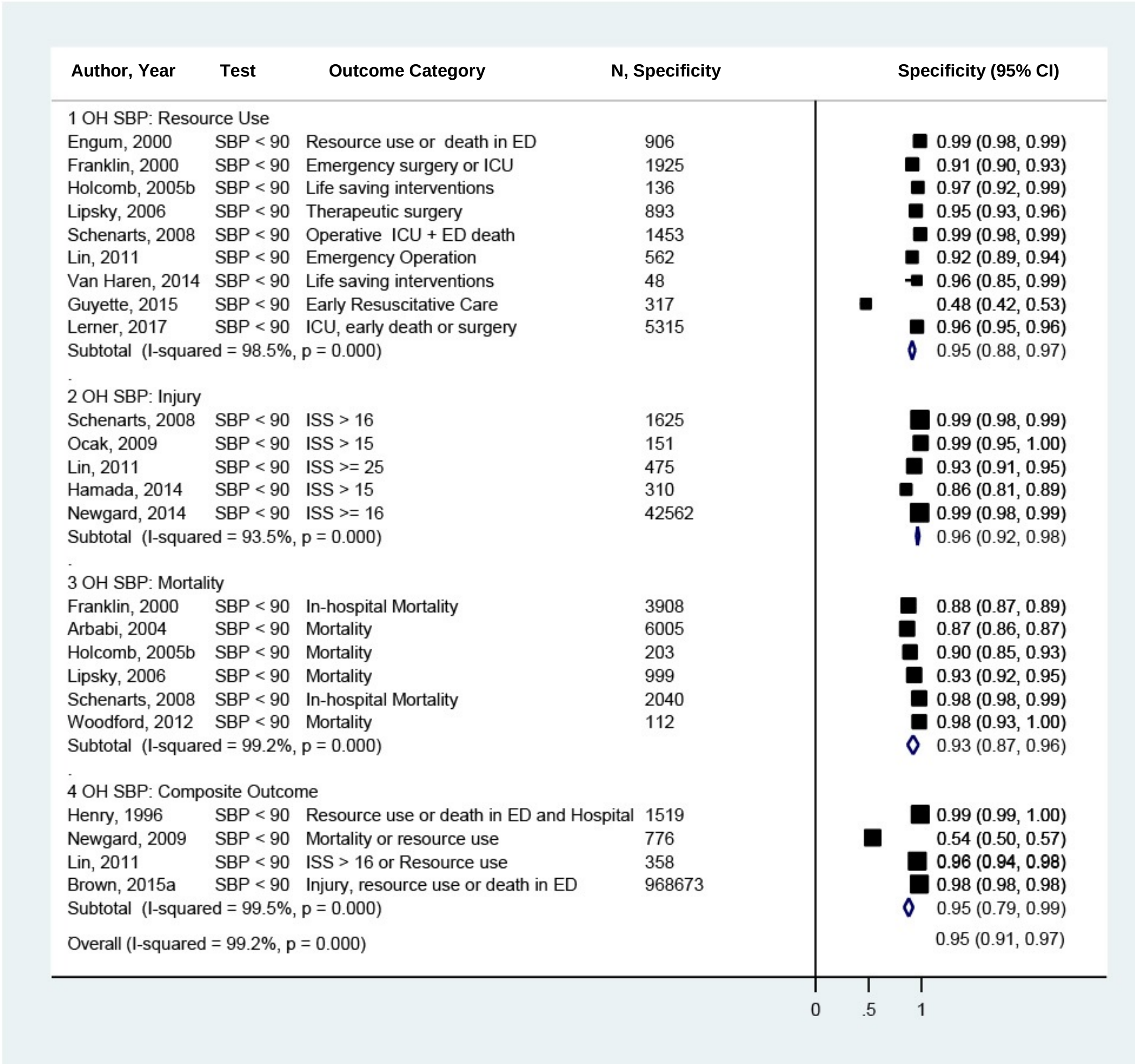


CI = confidence interval; ED = emergency department; ICU = intensive care unit; ISS = injury severity score; N = number; OH = out-of-hospital; SBP = systolic blood pressure.

Note: Holcomb, 2005b = Reference no. 70 in this report.

Note: Overall results are from the bivariate logistic mixed effects model analysis.

Figure 5. Pooled specificity of out-of-hospital blood pressure <90 mmHg

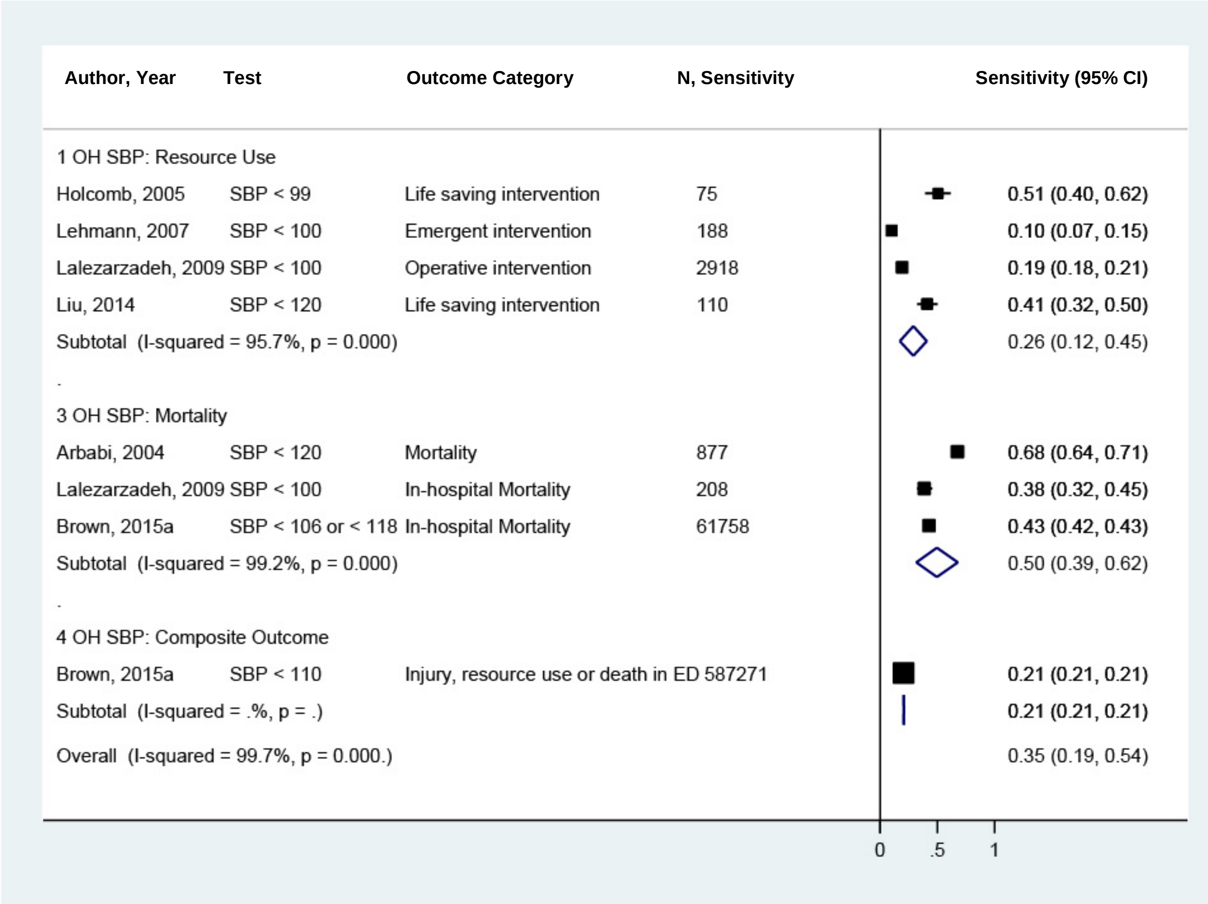


CI = confidence interval; ED = emergency department; ICU = intensive care unit; ISS = injury severity score; N = number; OH = out-of-hospital; SBP = systolic blood pressure.

Note: Holcomb, 2005b = Reference no. 70 in this report.

Note: Overall results are from the bivariate logistic mixed effects model analysis.

Figure 6. Pooled sensitivity of out-of-hospital blood pressure <100 mmHg

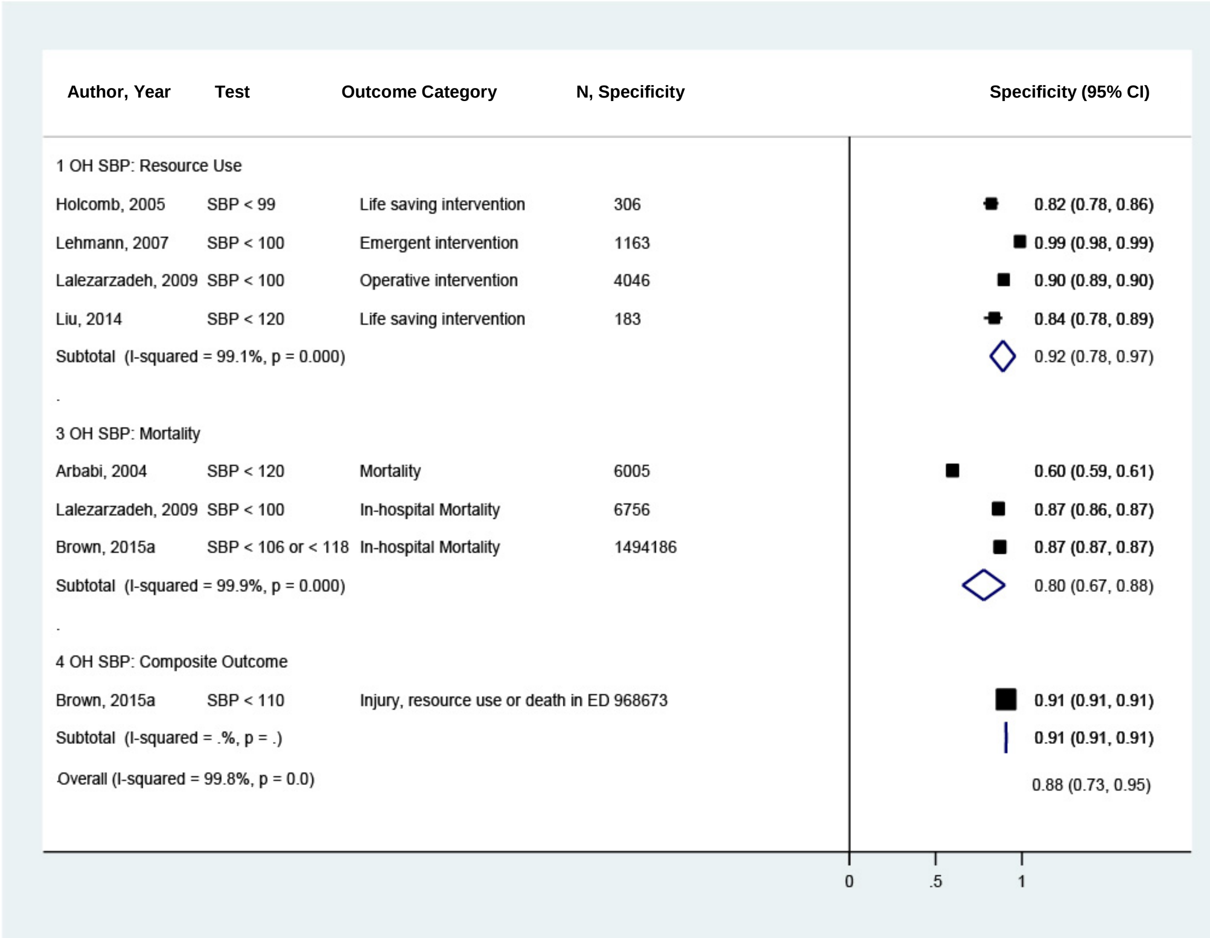


CI = confidence interval; ED = emergency department; N = number; OH = out-of-hospital; SBP = systolic blood pressure.

Note: Holcomb, 2005 = Reference no. 69 in this report; Liu, 2014 = Reference no. 80 in this report.

Note: Overall results are from the bivariate logistic mixed effects model analysis.

Figure 7. Pooled specificity of out-of-hospital systolic blood pressure <100 mmHg

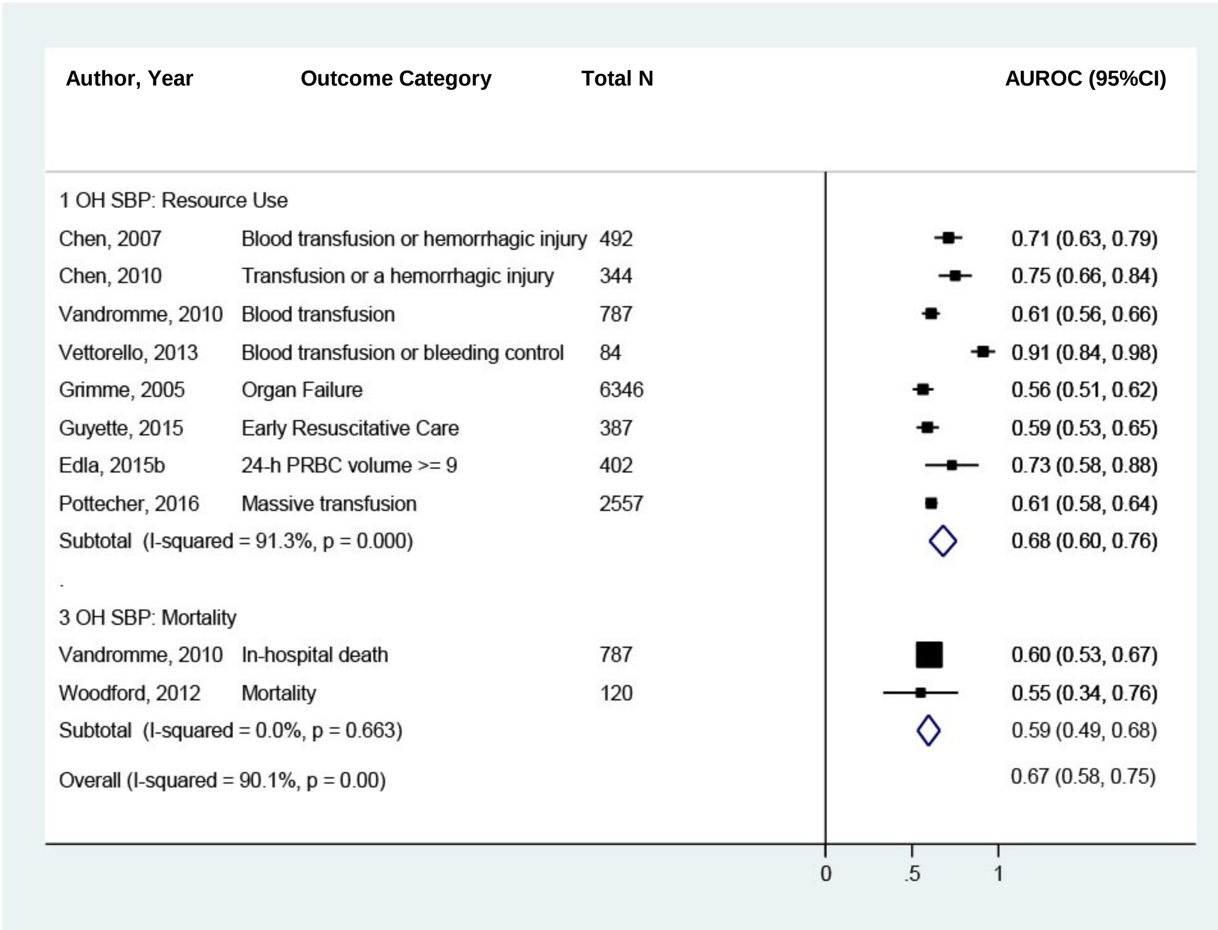


CI = confidence interval; ED = emergency department; N = number; OH = out-of-hospital; SBP = systolic blood pressure.

Note: Holcomb, 2005 = Reference no. 69 in this report; Liu, 2014 = Reference no. 80 in this report.

Note: Overall results are from the bivariate logistic mixed effects model analysis.

Figure 8. Pooled AUROC of out-of-hospital systolic blood pressure



AUROC = area under the receiver operating characteristic curve; CI = confidence interval; N = number; OH = out-of-hospital; pRBC = packed red blood cells; SBP = systolic blood pressure.

Note: Overall results are from the bivariate logistic mixed effects model analysis.

Heart Rate

Heart rate is a commonly measured vital sign and is also a component of other combination measures such as SI. It can be measured manually or automatically with monitoring devices ranging from simple to complex. HR is rarely measured alone and some studies provided data collected on HR in the course of studying other measures (e.g., HRV[59] or hemoglobin oximetry[108]) or comparing continuous vital sign monitoring with point-in-time measures.[107]

We included 24 studies that evaluated HR measured either out-of-hospital or in the ED. Five studies were not included in the pooled estimates.[54,80,83,103,165] Four of these used lower cut-offs (HR >100 or 105 beats per minute [bpm])[80,83,103,165] and one was not included because the population overlapped with a larger study.[54] The remainder are cited in the tables and figures below. We combined four studies of out-of-hospital HR ≥110 bpm and calculated a pooled sensitivity of 28 percent (95% CI 20 to 37, I^2=41.3%) and a pooled specificity of 85 percent (95% CI 74 to 91, I^2=95.8.0%) across all serious injury indicators. Figures 9 and 10 provide the estimates stratified by type of serious injury indicator (resource use, mortality, and composite indicators). Table 8 reports these values as well as the estimates from five studies using HR >110 bpm measured in the ED.[61,116,124,137,156] Plots for the ED analyses are included in Appendix I.

The pooled AUROC for out-of-hospital HR ≥110 bpm was 0.67 (95% CI 0.56 to 0.79, I^2=84.5%) based on five studies[55,59,62,106,107] (Figure 11) and 0.66 (95% CI 0.62 to 0.70, I^2=83.9%) for ED HR based on nine studies (Appendix I).[61,115,116,125,147-149,159,162,170]

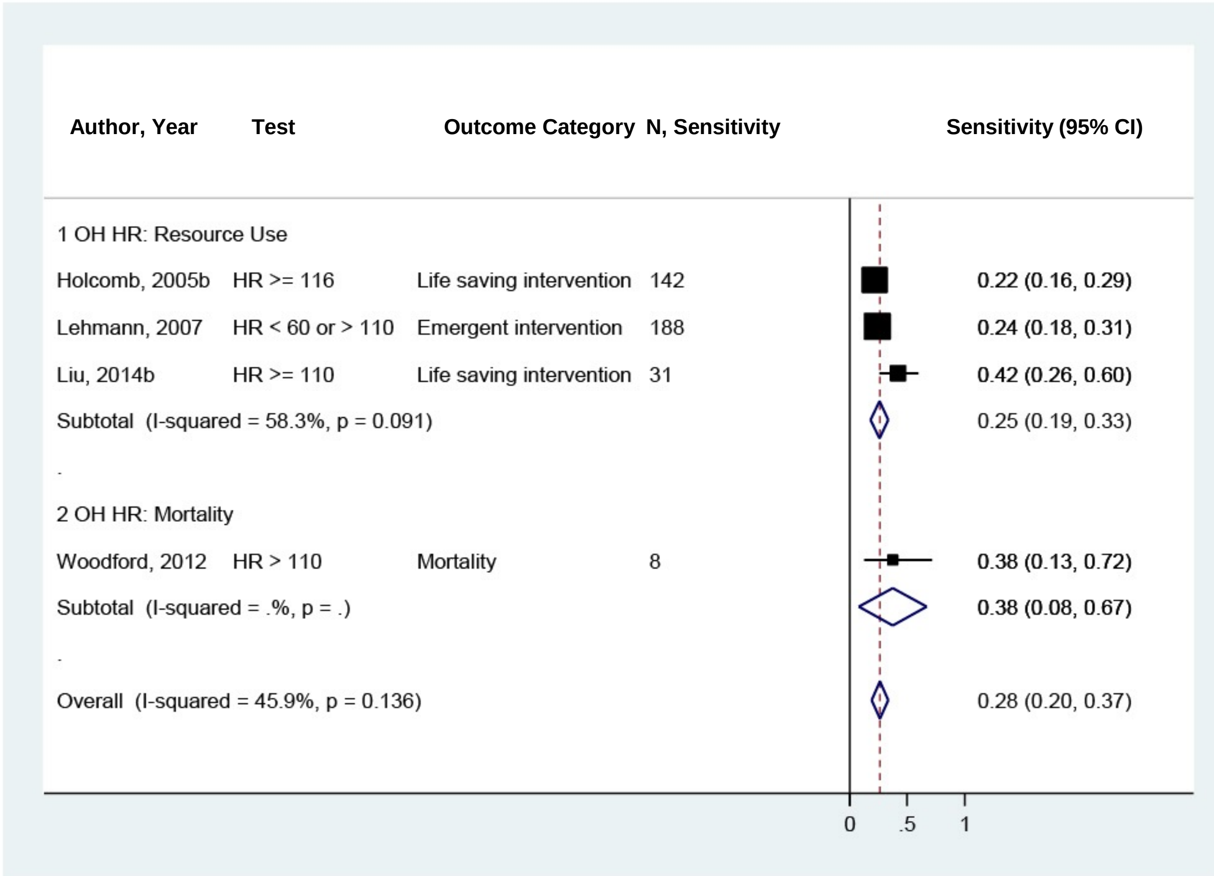
Table 8. Pooled sensitivity and specificity for predictive utility of heart rate across all serious injury indicators

Measure, Setting	Number of Studies	Sensitivity (95% CI, I^2)	Specificity (95% CI, I^2)
HR ≥110 bpm,* OH	4[70,76,80,107]	28% (20 to 37, 41.3%)	85% (74 to 91, 88.0%)
HR ≥110 bpm, ED	5[48,61,124,137,156]	29% (26 to 32, 26.7%)	93% (90 to 95, 94.5%)

bpm = beats per minute; CI = confidence interval; ED = emergency department; HR = heart rate; OH = out-of-hospital

*The exact threshold varied across studies (i.e., >110, ≥110, or ≥116 beats per minute)

Figure 9. Pooled sensitivity of out-of-hospital heart rate ≥110 beats per minute*



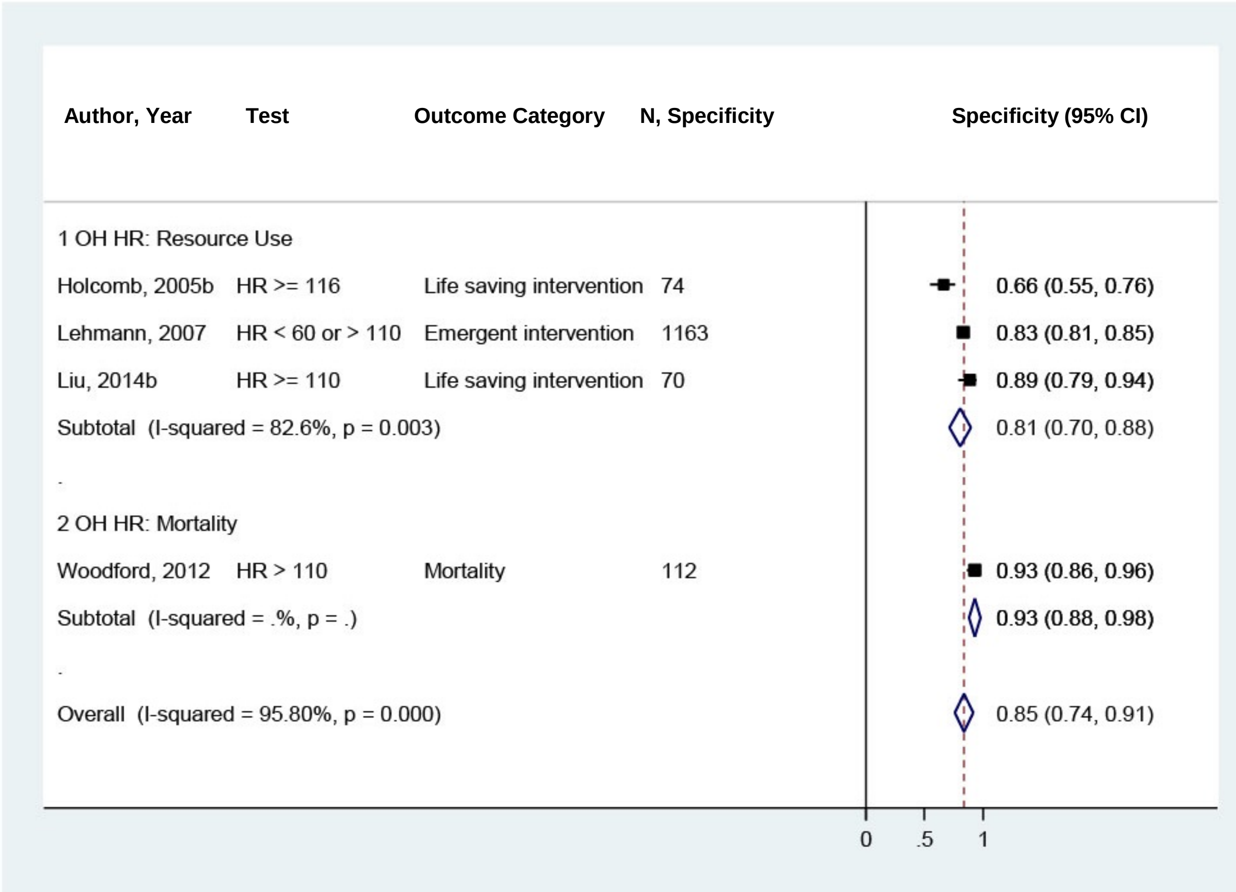
CI = confidence interval; HR = heart rate; N = number; OH = out-of-hospital.

Note: Holcomb, 2005b = Reference no. 70 in this report; Liu, 2014b = Reference no. 81 in this report.

Note: Overall results are from the bivariate logistic mixed effects model analysis.

*The exact threshold varied across studies (i.e., >110, ≥110, or ≥116 beats per minute)

Figure 10. Pooled specificity of out-of-hospital heart rate ≥110 beats per minute*



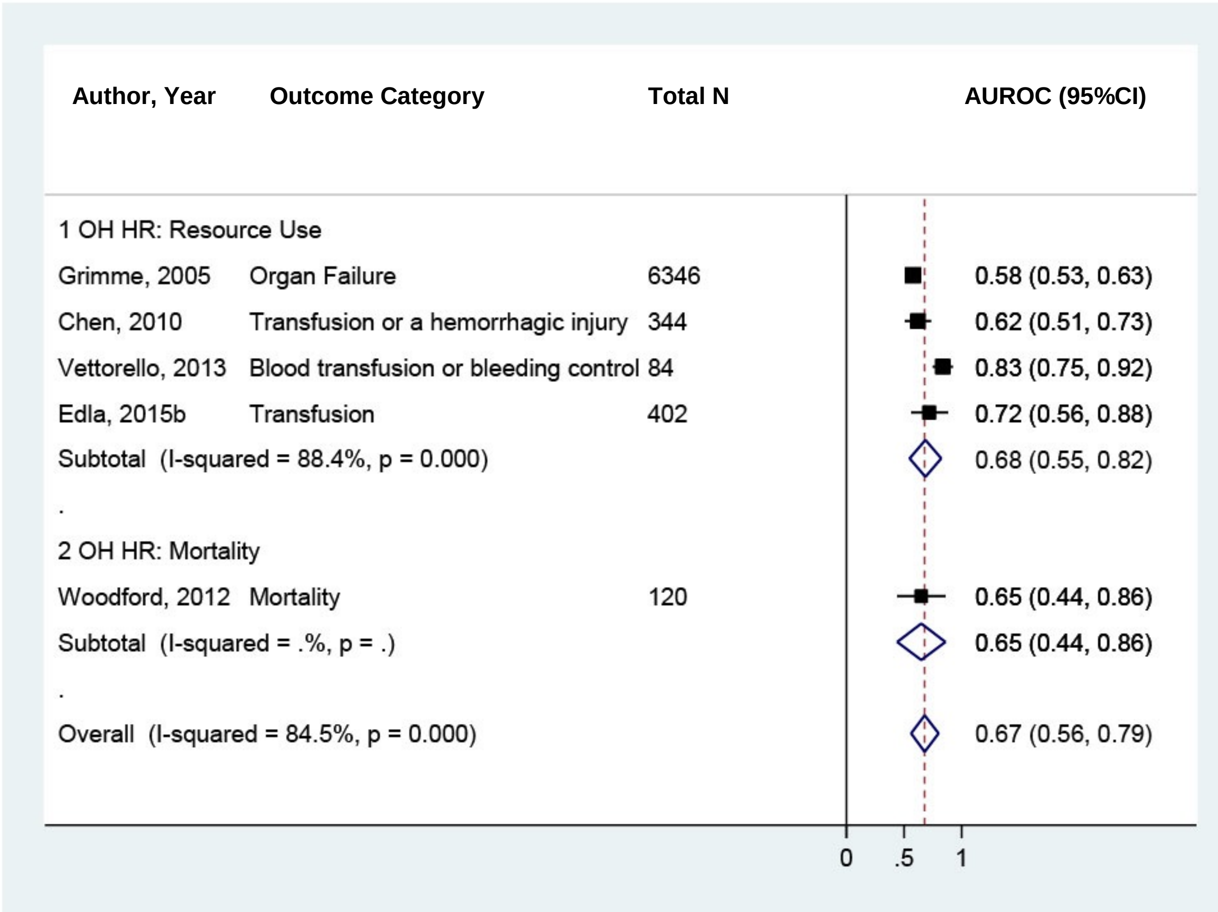
CI = confidence interval; HR = heart rate; N = number; OH = out-of-hospital.

Holcomb, 2005b = Reference no. 70 in this report; Liu, 2014b = Reference no. 81 in this report.

Overall results are from the bivariate logistic mixed effects model analysis.

*The exact threshold varied across studies (i.e., >110, ≥110, or ≥116 beats per minute)

Figure 11. Pooled AUROC of out-of-hospital heart rate



AUROC = area under the receiver characteristic curve; CI = confidence interval; HR = heart rate; N = number; OH = out-of-hospital.

Note: Overall results are from the bivariate logistic mixed effects model analysis.

Shock Index

SI combines two measures of circulatory function: SBP and HR, by dividing HR by SBP. SI has been shown to predict hemorrhage and indicate the severity of shock and the need for transfusion. Values of 0.5 to 0.7 are considered normal in healthy adults, while values greater than 0.9 or 1.0 are considered abnormal and indicators of underlying shock. In trauma triage, a threshold of 1.0 is often used, as it is simpler to determine; the person doing the assessment must only realize that the patient’s HR is higher than their SBP.

We identified 26 studies reported in 28 articles (see Table 9 for citations). All but two[66,108] were included in the pooled measures for either out-of-hospital or ED. We combined five studies of out-of-hospital SI and calculated a pooled sensitivity of 37 percent (95% CI 22 to 56, I^2=94.5%) and a pooled specificity of 85 percent (95% CI 72 to 92, I^2=99.6%) across all serious injury indicators. Figures 12 and 13 provide the estimates stratified by type of serious injury indicator (resource use, injury type or severity, mortality, or composite indicators). Table 9 reports these values as well as the estimates from 11 studies using SI measured in the ED. Plots for the ED analyses are included in Appendix I.

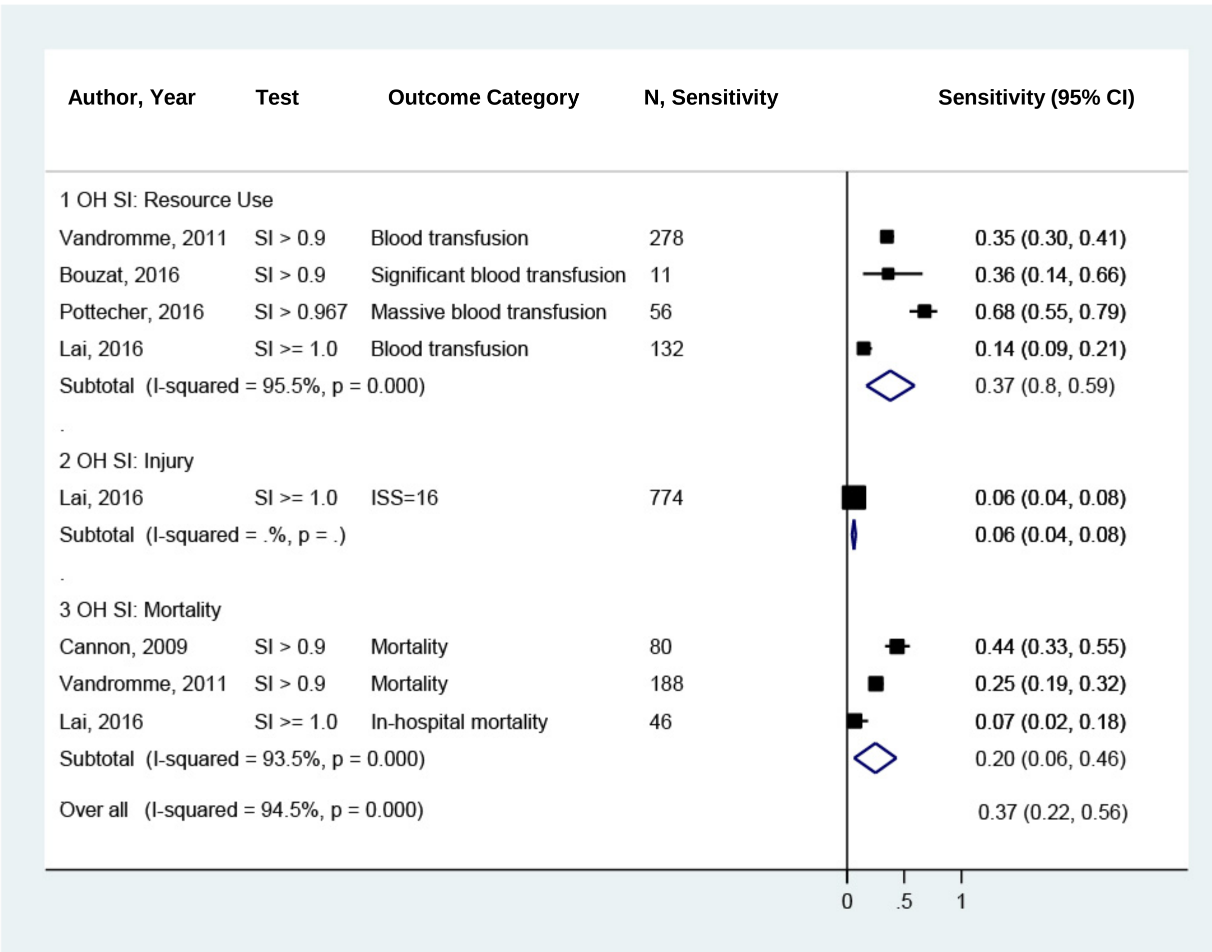
The pooled AUROC for out-of-hospital SI was 0.72 (95% CI 0.66 to 0.77, I^2=54.6%) based on seven studies[44,52,53,62,65,93,107] (Figure 14) and 0.71 (95% CI 0.66 to 0.76, I^2=94.7%) for ED SI based on 11 studies (reported in 12 articles) (Appendix I).[116,123,125,131,136,137,142,145,147,148,159,170]

Table 9. Pooled sensitivity and specificity for predictive utility of shock index across all serious injury indicators

Measure, Setting	Number of Studies	Sensitivity (95% CI, I^2)	Specificity (95% CI, I^2)
SI >0.9 or 1, OH	5[44,50,74,93,165]	37% (22 to 56, 94.5%)	85% (72 to 92, 99.6%)
SI >0.9 or 1, ED	11[50,74,116,123,136,144,145,147,148,151,166]	40% (24 to 57, 99.7%)	93% (85 to 96, 99.6%)

CI = confidence interval; ED = emergency department; OH = out-of-hospital; SI = shock index

Figure 12. Pooled sensitivity of out-of-hospital shock index >0.9

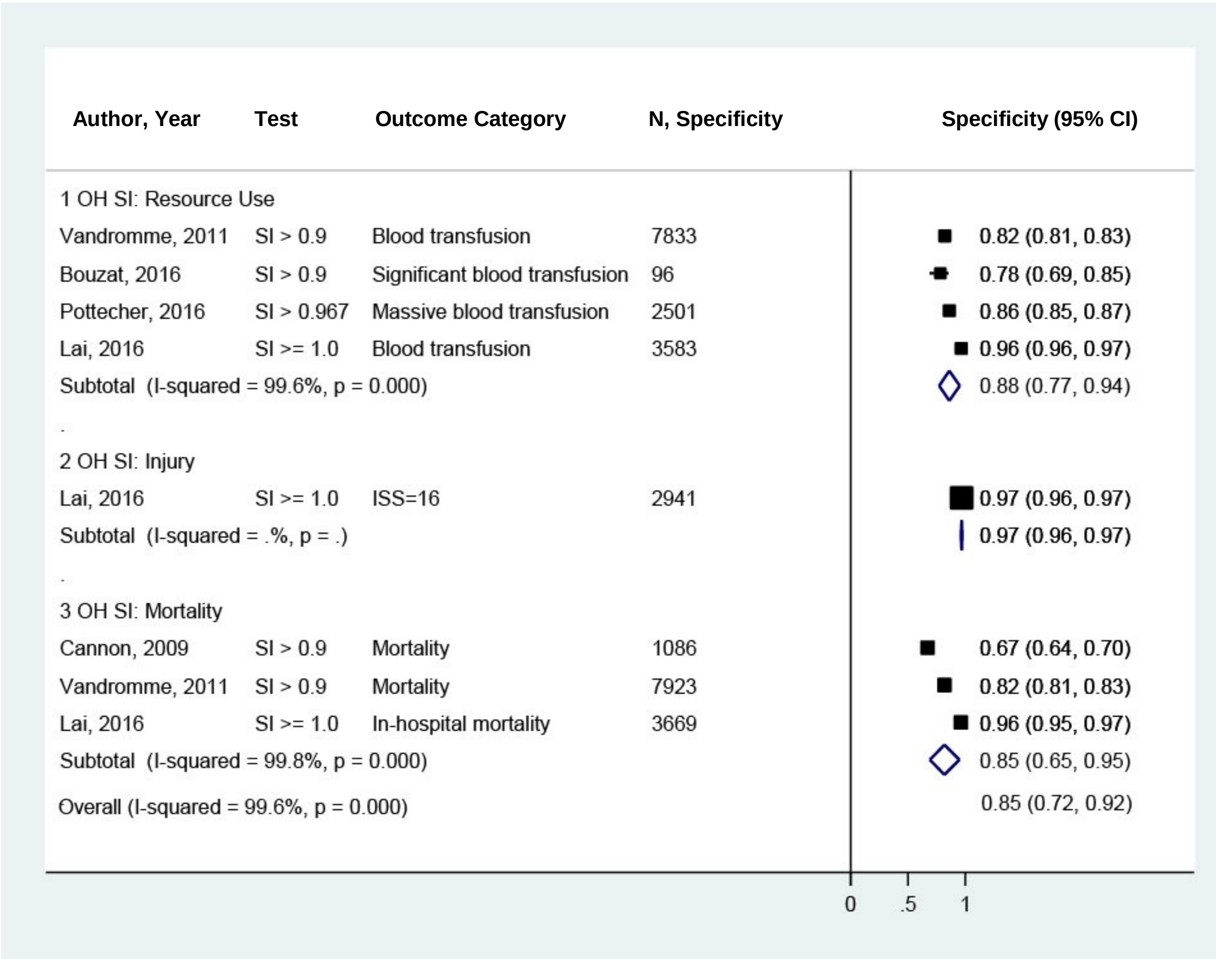


CI = confidence interval; ISS = injury severity score; N = number; OH = out-of-hospital; SI = shock index.

Note: Vandromme, 2011 = Reference no. 105 in this report.

Note: Overall results are from the bivariate logistic mixed effects model analysis.

Figure 13. Pooled specificity of out-of-hospital shock index >0.9

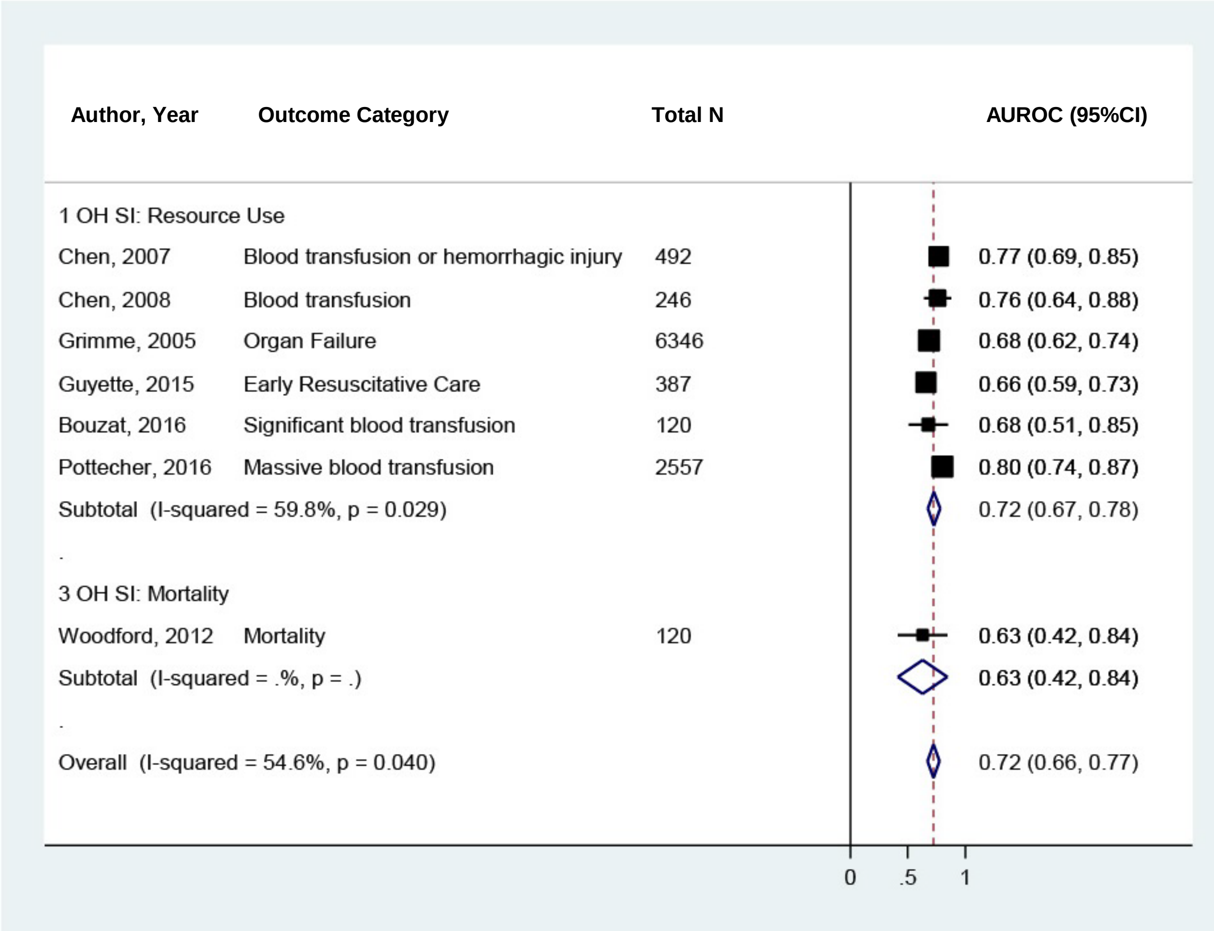


CI = confidence interval; ISS = injury severity score; N = number; OH = out-of-hospital; SI = shock index.

Note: Vandromme, 2011 = Reference no. 105 in this report.

Note: Overall results are from the bivariate logistic mixed effects model analysis.

Figure 14. Pooled AUROC of out-of-hospital shock index



AUROC = area under the receiver characteristic curve; CI = confidence interval; N = number; OH = out-of-hospital; SI = shock index.

Note: Overall results are from the bivariate logistic mixed effects model analysis.

Lactate

Lactate is produced predominately from anaerobic metabolism and cleared from the blood primarily through utilization by the liver.[176,177] Elevated lactate is present in states of inadequate perfusion, such as shock, in which decreased oxygen delivery leads to tissue hypoxia resulting in increased anaerobic metabolism and consequent lactate production.[177,178] Hyperlactatemia is not restricted to shock states, may be caused by other mechanisms, and is often multifactorial in etiology. Trauma patients in particular may have elevated lactate due to local tissue ischemia from burn or crush injuries, ethanol or illicit drug intoxication, or increased epinephrine seen in the stress response. Comorbidities such as liver disease or malignancy, and use of certain medications are also known causes of hyperlactatemia.[179,180]

Plasma lactate concentration can be obtained from arterial, venous, or capillary blood samples. A normal lactate concentration is considered to be less than 2 mmol/L, and levels greater than 4 mmol/L are considered markers of perfusion failure.[177] Lactate levels between 2 and 4 mmol/L are challenging to interpret since they can be caused by many factors, including

the stress response, which may be normal following traumatic injury. The use of lactate testing to inform field triage of trauma patients is of particular interest—availability of point-of-care testing devices in recent years and their use both out-of-hospital and in EDs make lactate testing potentially feasible to incorporate into out-of-hospital triage.

The predictive utility of lactate concentration in trauma was examined in multiple studies. As point-of-care measurement is relatively recent, fewer studies using out-of-hospital data were identified. We identified 23 studies in 24 articles, and all but one[165] included data that could be pooled. The figures below report the pooled sensitivity and specificity for lactate measured out-of-hospital using different cutoff values. Similar figures for lactate measured in the ED are in Appendix I. Figures 15 and 16 contain the results for three studies that used a cutoff value of 2 or 2.5 mmol/L or higher. Figures 17 and 18 are for the one study that used a higher threshold of 4 mmol/L or higher as the definition of abnormal. Table 10 summarizes the pooled sensitivity and specificity at the lower cutoff value and the higher value for both out-of-hospital and ED.

Comparing the lower threshold to the higher demonstrates the trade-offs between sensitivity and specificity: for the out-of-hospital measures sensitivity decreases from 72 percent at the lower threshold to 23 percent at the higher threshold, while specificity increases from 62 to 93 percent, though there was only one study that evaluated the higher threshold.[47] We pooled the two studies that reported an AUROC for out-of-hospital measurements[65,101](Figure 19) to obtain a combined estimate of 0.77 (95% CI 0.67 to 0.82, I^2=10.2%), and the 14 studies that reported an AUROC for ED lactate to obtain an estimate of 0.68 (95% CI 0.65 to 0.71, I^2=66.6%).[44,97,104,113,114,117,120,128,146-148,150,152,158,161] It is also possible that the change in lactate or lactate clearance could be an important predictor once volume is restored or stable, but this change is usually reported over 2 hours, making it less useful for field triage. This was explored in one included study that reported a higher AUROC for initial lactate values than lactate clearance (0.78 vs. 0.70).[158]

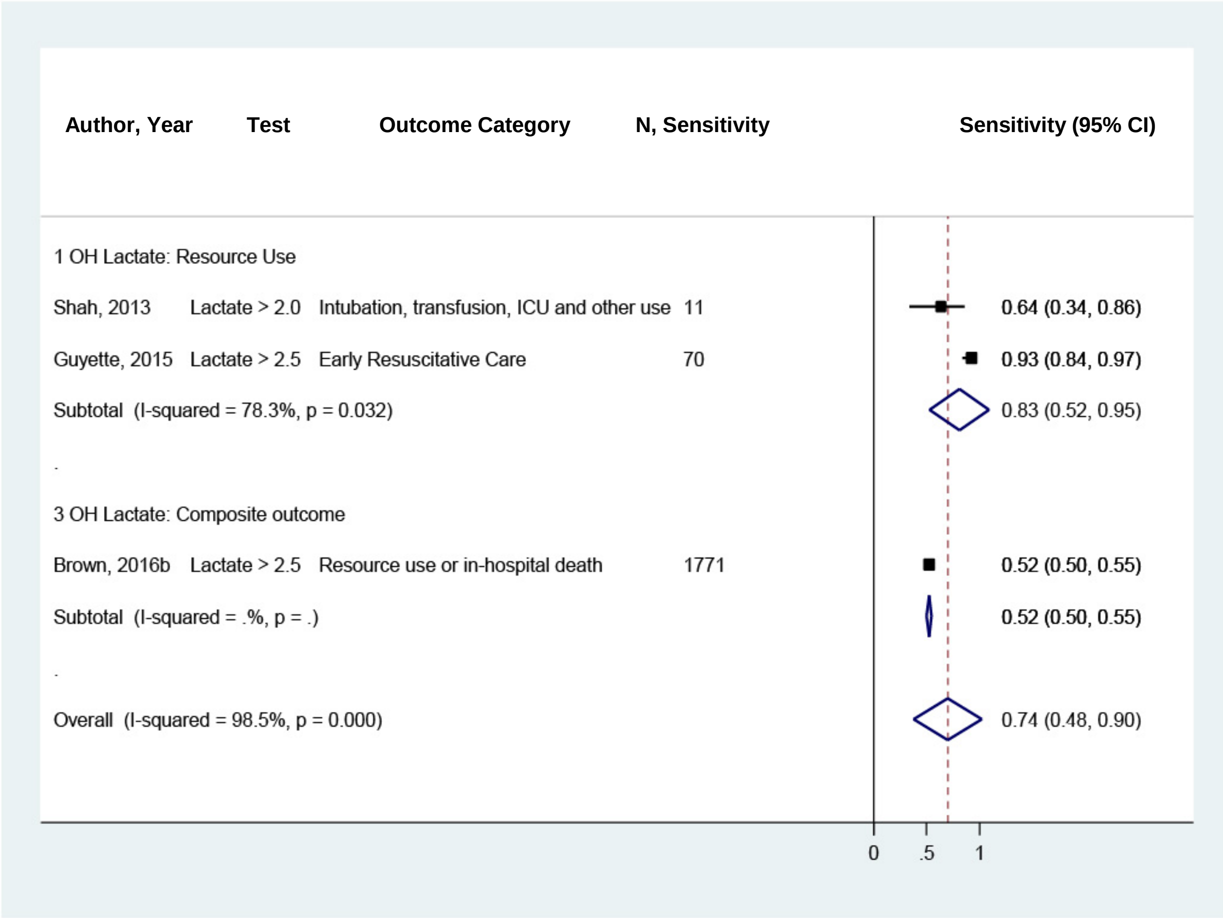
As most of the studies to date have been done in the ED, more out-of-hospital research is needed to directly evaluate how lactate would perform as a field triage measure. This is important because early interventions, particularly use of intravenous fluids, influence lactate levels, making it plausible that out-of-hospital lactate levels will differ from those obtained in the ED and the predictive utility of this measure for out-of-hospital may be significantly different compared to performance when used in the ED.

Table 10. Pooled sensitivity and specificity for predictive utility of lactate across all serious injury indicators

Measure, Setting	Number of Studies	Sensitivity (95% CI, I^2)	Specificity (95% CI, I^2)
Lactate >2 or 2.5 mmol/L Out-of-hospital	3[47,65,101]	74% (48 to 90, 98.5%)	62% (51 to 72, 98.6%)
Lactate >4 mmol/L Out-of-hospital	1[47]	23% (21 to 25, NA)	93% (92 to 94, NA)
Lactate >2 or 2.5 mmol/L Emergency department	9[104,117,128,143,146-148,157,158,161]	74% (66 to 81, 89.6%)	52% (43 to 60, 98.7%)
Lactate >4 or 5 mmol/L Emergency department	9[44,104,112,117,119,120,126,143,157]	50% (37 to 63, 93.5%)	86% (78 to 91, 92.1%)

CI = confidence interval; NA = not applicable

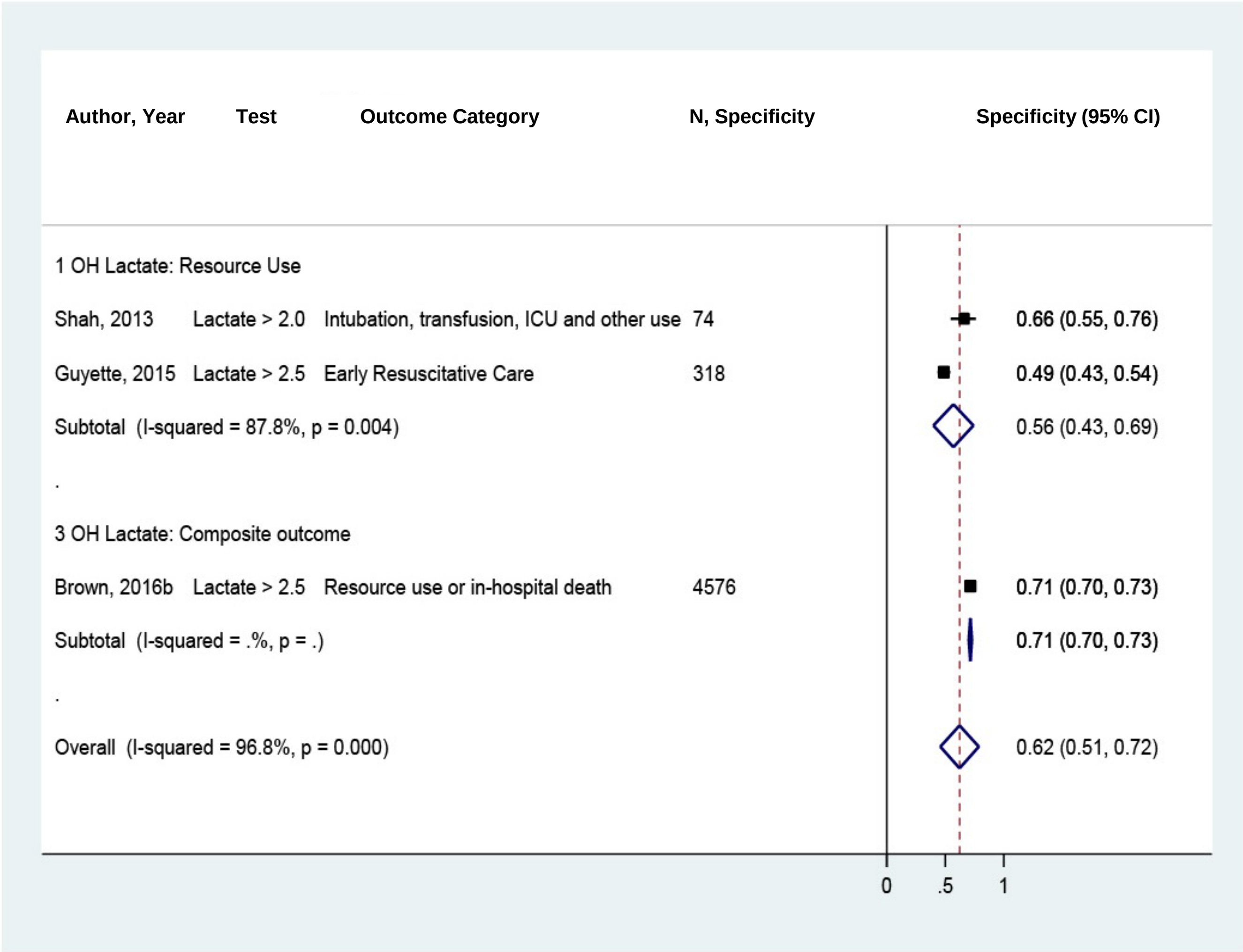
Figure 15. Pooled sensitivity of out-of-hospital lactate >2 mmol/L



CI = confidence interval; ICU = intensive care unit; N = number; OH = out-of-hospital.

Note: Overall results are from the bivariate logistic mixed effects model analysis.

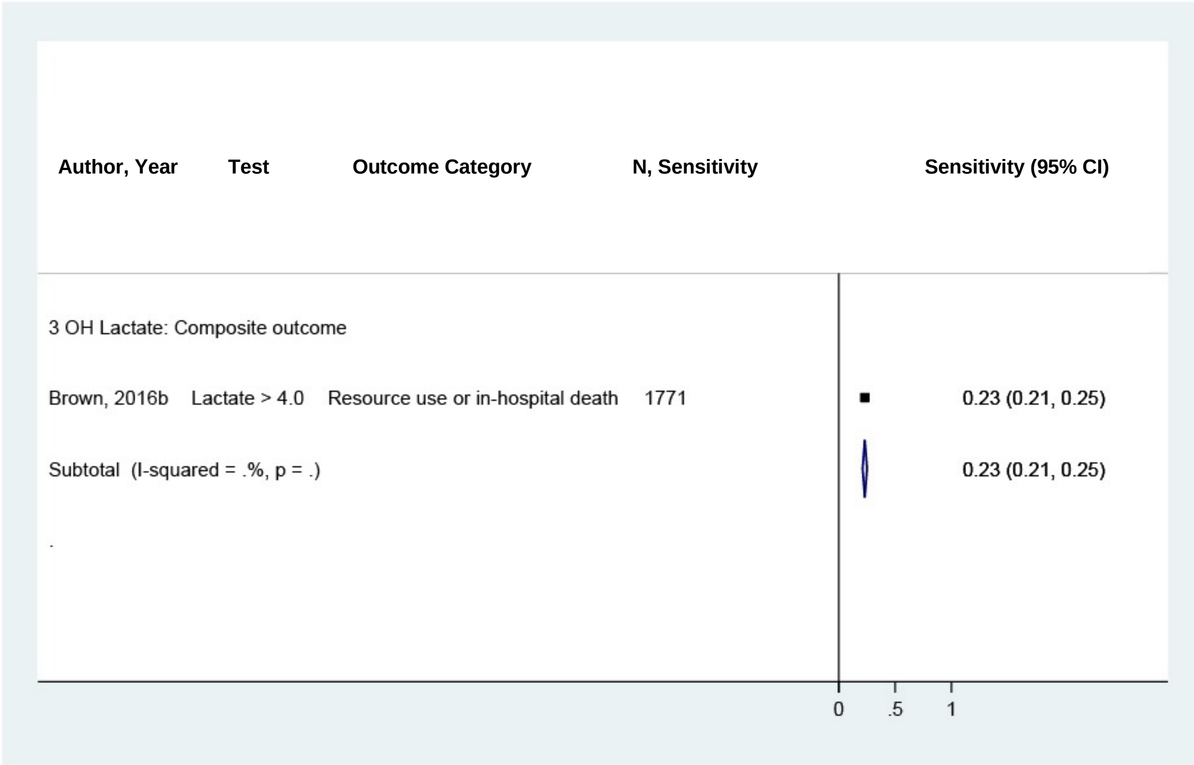
Figure 16. Pooled specificity of out-of-hospital lactate >2 mmol/L



CI = confidence interval; ICU = intensive care unit; N = number; OH = out-of-hospital.

Note: Overall results are from the bivariate logistic mixed effects model analysis.

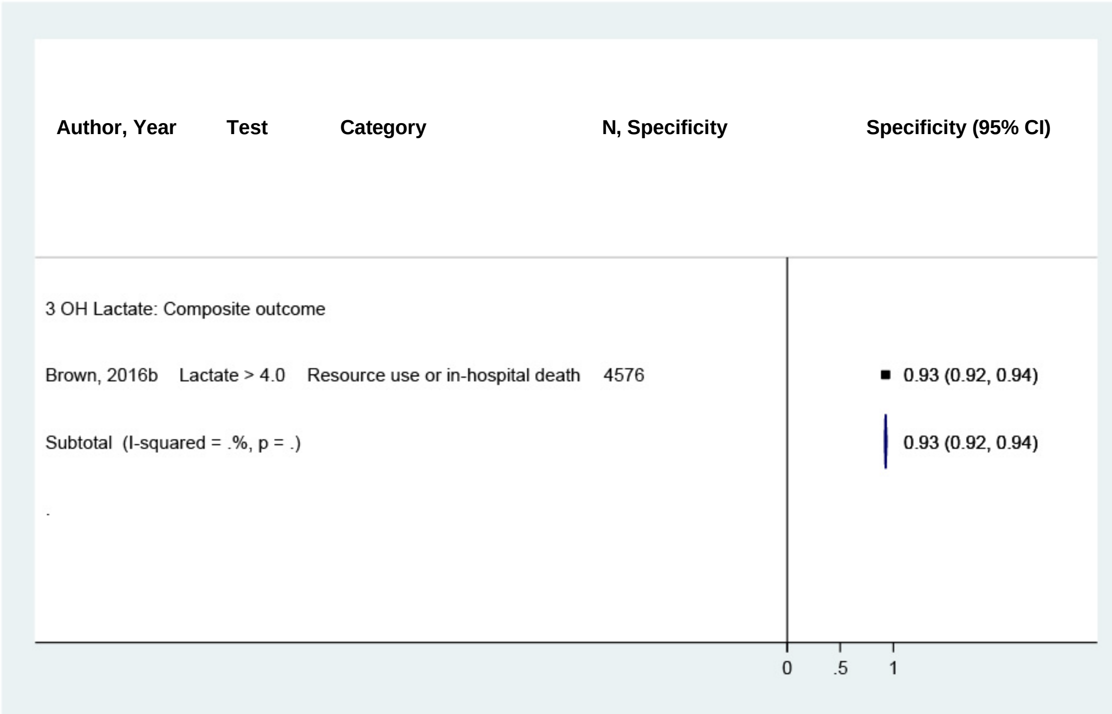
Figure 17. Sensitivity of out-of-hospital lactate >4 mmol/L



CI = confidence interval; N = number; OH = out-of-hospital.

Note: Overall results are from the bivariate logistic mixed effects model analysis.

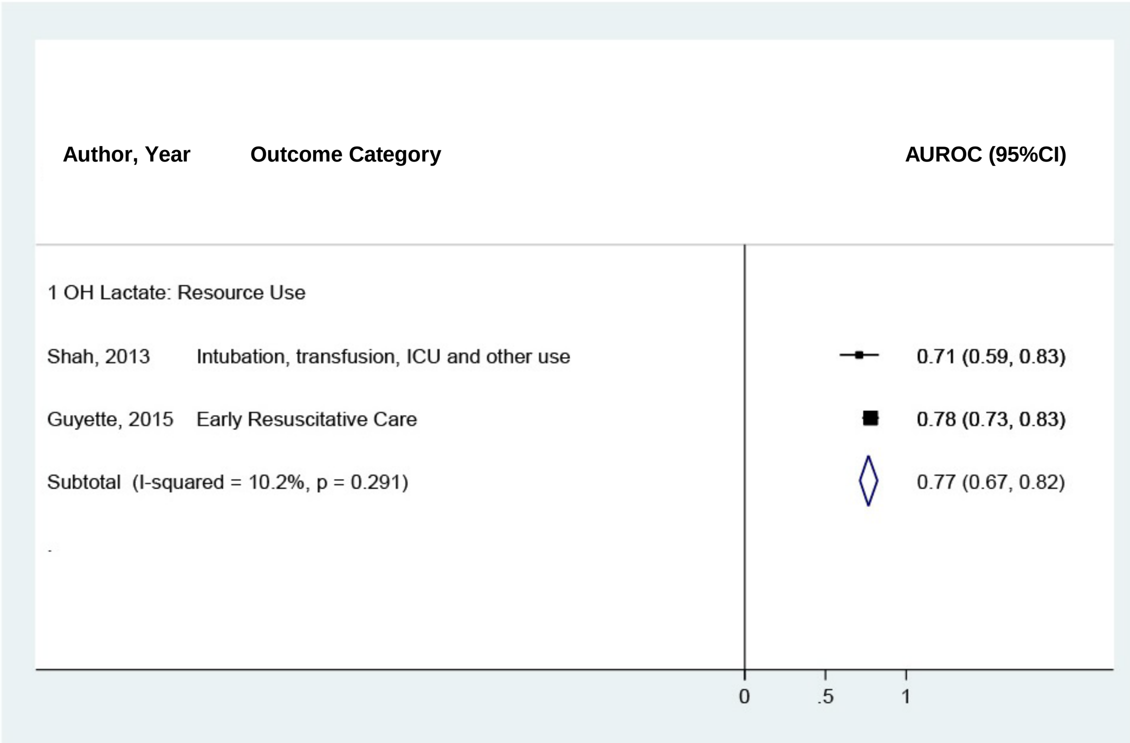
Figure 18. Specificity of out-of-hospital lactate >4 mmol/L



CI = confidence interval; N = number; OH = out-of-hospital.

Note: Overall results are from the bivariate logistic mixed effects model analysis.

Figure 19. Pooled AUROC of out-of-hospital lactate



AUROC = area under the receiver operating characteristic curve; CI = confidence interval; ICU = intensive care unit; N = number; OH = out-of-hospital.

Note: Overall results are from the bivariate logistic mixed effects model analysis.

Base Deficit

Base deficit is a negative base excess and is equivalent to an acid excess or insufficient level of bicarbonate. Base excess is the amount of acid (H^+ ions) that would be needed to return the blood pH to normal (7.4), assuming a normal partial pressure of carbon dioxide (pCO_2).[181] Base deficit is clinically similar to lactate concentration, in that base deficit is a nonspecific indicator of metabolic acidosis and correlates with anaerobic metabolism.[182] Normal base excess is -2 to +2 mEq/L.[181] Large base deficit can be due to shock and respiratory failure, resulting in tissue hypoperfusion and hypoxemia.

Table 11 provides the results from 15 studies reported in 16 articles that included data evaluating base deficit. Many of these studies tested different thresholds and repeated the analysis using different indicators of serious injury. We included the highest and lowest threshold tested in each study in Table 11 below (results for every threshold reported are available in the evidence tables in Appendix D). The results are grouped by type of serious injury indicator within the table. All of the identified studies analyzed base deficit measured in the ED; we did not identify any studies of base deficit in the out-of-hospital setting. As more advanced technologies are developed for out-of-hospital monitoring, resuscitation, and treatment, base deficit may become more useful or feasible in emergency medical services (EMS) trauma assessment.

Table 11. Predictive utility of base deficit measured in emergency department

Measure Threshold(s)	Author, Year Risk of Bias	Serious Injury Indicator Type: Indicator	Number Analyzed Age Mean (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
Base Deficit <-2	Caputo, 2015[120] Low	R: operative intervention	100 34 (NR)	Sen: 57% (42 to 76) Sp: 61% (52 to 77)	0.67 (0.58 to 0.76)
Base Deficit <-4 <-7	Beekley, 2010[115] Moderate	R: LSI	147 27 (11)	Base Deficit <-4 Sen: 28% (17 to 40) Sp: 91% (81 to 96 Base Deficit <-7Sen: 15% (8 to 26) Sp: 97% (89 to 100)	0.71 (0.64 to 0.78)
Base Deficit	Raux, 2017[97] Moderate	R: emergency procedure	1,075 39 (18)	NR	0.74 (0.68 to 0.80)
Base Deficit <-4 <-7	Beekley, 2010[115] Moderate	R: massive transfusion	147 27 (11)	Base Deficit <-4 Sen: 38% (9 to 76) Sp: 83% (75 to 89) Base Deficit <-7 Sen: 25% (3 to 65) Sp: 92% (85 to 96)	0.69 (0.51 to 0.87)
Base Deficit <-2	Caputo, 2015[120] Low	R: massive transfusion	100 34 (NR)	Sen: 59% (45 to 72) Sp: 59% (45 to 71)	0.82 (0.75 to 0.89)
Base Deficit <-5	Rainer, 2011[156] Moderate	R: massive transfusion	1,891 44 (19)	*Sen: 41% (31 to 52) *Sp: 94% (93 to 95)	NR
Base Deficit	Raux, 2017[97] Moderate	R: massive hemorrhage	1,075 39 (18)	NR	0.85 (0.81 to 0.89)
Base Deficit <-4 <-7	Beekley, 2010[115] Moderate	R: blood transfusion	147 27 (11)	Base Deficit <-4 Sen: 40% (24 to 57) Sp: 90% (82 to 95) Base Deficit <-7 Sen: 21% (10 to 37) Sp: 96% (89 to 99)	0.70 (0.61 to 0.79)
Base Deficit -3 to -5 ≤-10	Davis, 1996[122] Moderate	R: blood transfusion	2,954 32 (0.3)	Base Deficit -3 to -5 *Sen: 23% (21 to 26) *Sp: 73% (71 to 75) Base Deficit ≤-10 *Sen: 27% (24 to 30) *Sp: 98% (97 to 98)	NR
Base Deficit	Mutschler, 2013[145] Moderate	R: blood transfusion	21,853 45 (20)	NR	0.71 (0.70 to 0.72)
Base Deficit	Baron, 2004 [113] Moderate	R: Blood loss	N=108 28 (11)	NR	0.76 (0.68 to 0.85)
Base Deficit	Baron, 2007[114] Moderate	M: mortality	86 35 (17)	NR	0.87 (0.77 to 0.98)

Measure Threshold(s)	Author, Year Risk of Bias	Serious Injury Indicator Type: Indicator	Number Analyzed Age Mean (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
Base Deficit	Callaway, 2009[117] Moderate	M: mortality	1,776 38 (14)	NR	0.65 (NR)
Base Deficit -3 to -5 ≤-10	Davis, 1996[122] Moderate	M: mortality	2,954 32 (0.3)	Base Deficit -3 to -5 *Sen: 19% (16 to 24) *Sp: 73% (71 to 74) Base Deficit ≤-10*Sen: 33% (29 to 38) *Sp: 94% (93 to 95)	NR
Base Deficit	Dunham, 2017[125] High	M: mortality	1,863 29 (11)	NR	0.90 (0.85 to 0.94)
Base Deficit <-5 <-10	Mizushima, 2011[143] Moderate	M: mortality	1,742 44 (20)	Base Deficit <-5 *Sen: 56% (47 to 64) *Sp: 87% (86 to 89) Base Deficit <-10 *Sen: 32% (25 to 40) *Sp: 96% (95 to 97)	NR
Base Deficit ≤-6	Aslar, 2004[112] Moderate	M: 30-day in-hospital mortality	64 36 (19)	*Sen: 76% (54 to 90) *Sp: 62% (44 to 77)	NR
Base Deficit	Raux, 2017[97] Moderate	M: 30-day in-hospital 48-hour	1,075 39 (18)	NR	0.75 (0.70 to 0.80) 0.82 (0.75 to 0.87)
Base Deficit	Raux, 2017[97] Moderate	I: ISS >15	1,075 39 (18)	NR	0.67 (0.63 to 0.70)
Base Deficit <-1.3: subgroup with normal vital signs	Paladino, 2008, 2011[147,148] Moderate	C: major injury (blood transfusion, hemorrhage or ISS ≥16)	1,034 (total n=1,435) *Overall: 35 (17)*	Sen: 56% (NR) Sp: 71% (NR)	0.68 (0.63 to 0.73) For total n 0.72 (0.69 to 0.76)
Base Deficit	Paladino, 2010a,b[149,150]† Moderate	C: major injury (blood transfusion, hemorrhage or ISS ≥16)	1,649 36 (range 13 to 95)	NR	0.72 (0.68 to 0.76)
Base Deficit	Raux, 2017[97] Moderate	C: ICU LOS >2 days or in-hospital mortality	1,075 39 (18)	NR	0.70 (0.67 to 0.73)

AUROC = area under the receiver operating characteristic curve; C = composite; CI = confidence interval; I = injury; ICU = intensive care unit; ISS = injury severity score; LOS = length of stay; LSI = life-saving intervention; M = mortality; NR = not reported; R = resource use; SD = standard deviation; Sen = sensitivity; Sp = specificity

*Results calculated by reviewers
†Samples in the two articles appear to overlap; results reported for larger sample

Heart Rate Variability or Heart Rate Complexity

Routine electrocardiography (ECG) can be used to measure characteristics of heart beats that reflect the state of a patient's autonomic nervous system. Several metrics exist, including standard deviation of the normal-to-normal intervals, rate of sinus arrhythmia, sample entropy (SampEn), and detrended fluctuations analysis. Lack of variability or complexity can be an indicator of reduced physiologic capacity or increased stress. These changes may be detectible before the impact of trauma is seen in the commonly measured vital signs such as blood pressure, HR, and RR. That is, they may help identify critically injured patients who would otherwise not be recognized as seriously injured using traditional vital signs. The availability of ECG and software that analyzes ECG output in real time makes it possible to use these measures in field triage.

Eight studies analyzed HRV or HRC (Tables 12, 13, and 14). Seven[40,41,49,56,59,73,106] studies collected prehospital data during helicopter transport, while one study evaluated patients in the ED waiting for CT scans to evaluate head trauma.[160] Two studies were different analyses of the same patient population.[40,41] The out-of-hospital studies were divided into two tables: Table 12 reports the results based on a single metrics from the ECG, which is most similar to the analysis of other individual measures in this report, while Table 13 reports results that combine metrics from the ECG. Five studies were conducted in the state of Texas, with common researchers among the authors,[40,41,49,56,59] while the others were conducted in Florida[73] and Italy[106] by different researchers.

Overall, the studies reported AUROCs ranging from 0.60 to 0.95. However, the highest value was produced by an analysis that excluded outliers.[40] The risk of bias in some studies was rated as high if in addition to one or more other methodologic concerns, a significant proportion of cases were dropped if the data were incomplete due to interference and instrumentation issues, which could plausibly be confounded with severity of injury. Additionally, as the patients were transported by helicopter, these patients may be inherently different than patients transported by ground ambulance, and this may make these results less generalizable to all trauma patients.

As this is a developing technology, the earlier studies had smaller sample sizes (e.g., n=75, n=84). The most recent study was larger (n=402) and combined data from two air ambulance services – one in Texas and the other in Massachusetts.[59] This study reported AUROC estimates which were similar for HRV metrics and routine vital signs, but also found that adding HRV to vital signs did not improve diagnostic performance (in this case, the ability to predict need for transfusion). The authors conducted sensitivity analyses that involved repeating their analyses on all cases, including those without complete reliable data, and using different transfusion volumes (≥1, 5, or 9 units of packed red blood cells in 24 hours) as the serious injury indicator. The results of these repeated analyses did not change the conclusions.

Table 12. Predictive utility of heart rate variability/complexity: out-of-hospital

Measure **Threshold**	**Author, Year** **Risk of Bias**	**Serious Injury Indicator Type: Indicator**	**Number Analyzed** **Age** **Mean (SD)**	**Sensitivity** **Specificity** **(95% CI)**	**AUROC (95% CI)**
HRV Heart-to-arm time index (iHAT) >58.78%	Vettorello, 2013[106] High	R: blood transfusion or bleeding control	84 Median (range) 41 (18-83) for no hemorrhage group 29 (18-74) for hemorrhage group	Sen: 90.9% (58.7 to 99.8) Sp: 100% (94.9 to 100)	0.952 (0.880 to 0.987)
HRV Rate of sinus arrhythmia (RSA)	Edla, 2015b[59] Moderate	R: blood transfusion ≥1 pRBC units in 24 hours	402 39 (16)	NR	0.72 (0.64 to 0.79)
HRV Rate of sinus arrhythmia (RSA)	Edla, 2015b[59] Moderate	R: blood transfusion ≥5 pRBC units in 24 hours	402 39 (16)	NR	0.76 (0.62 to 0.85)
HRV Rate of sinus arrhythmia (RSA)	Edla, 2015b[59] Moderate	R: blood transfusion ≥9 pRBC units in 24 hours	402 39 (16)	NR	0.79 (0.64 to 0.89)
HRV Sample entropy (SampEn)	Edla, 2015b[59] Moderate	R: blood transfusion ≥1 pRBC units in 24 hours	402 39 (16)	NR	0.60 (0.53 to 0.68)
HRV Sample entropy (SampEn)	Edla, 2015b[59] Moderate	R: blood transfusion ≥5 pRBC units in 24 hours	402 39 (16)	NR	0.63 (0.52 to 0.73)
HRV Sample entropy (SampEn)	Edla, 2015b[59] Moderate	R: blood transfusion ≥9 pRBC units in 24 hours	402 39 (16)	NR	0.62 (0.46 to 0.75)
HRV Standard deviation of the R-to-R intervals (SDNN)	Edla, 2015b[59] Moderate	R: blood transfusion ≥1 pRBC units in 24 hours	402 39 (16)	NR	0.67 (0.59 to 0.75)
HRV Standard deviation of the R-to-R intervals (SDNN)	Edla, 2015b[59] Moderate	R: blood transfusion ≥5 pRBC units in 24 hours	402 39 (16)	NR	0.72 (0.61 to 0.82)

Measure Threshold	Author, Year Risk of Bias	Serious Injury Indicator Type: Indicator	Number Analyzed Age Mean (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
HRV Standard deviation of the R-to-R intervals (SDNN)	Edla, 2015b[59] Moderate	R: blood transfusion ≥9 pRBC units in 24 hours	402 39 (16)	NR	0.71 (0.57 to 0.82)
HRV Standard deviation of the R-to-R intervals (SDNN) <24 msec	King, 2009[73] Moderate	R: LSI	75 47 (20)	Sen: 80% (NR) Sp: 75% (NR)	0.74 (NR)
HRV Standard deviation of the R-to-R intervals (SDNN) <39 msec <55 msec	King, 2009[73] Moderate	C: serious injury including death	75 47 (20)	Sen: 80% (NR) Sp: NR Sen: 94% (NR) Sp: NR	0.80 (NR)

AUROC = area under the receiver operating characteristic curve; C = composite; CI = confidence interval; HRV = heart rate variability; iHAT = heart-to-arm time index; LSI = life-saving intervention; NR = not reported; pRBC = packed red blood cells; R = resource use; R-R interval = time between heart beats; RSA = rate of sinus arrhythmia; SampEn = sample entropy; SD = standard deviation; SDNN = standard deviation of normal-to-normal R-to-R intervals; Sen = sensitivity; Sp = specificity

Table 13. Predictive utility of heart rate variability/complexity: out-of-hospital heart rate measure models

Measure	Author, Year Risk of Bias	Serious Injury Indicator Type: Indicator	Number Analyzed Age Mean (SD)	Measures in Model	AUROC (95% CI)
Heart Rate Complexity	Cancio, 2008[49] High	R: LSI	192 37 (NR)	SampEn and DFA	0.76 (0.68 to 0.83)
Heart Rate Variability	Batchinsky, 2007[40] Moderate	M: mortality	31 38 (3) for survivors 43 (6) for deceased	R-to-R interval derived data, approximate entropy, and distribution of symbol 2	0.956 (0.86 to 1.0) 0.86 (0.71 to 1.0) including outliers

Measure	Author, Year Risk of Bias	Serious Injury Indicator Type: Indicator	Number Analyzed Age Mean (SD)	Measures in Model	AUROC (95% CI)
Heart Rate Variability	Batchinsky, 2009[41] Moderate	M: mortality	31* same patients as Batchinsky 2007, different analysis	SampEn combined with data set derived weights and intercepts	Data set length = 800 beats (longest reported) 0.895 (0.780 to 1.010) Data set length = 200 beats: 0.895 (0.781 to 1.000) Data set length = 100 beats: 0.821 (0.662 to 0.980)
Heart Rate Variability	Cooke, 2006a[56] High	M: mortality	30 43 (2) for deceased 35 (3) for survivors	R-to-R interval oscillations: HF/LF ratio as a global index of changes in autonomic balance *HF = R-to-R interval spectral power at the high frequency (0.15-0.4 Hz) *LF = R-to-R interval spectral power at the low frequency (0.05-0.15 Hz)	Likelihood ratio (AUROC not reported) HF/LF: 9.96 With adjustments: HF/LF, covariate age: 5.19 HF/LF, covariate R-to-R interval: 7.06 HF/LF, covariate GCS: 1.96 HF/LF, covariates age, R-to-R interval, and GCS: 0.43

AUROC = area under the receiver operating characteristic curve; CI = confidence interval; DFA = detrended fluctuations analysis; GCS = Glasgow Coma Scale; HF = high frequency; HR = heart rate; IQR = interquartile range; LF = low frequency; LSI = life-saving intervention; M = mortality; NR = not reported; pRBC = packed red blood cells; R = resource use; R-to-R interval = time between heart beats; SampEn = sample entropy; Sen = sensitivity; Sp = specificity

Table 14. Predictive utility of heart rate variability/complexity: emergency department

Measure	Author, Year Risk of Bias	Serious Injury Indicator Type: Indicator	Number Analyzed Age Mean (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
HRV low to high frequency index ratio (LF/HF)	Ryan, 2011b[160] Moderate	M: mortality	216 50 (1)	NR	0.68 (NR)
HRV spectral power at very low frequency (VLF)	Ryan, 2011b[160] Moderate	M: mortality	216 50 (1)	NR	0.67 (NR)

AUROC = area under the receiver operating characteristic curve; CI = confidence interval; HF = high frequency; HRV = heart rate variability; LF = low frequency; M = mortality; NR = not reported; SD = standard deviation; Sen = sensitivity; Sp = specificity; VLF = very low frequency

Other Measures of Circulatory Compromise

In addition to SBP, lactate, base deficit, HR, SI, and HRV and HRC, the literature on measures of circulatory compromise contains additional measures. These are categorized into those using out-of-hospital measures and those using ED measures in Tables 15 and 16 below. Within the tables similar measures are grouped between bold dividing lines. First, measures similar or related to SBP, which is addressed by a large volume of studies and reported in the first detailed results section, are listed. These are diastolic blood pressure (DBP), mean arterial pressure (MAP), and pulse pressure (PP). The second group contains variations on SI including HR/PP, PP/HR, and modified SI (HR/MAP). The last section of the tables includes miscellaneous measures such as radial pulse character, min pulse, pulse max index, capillary refill, cardiac index, and data collected through photoplethysmography (PPG).

One unique aspect of this group of measures is that two, radial pulse character[86] and capillary refill,[70] do not require instruments of any kind, but depend on the technique and judgment of the person doing the assessment.

Table 15. Predictive utility of other circulatory measures: out-of-hospital

Measure Threshold	Author, Year Risk of Bias	Serious Injury Indicator Type: Indicator	Number analyzed Age Mean (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
Diastolic Blood Pressure	Chen, 2009[54] Moderate	R: blood transfusion with hemorrhagic injury	326 38 (16)	NR	0.55 (0.43 to 0.67)
Mean Arterial Pressure	Chen, 2009[54] Moderate	R: blood transfusion with hemorrhagic injury	326 38 (16)	NR	0.60 (0.49 to 0.71)

Measure Threshold	Author, Year Risk of Bias	Serious Injury Indicator Type: Indicator	Number analyzed Age Mean (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
Pulse Pressure linear classifier	Chen, 2007[52] High	R: blood transfusion with hemorrhagic injury	492 NR	NR	0.73 (NR)
Pulse Pressure	Chen, 2008[53] Moderate	R: blood transfusion with hemorrhagic injury	627 39 (NR)	NR	0.73 (SD 0.06)
Pulse Pressure reliable data	Chen, 2009[54] Moderate	R: blood transfusion with hemorrhagic injury	326 38 (16)	NR	0.78 (0.69 to 0.86)
Pulse Pressure	Edla, 2015b[59] Moderate	R: blood transfusion ≥1 pRBC unit in 24 hours	402 39 (16)	NR	0.74 (0.65 to 0.81)
Pulse Pressure	Edla, 2015b[59] Moderate	R: blood transfusion ≥9 pRBC unit in 24 hours	402 39 (16)	NR	0.79 (0.61 to 0.90)
HR/PP Ratio	Chen, 2008[53] Moderate	R: hemorrhage	627 39 (NR)	NR	0.75 (SD 0.10)
PP/HR Ratio <0.443	Pottecher, 2016[93] Moderate	R: massive transfusion (≥10 pRBC units in 24 hours)	2,557 37 (19)	Sen: 75% (NR) Sp: 74% (NR)	0.767 (0.70 to 0.84)
PP/HR ratio <0.443	Pottecher, 2016[93] Moderate	R: massive transfusion (≥3 pRBC units in 1 hour)	2,557 37 (19)	Sen: 75% (NR) Sp: 62% (NR)	0.713 (0.67 to 0.76)
Radial Pulse Character Weak	McManus, 2005[86] High	R: ICU admission	314+ 32 (NR)	*Sen: 14.0% (8.2 to 21.8) *Sp: 97.0% (93.6 to 98.9)	NR
Radial Pulse Character Weak	McManus, 2005[86] High	R: intubation	341+ 32 (NR)	*Sen: 26.7% (16.1 to 39.7) *Sp: 95.4% (92.2 to 97.5)	NR
Radial Pulse Character Weak	McManus, 2005[86] High	M: mortality	340+ 32 (NR)	*Sen: 50.0% (24.7 to 75.4) *Sp: 93.8% (90.6 to 96.2)	NR
Capillary Refill Delayed	Holcomb, 2005b[70] Moderate	R: LSI	216 33 (17)	*Sen: 22.1% (13.4 to 33.0) *Sp: 98.4% (94.3 to 99.8)	NR

Measure Threshold	Author, Year Risk of Bias	Serious Injury Indicator Type: Indicator	Number analyzed Age Mean (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
PPG metric amplitude IQR	Chen, 2010[55] Moderate	R: blood transfusion with hemorrhagic injury	344 37 (15)	NR	0.64 (0.51 to 0.75)
PPG metric amplitude maximum-minimum	Chen, 2010[55] Moderate	R: blood transfusion with hemorrhagic injury	344 37 (15)	NR	0.57 (0.45 to 0.68)
PPG metric peak height maximum-minimum	Chen, 2010[55] Moderate	R: blood transfusion with hemorrhagic injury	344 37 (15)	NR	0.60 (0.48 to 0.71)
PPG metric peak height IQR	Chen, 2010[55] Moderate	R: blood transfusion with hemorrhagic injury	344 37 (15)	Sen: 54% (NR) Sp: 73% (NR)	0.65 (0.54 to 0.76)

AUROC = area under the receiver operating characteristic curve; C = composite; CI = confidence interval; DBP = diastolic blood pressure; HR = heart rate; ICU = intensive care unit; IQR = interquartile range; ISS = injury severity score; LSI = life-saving intervention; M = mortality; MAP = mean arterial pressure; NR = not reported; PP = pulse pressure (SBP-DBP); PPG = photoplethysmogram; pRBC = packed red blood cell; R = resource use; SD = standard deviation; Sen = sensitivity; Sp = specificity

Note: Similar measures are grouped between bold dividing lines.

*Results calculated by reviewers. +n varies by serious injury indicator in this study

Table 16. Predictive utility of other circulatory measures: emergency department

Measure	Author, Year Risk of Bias	Serious Injury Indicator Type: Indicator	Number Analyzed Age Mean (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
Diastolic Blood Pressure	Beekley, 2010[115] Moderate	R: LSI	147 27 (11)	NR	0.59 (0.51 to 0.67)
Diastolic Blood Pressure	Beekley, 2010[115] Moderate	R: massive transfusion	147 27 (11)	NR	0.70 (0.54 to 0.86)
Diastolic Blood Pressure	Paladino, 2010a[149] Moderate	C: major injury (blood transfusion, hemorrhage or ISS ≥16)	805 39 (range 13 to 95)	NR	0.49 (NR)

Measure	Author, Year Risk of Bias	Serious Injury Indicator Type: Indicator	Number Analyzed Age Mean (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
Mean Arterial Pressure (MAP)	Shoemaker, 2005[162] Low	M: mortality	185 32 (15) for survivors 39 (21) for non-survivors	NR	0.73 (NR)
Pulse Pressure (PP)	Reisner, 2016[159] Moderate	R: hemorrhagic injury requiring blood transfusion of ≥3 units pRBCs	487 Median 47 (IQR 31-64)	NR	0.68 (0.54 to 0.80)
Modified Shock Index ≥0.9 ≥1.1 ≥1.3	Kim, 2016[136] High	M: in-hospital mortality	45,880 Median 72 (IQR 68-78)	Sen: 75.8% (NR) Sp: 65.4% (NR) Sen: 55.9% (NR) Sp: 90.9% (NR) *Sen: 38.7% (34.5 to 42.9) *Sp: 97.8% (97.6 to 97.9)	0.788 (0.765 to 0.812) continuous model 0.682 (0.661 to 0.703) binary model at ≥1.3
Modified Shock Index continuous model ≥1.3 binary model	Kim, 2016[136] High	R: ED mortality	45,880 Median 72 (IQR 68-78)	NR	0.884 (0.853 to 0.915) continuous model 0.779 (0.744 to 0.814) binary model
Radial Pulse Character	Beekley, 2010[115] Moderate	R: LSI	147 27 (11)	NR	0.58 (0.50 to 0.66)
Radial Pulse Character	Beekley, 2010[115] Moderate	R: massive transfusion	147 27 (11)	NR	0.72 (0.57 to 0.87)
Minpulse ≤44 ≤54	Bruijns, 2013[116] Moderate	M: 48-hour mortality	69,367 Median 49 (IQR 32-67)	Sen: 30.9% (25.5 to 36.9) Sp: 94.9% (94.8 to 95.1) Sen: 43.0% (37.0 to 49.2) Sp: 90.0% (89.8 to 90.2)	0.77 (0.74 to 0.80)

Measure	Author, Year Risk of Bias	Serious Injury Indicator Type: Indicator	Number Analyzed Age Mean (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
Pulse Max Index ≥60 ≥70	Bruijns, 2013[116] Moderate	M: 48-hour mortality	69,367 Median 49 (IQR 32-67)	Sen: 46.0% (40.0 to 52.2) Sp: 90.0% (89.7 to 90.2) Sen: 34.0% (28.3-40.1) Sp: 95.0% (94.8-95.1)	0.77 (0.73 to 0.80)
Capillary Refill >2 seconds	Garner, 2001[61] Moderate	R: LSI	1,144 Median 33 (IQR 21-53)	Sen: 36.3% (NR) Sp: 93.2% (NR)	NR
Cardiac Index initial value data over first 4 hours	Shoemaker, 2005[162] Low	M: mortality	185 32 (15) for survivors 39 (21) for non-survivors	NR	0.61 (NR) 0.68 (NR)
PPG Algorithm used 30 PPG features	Mackenzie, 2015[84] Moderate	R: blood transfusion within 6 hours	135 39 (17)	Sen: 100% (NR) Sp: 70% (NR)	0.92 (NR)
PPG Algorithm used 30 PPG features	Mackenzie, 2015[84] Moderate	R: endotracheal intubation within 1 hour	135 39 (17)	NR	0.92 (NR)
PPG Algorithm used 30 PPG features	Mackenzie, 2015[84] Moderate	R: surgical intervention	135 39 (17)	NR	0.74 (NR)

AUROC = area under the receiver operating characteristic curve; CI = confidence interval; DBP = diastolic blood pressure; HR = heart rate; ICU = intensive care unit; IQR = interquartile range; LSI = life-saving intervention; M = mortality; MAP = mean arterial pressure; NR = not reported; PP = pulse pressure (SBP-DBP); PPG = photoplethysmogram; pRBC = packed red blood cell; R = resource use; SD = standard deviation; Sen = sensitivity; SI = shock index; Sp = specificity

Note: Similar measures are grouped between bold dividing lines.

*Results calculated by reviewers

Key Question 2: Measures of Respiratory Compromise

To summarize evidence to address Key Question 2, we included the results from 38 studies reported in 40 articles (Table 17). These studies evaluated six different measures of respiratory compromise. These measures are listed in Table 17 along with the corresponding citations and the detailed results are provided for each measure.

The focus of this section is RR. We identified enough studies with similar data that we were able to produce pooled estimates. The forest plots for the out-of-hospital RR data are provided in the next section in Figures 20, 21, and 22. Forest plots based on ED data are included in Appendix I. Tables are provided for oxygen saturation, which is measured in different ways; the

need for ventilatory support, which includes intubation, as well as studies that considered any form of airway support. We report studies of arterial blood pH, end tidal carbon dioxide, sublingual carbon dioxide, and respiratory effort in the last section.

Table 17. Measures of respiratory compromise (Key Question 2) evaluated by included studies

Measure Evaluated	Number of Studies (articles)†	References
Respiratory rate	20 (21 articles)	48,54,59,61,62,70,77,80-83,88,89,91,94,110,116,124,133,140,171
Oxygen saturation*	8	64,67,94,103,107,115,135,159
Airway support	7 (8 articles)	56,57,67,89,95,96,133,160
Arterial blood pH	4	112,115,156,157
End-tidal CO_2	2	119,168
Sublingual CO_2	2	113,114

CO2 = carbon dioxide

*Studies noted oxygen saturation with various abbreviations: SmO2, SpO2, StO2
†Five publications evaluated multiple measures67,89,94,115,133

Respiratory Rate

RR, like SBP, is part of the National Trauma Triage Protocol Step 1 criteria. In the current Field Triage Decision Scheme,[183] RR <10 or >29 breaths per minute is used as an indicator of the potential for serious injury and the need for higher-level trauma care. Breathing that is too slow or too fast may in and of itself be a change in function caused by serious trauma or an indication that the body is trying to compensate for underlying injuries.

We identified 20 studies that reported RR data (see Table 17). Six studies[48,62,70,80-82,140] were not included in the pooled analyses presented below, but the data were abstracted and are included in the evidence tables in Appendix D. These studies were not included in the pooled estimates because they used lower thresholds of RR ≥24[70] or RR ≥20,[80-82] used age-specific rates defined as abnormal,[140] reported change in rate[48] and did not provide raw data, or used a different indicator of serious injury, in this case, organ failure.[62] We repeated the meta-analyses including the studies with lower thresholds and organ failure and confirmed that the estimates were not affected enough to change our conclusions. We combined data on out-of-hospital RR from six studies and calculated a pooled sensitivity of 13 percent (95% CI 5 to 29, I^2=97.8%) and a pooled specificity of 96 percent (95% CI 83 to 99, I^2=99.6%) across all serious injury indicators.[77,83,88,89,91,171] Figures 20 and 21 provide the estimates stratified by type of serious injury indicator (resource use, injury type or severity, and composite indicators). Table 18 reports these values as well as the estimates from four studies using ED data. Plots for the ED analyses are included in Appendix I.

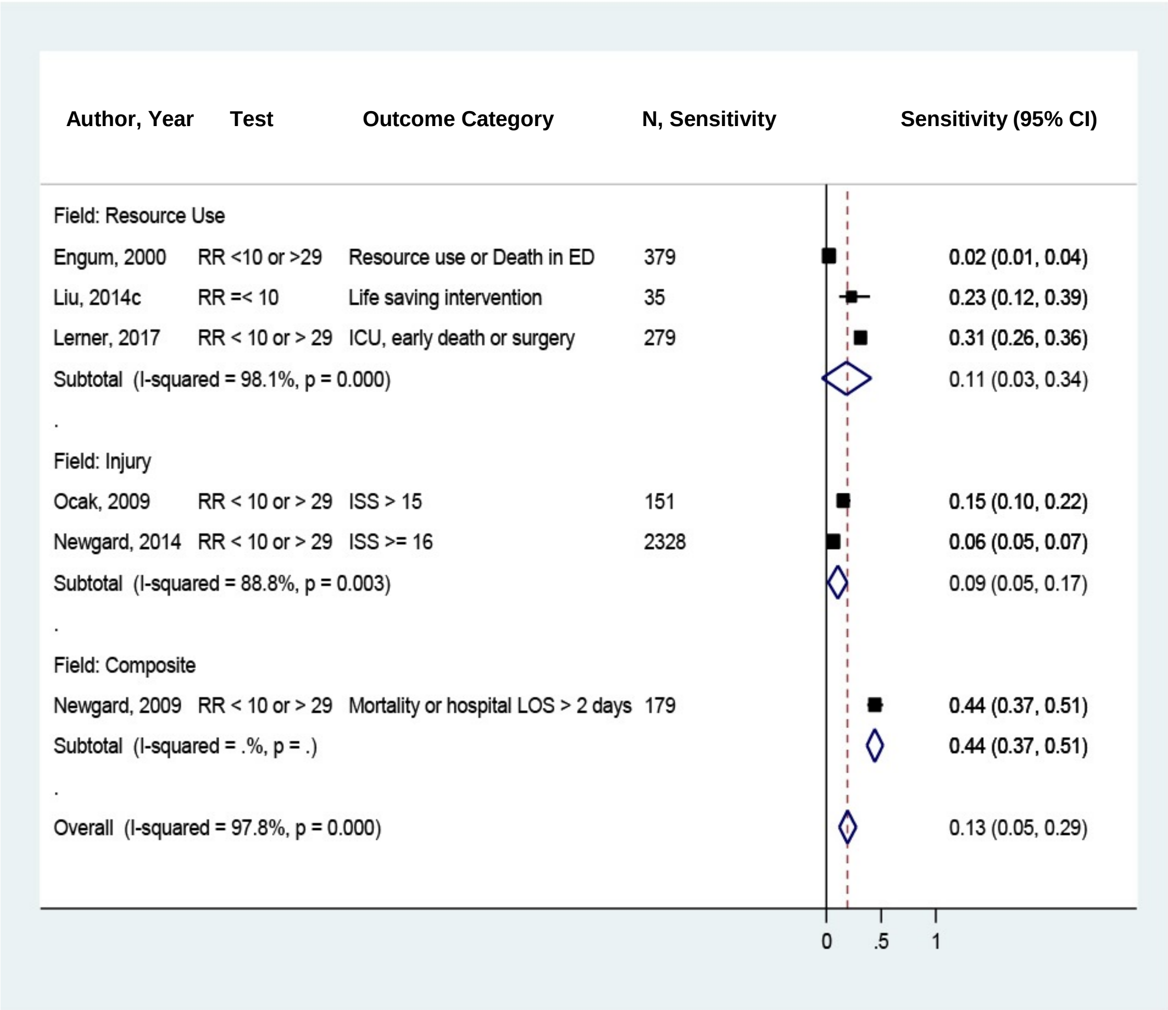
The pooled AUROC for out-of-hospital RR was 0.70 (95% CI 0.66 to 0.79, I^2=16.6%) based on three studies[54,59,94] (Figure 22) and 0.61 (95% CI 0.48 to 0.74, I^2=90.5%) for ED RR based on three different studies[61,110,116] (Appendix I).

Table 18. Pooled sensitivity and specificity for predictive utility of respiratory rate across all serious injury indicators

Measure, Setting	Number of Studies	Sensitivity (95% CI, I^2)	Specificity (95% CI, I^2)
RR <10 or >29 breaths per minute OH	6[77,83,88,89,91,171]	13% (5 to 29, 97.8%)	96% (83 to 99, 99.6%)
RR <10 or >29 breaths per minute ED	4[61,116,124,133]	27% (21 to 35, 95.2%)	95% (94 to 96, 93.5%)

CI = confidence interval; ED = emergency department; OH = out-of-hospital; RR = respiratory rate

Figure 20. Pooled sensitivity of out-of-hospital respiratory rate <10 or >29 breaths per

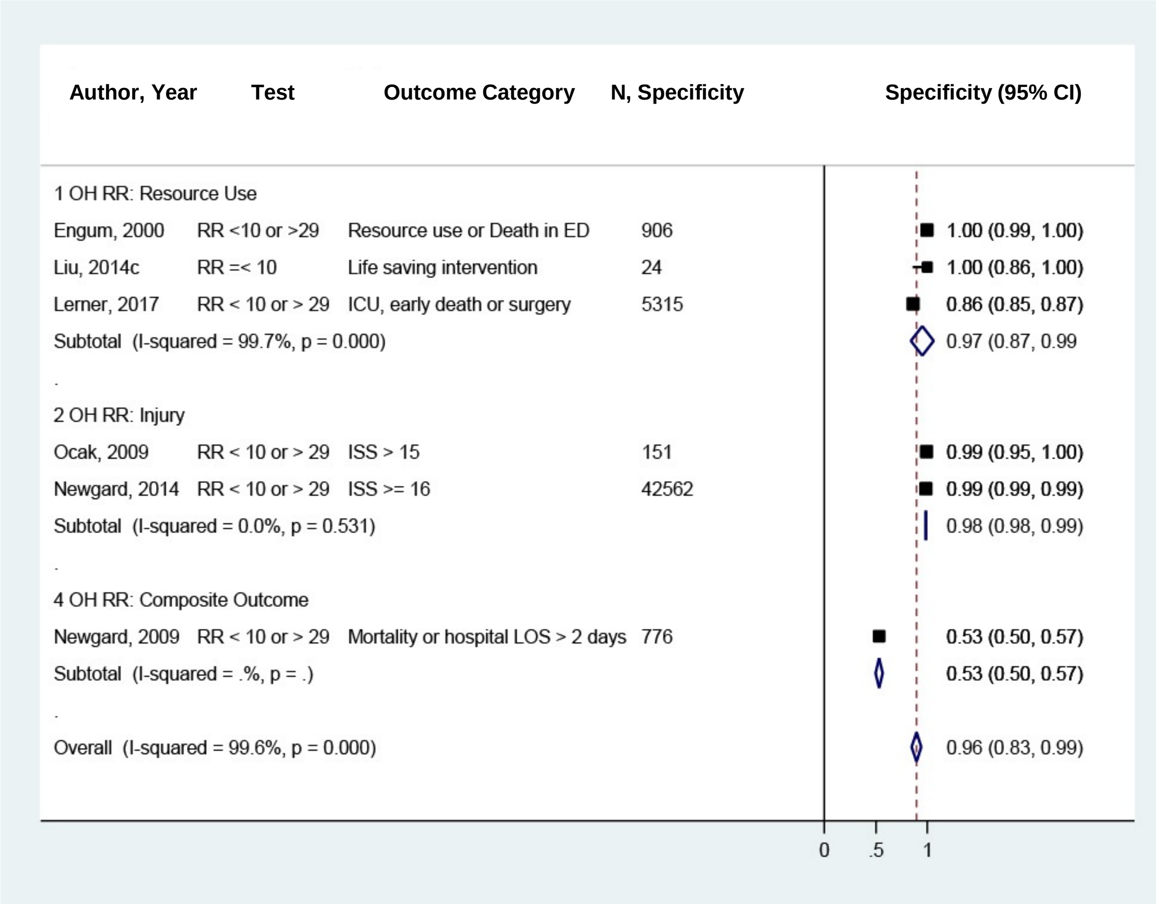


CI = confidence interval; ED = emergency department; ICU = intensive care unit; ISS = injury severity score; LOS = length of stay; N = number; OH = out-of-hospital; RR = respiratory rate.

Note: Liu, 2014c = Reference no. 83 in this report.

Note: Overall results are from the bivariate logistic mixed effects model analysis.

Figure 21. Pooled specificity of out-of-hospital respiratory rate <10 or >29 breaths per minute

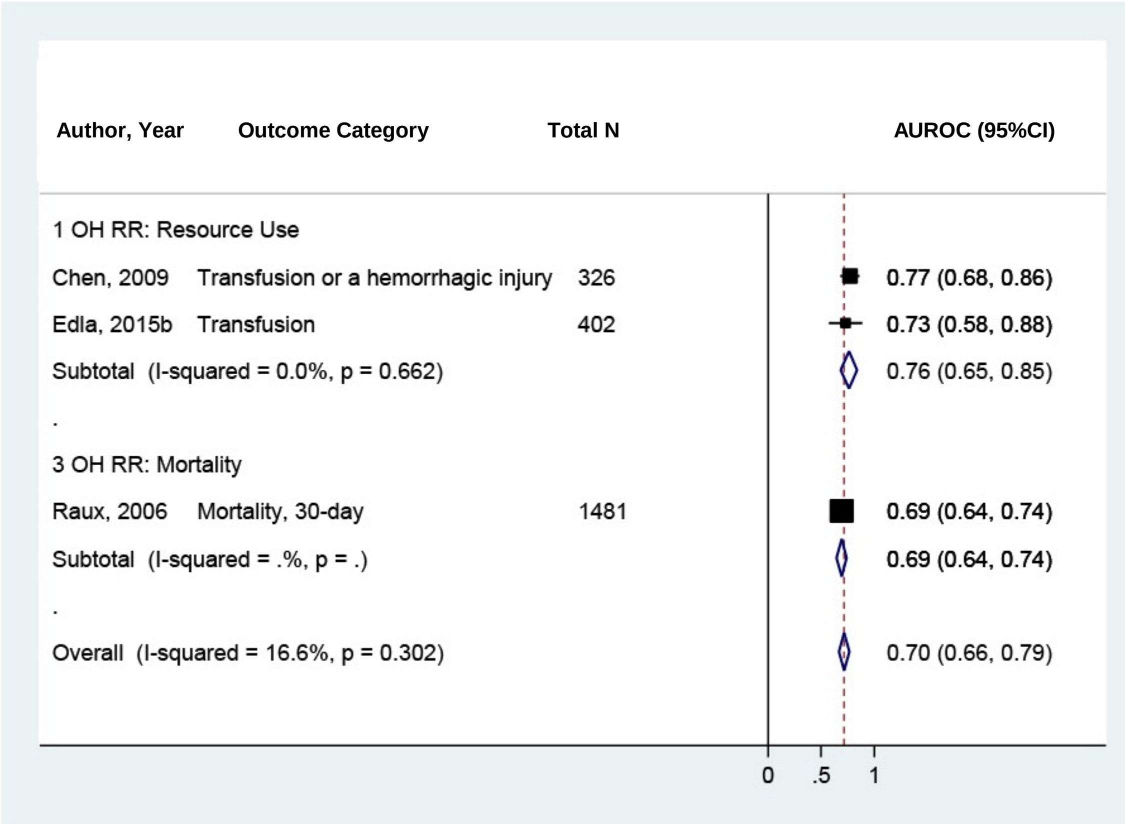


CI = confidence interval; ED = emergency department; ICU = intensive care unit; ISS = injury severity score; LOS = length of stay; N = number; OH = out-of-hospital; RR = respiratory rate.

Note: Liu, 2014c = Reference no. 83 in this report.

Note: Overall results are from the bivariate logistic mixed effects model analysis.

Figure 22. Pooled AUROC of out-of-hospital respiratory rate



AUROC = area under the receiver operating characteristic curve; CI = confidence interval; N = number; OH = out-of-hospital; RR = respiratory rate.

Note: Overall results are from the bivariate logistic mixed effects model analysis.

Oxygen Saturation

Various types of monitoring devices are now available to assess measures of arterial oxygen (SaO_2 and SpO_2) and measures of tissue oxygenation (StO_2 and SmO_2). These present an opportunity to add a direct measure to field triage and replace or supplement RR, which can be unreliable as it requires counting and calculation by the field provider and there is no standardized method, hence the result is prone to error. Measures of arterial oxygen have been standardized and estimates are often consistent.[94] As measuring oxygen saturation requires technology, most of the studies assessed the measure, the technology, and the utility of continuous versus point-in-time measurement.

Table 19 reports the results of five studies of SaO_2, SpO_2, or StO_2 collected in the field.[64,67,94,103,107] In all of these studies patients were either transported via helicopter or specialty ground transport and the monitors used were more complex than current standard EMS equipment.

Three of the studies were smaller, reflecting the fact that they employed technologies or monitors that are not widely used.[64,103,107] Another study consisted of two cohorts of patients treated using physician-staffed mobile intensive care units in the suburbs of Paris, France.[67] Finally, the largest study in this group was a subanalysis of a larger epidemiologic study of prehospital variables.[94]

The three studies conducted in EDs (Table 20) used measures of tissue oxygenation (StO_2 and SmO_2), which are intended to reflect tissue perfusion (how well tissues are getting oxygen versus how much is in the blood). One study used these measures in a U.S. military field hospital[115] and examined the utility of different threshold values as well as mean and minimum values. All three studies focused on the ability to predict hemorrhage and the need for transfusions.

Table 19. Predictive utility of oxygen saturation: out-of-hospital

Measure Threshold	Author, Year Risk of Bias	Serious Injury Indicator Type: Specific Indicator	Number Analyzed Age Mean (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
Oxygen Saturation SpO_2 <95%	Van Haren, 2014[103] Moderate	R: LSI	96 48 (19)	Sen: 13% (NR) Sp: 94% (NR)	0.530 (NR)
Oxygen Saturation StO_2 deoxygenation slope	Guyette, 2012[64] Moderate	R: LSI	150 47 (20)	NR	0.712 (NR)
Oxygen Saturation SpO_2 <90%	Hamada, 2014[67] Moderate	I: major trauma	825 37 (17)	Sen: 16% (NR) Sp: 94% (NR)	NR
Oxygen Saturation SpO_2	Raux, 2006[94] Moderate	M: mortality 30-day	1481 37 (18)	NR	0.747 (SE 0.022)
Oxygen Saturation Mean SpO_2, continuous	Woodford, 2012[107] Moderate	M: mortality	120 42 (NR)	Sen: 63% (NR) Sp: 85% (NR)	0.76 (0.56 to 0.96)
Oxygen Saturation SpO_2 <90%, manual	Woodford, 2012[107] Moderate	M: mortality	120 42 (NR)	Sen: 38% (NR) Sp: 99% (NR)	0.68 (0.47 to 0.89)
Oxygen Saturation Mean SpO_2 <90%, continuous	Woodford, 2012[107] Moderate	M: mortality	120 42 (NR)	Sen: 50% (NR) Sp: 96% (NR)	0.73 (0.53 to 0.94)
Oxygen Saturation SpO_2 readings <90% only, manual	Woodford, 2012[107] Moderate	M: mortality	120 42 (NR)	Sen: 38% (NR) Sp: 99% (NR)	0.59 (0.38 to 0.81)

AUROC = area under the receiver operating characteristic curve; CI = confidence interval; I = injury; LSI = life-saving intervention; M = mortality; NR = not reported; R = resource use; SD = standard deviation; SE = standard error; Sen = sensitivity; Sp = specificity; SpO_2 = peripheral oxygen saturation; StO_2 = tissue oxygen saturation

Table 20. Predictive utility of oxygen saturation: emergency department

Measure Threshold	Author, Year Risk of Bias	Serious Injury Indicator Type: Specific Indicator	Number Analyzed Age Mean (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
Oxygen Saturation Minimum StO_2 ≤75%	Beekley, 2010[115] Moderate	R: LSI	147 27 (11)	Sen: 61% (49 to 72) Sp: 65% (53 to 76)	NR
Oxygen Saturation Minimum StO_2 ≤75%	Beekley, 2010[115] Moderate	R: blood transfusion	147 27 (11)	Sen: 64% (48 to 78) Sp: 59% (49 to 69)	NR
Oxygen Saturation Minimum StO_2 ≤75%	Beekley, 2010[115] Moderate	R: massive transfusion	147 27 (11)	Sen: 90% (56 to 100) Sp: 55% (47 to 64)	NR
Oxygen Saturation Minimum StO_2 ≤78%	Beekley, 2010[115] Moderate	R: LSI or blood transfusion	147 27 (11)	Sen: 71% (NR) Sp: NR	NR
Oxygen Saturation Minimum StO_2 ≤78%	Beekley, 2010[115] Moderate	R: massive transfusion	147 27 (11)	Sen: 100% (NR) Sp: NR	NR
Oxygen Saturation Minimum StO_2 ≤80%	Beekley, 2010[115] Moderate	R: LSI	147 27 (11)	Sen: 75% (63 to 84) Sp: 47% (35 to 59)	NR
Oxygen Saturation Minimum StO_2 ≤80%	Beekley, 2010[115] Moderate	R: blood transfusion	147 27 (11)	Sen: 76% (61 to 88) Sp: 41% (31 to 51)	NR
Oxygen Saturation Minimum StO_2 ≤80%	Beekley, 2010[115] Moderate	R: massive transfusion	147 27 (11)	Sen: 100% (69 to 100) Sp: 39% (30 to 47)	NR
Oxygen Saturation Average StO_2 over 2 minutes following arrival	Beekley, 2010[115] Moderate	R: LSI	147 27 (11)	NR	0.61 (0.53 to 0.69)
Oxygen Saturation Average StO_2 over 2 minutes following arrival	Beekley, 2010[115] Moderate	R: blood transfusion	147 27 (11)	NR	0.64 (0.55 to 0.73)
Oxygen Saturation Minimum StO_2 during ED course	Beekley, 2010[115] Moderate	R: LSI	147 27 (11)	NR	0.67 (0.60 to 0.74)
Oxygen Saturation Minimum StO_2 during ED course	Beekley, 2010[115] Moderate	R: blood transfusion	147 27 (11)	NR	0.69 (0.61 to 0.77)
Oxygen Saturation StO_2 <65%	Khasawneh, 2014[135] Moderate	R: massive transfusion	325 46 (NR)	Sen: 25% (9 to 49) Sp: 94% (90 to 96)	NR

Measure Threshold	Author, Year Risk of Bias	Serious Injury Indicator Type: Specific Indicator	Number Analyzed Age Mean (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
Oxygen Saturation SmO_2	Reisner, 2016[159] Moderate	R: hemorrhagic injury requiring blood transfusion of ≥ 3 units pRBCs	487 Median 47 (IQR 31 to 64)	NR	0.76 (0.65 to 0.84)

AUROC = area under the receiver operating characteristic curve; CI = confidence interval; ED = emergency department; IQR = interquartile range; LSI = life-saving intervention; NR = not reported; pRBC = packed red blood cell; R = resource use; SD = standard deviation; Sen = sensitivity; SmO_2 = muscle oxygen saturation; Sp = specificity; StO_2 = tissue oxygen saturation

Airway/Ventilatory Support

A functional approach used in triage to assess respiration status is to categorize the patient as either needing or not needing airway or ventilatory support. This is part of the current trauma triage guideline,[183] which includes abnormal RR (>10 or <29 breaths per minute) or the need for this type of support as indicators of the need for higher-level trauma care. Support can include moving the head or jaw, bag-mask assisted ventilation, using devices that are introduced into the pharynx but not into the trachea (i.e., supraglottic airways), or intubation, which involves passing a tube through the glottis into the trachea. In extreme situations an incision may be made in the neck to bypass the upper respiratory tract and ensure air reaches the lungs.

We identified seven studies reported in eight articles with data on whether any type of airway support predicted serious injury.[56,57,67,89,95,96,133,160] In all of these studies, multiple measures were evaluated. Four studies (reported in 5 articles) used data collected in the field[56,67,89,95,96] (listed first in Table 21), and three were based on the status of the patient on arrival at the ED.[57,133,160] One study[89] was of adults over 55 years of age and one was of pediatric trauma patients.[57] Three studies compared patients who were intubated with those who were not,[56,57,133] while the others included any type of support[89] or did not provide specifics.[67,95,96,160]

Table 21. Predictive utility of airway support: out-of-hospital and upon ED arrival

Measure Setting	Author, Year Risk of Bias	Serious Injury Indicator Type: Indicator	Number Analyzed Age Mean (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
Mechanical ventilation OH	Raux, 2011[95]+ Moderate	R: emergency procedure	1,360 38 (17)	*Sen: 44.7% (41.0 to 48.6) *Sp: 61.1% (57.3 to 64.8)	NR
Airway support OH	Hamada, 2014[67] Moderate	I: ISS >15	825 37 (17)	Sen: 52% (NR) Sp: 88% (NR)	NR
Assisted ventilation OH	Newgard, 2014[89] Moderate	I: ISS ≥ 16	44,890 Median 77 (IQR 64 to 85)	*Sen: 7.9% (6.8 to 9.1) *Sp: 99.6% (99.5 to 99.7)	NR
Intubation status OH	Cooke, 2006a[56] High	M: mortality	30 39 (3)	*Sen: 53.3% (26.6 to 87.8) *Sp: 100.0% (78.2 to 100.0)	NR
Mechanical ventilation OH	Sartorius, 2010[96]+ Moderate	M: 30-day all-cause mortality	1,360 38 (17)	*Sen: 39.0% (35.0 to 43.2) *Sp: 96.5% (94.9 to 97.6)	NR

Measure Setting	Author, Year Risk of Bias	Serious Injury Indicator Type: Indicator	Number Analyzed Age Mean (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
Airway status **ED** Intubated, with or without chemical sedation	Courville, 2009[57] Low	M: in-hospital mortality	224,682 NR	*Sen: 55.3% (53.5 to 57.0) *Sp: 96.7% (96.6 to 96.8)	NR
Intubation status **ED**	Jones, 2014[133] Moderate	M: 30-day mortality	5,363 Median 33 (IQR 22 to 51)	*Sen: 56.6% (51.7 to 61.4) *Sp: 84.9% (83.9 to 85.9)	NR
Mechanical ventilation **ED**	Ryan, 2011b[160] Moderate	M: mortality	216 50 (1)	*Sen: 32.1% (15.9 to 52.4) *Sp: 95.2% (91.1 to 97.8)	NR

AUROC = area under the receiver operating characteristic curve; CI = confidence interval; ED = emergency department; I = injury type or severity; IQR = interquartile range; ISS = injury severity score; M = mortality; NR = not reported; OH = out-of-hospital; R = resource use; SD = standard deviation; Sen = sensitivity; Sp = specificity

*Results calculated by reviewers.
+Same study, different results reported in different articles

Other Respiratory Measures

Three other respiratory measures, arterial blood pH, end-tidal CO_2 ($ETCO_2$), and sublingual PCO_2 ($SLCO_2$) were also reported in the included studies. The primary findings from these studies are included in Table 22. All of these studies relied on data collected in EDs; we did not identify any studies that reported data collected out-of-hospital.

These measures are different ways of assessing levels of CO_2. CO_2 is a waste product of metabolism at the tissue level and is eliminated through the lungs. $ETCO_2$ measures the partial pressure of carbon dioxide in the exhaled breath of patients and correlates with the arterial CO_2 pressure. A low $ETCO_2$ can reflect decreased tissue perfusion and reduced removal of waste (i.e., CO_2). $ETCO_2$ however is also affected by respiratory rate and a low pressure can be due to an increased RR. $ETCO_2$ monitoring is routinely used in confirming intubation, ventilation, and efficacy of chest compressions during cardiopulmonary resuscitation. In these studies, $ETCO_2$ was measured in nonintubated patients, using nasal cannulas to explore the predictive utility of $ETCO_2$ for identifying high-risk patients.

Tissue CO_2 levels rise in the setting of perfusion failure and impaired oxygen delivery, mirroring the increase in arterial lactate, and where bicarbonate buffering of acids produced through anaerobic metabolism results in higher CO_2 concentration within the tissues.[184] Tissue CO_2 can be measured using sublingual capnometry as $SLCO_2$, with a capnometry sensor placed under the patient's tongue to measure the pressure of regional tissue CO_2.

Abnormal values for $ETCO_2$ are low (lower than 30 mmHg in the included studies) while abnormal $SLCO_2$ values are high (over 45 and 62 mmHg in the included studies).

Arterial blood pH is measured from a blood sample drawn from an artery. Abnormal arterial blood pH can be either high or low, though in trauma it is usually low. In trauma, some causes of low pH include metabolic acidosis in states of hypoperfusion and/or respiratory acidosis from

hypoventilation which may be due to obstruction, impaired respiratory drive, or chest or lung injury. Studies of arterial blood pH focused on pH below 7.3.

The four studies that included data on arterial blood pH reported this in the course of conducting studies on lactate,[112,157] comparing blood analysis to noninvasive near-infrared spectroscopy,[115] or creating a risk stratification score for massive blood transfusion.[156] One of these studies was limited to pediatric trauma patients.[157]

Both studies of $ETCO_2$ had moderate samples sizes (n=105 and n=170), but the authors highlighted statistical power issues and the need for additional research.[119,168] These two studies concluded that abnormal $ETCO_2$ can help predict which patients have a major injury or need procedures, but normal levels cannot be used to rule out serious injury.

The two identified studies of $SLCO_2$ were conducted by the same researchers and the studies evaluated whether this measure could predict blood loss, ICU stays, and mortality.[113,114] While $SLCO_2$ was limited in its ability to predict resource use, it was equivalent to base deficit and lactate in predicting mortality, and it has the advantage of being noninvasive.[113,114]

Table 22. Predictive utility of other respiratory measures: emergency department

Measure Threshold	Author, Year Risk of Bias	Serious Injury Indicator Type: Indicator	Number Analyzed Age Mean (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
Arterial blood pH	Beekley, 2010[115] Moderate	R: LSI	147 27 (11)	NR	0.68 (0.60 to 0.76)
Arterial blood pH	Beekley, 2010[115] Moderate	R: blood transfusion	147 27 (11)	NR	0.70 (0.61 to 0.79)
Arterial blood pH	Beekley, 2010[115] Moderate	R: massive transfusion	147 27 (11)	NR	0.75 (0.59 to 0.91)
Arterial blood pH <7.33	Rainer, 2011[156] Moderate	R: massive transfusion	1,891 44 (19)	*Sen: 35.9% (26.1 to 46.5) *Sp: 95.2% (94.1 to 96.1)	NR
Arterial blood pH <7.30	Ramanathan, 2015[157] Low	I: ISS >15	236 9 (5)	Sen: 56.8% (41.0 to 71.6) Sp: 94.3% (89.9 to 97.2)	NR
Arterial blood pH ≤7.3	Aslar, 2004[112] Moderate	M: 30-day in-hospital mortality	64 36 (19)	*Sen: 72.0% (50.6 to 87.9) *Sp: 84.6% (69.5 to 94.4)	NR
$ETCO_2$ ≤30 mmHg	Williams, 2016[168] Moderate	R: invasive procedure	170 43 (NR)	*Sen: 47.2% (30.4 to 64.5) *Sp: 69.4% (60.9 to 77.1)	NR
$ETCO_2$ ≤30 mmHg	Williams, 2016[168] Moderate	R: blood transfusion	170 43 (NR)	*Sen: 62.5% (24.5 to 91.5) *Sp: 67.3% (59.5 to 74.4)	NR
$ETCO_2$ ≤30 mmHg	Williams, 2016[168] Moderate	R: ICU or admission	170 43 (NR)	*Sen: 63.6% (40.7 to 82.8) *Sp: 70.3% (62.2 to 77.5)	NR
$ETCO_2$ ≤30 mmHg	Williams, 2016[168] Moderate	R: severe injury composite	170 43 (NR)	*Sen: 52.7% (38.8 to 66.4) *Sp: 74.8% (65.8 to 82.4)	NR
$ETCO_2$ <35 mmHg	Caputo, 2012[119] Moderate	R: operative intervention	105 26 (NR)	*Sen: 82.0% (70.0 to 90.6) *Sp: 81.8% (67.3 to 91.8)	NR

Measure Threshold	Author, Year Risk of Bias	Serious Injury Indicator Type: Indicator	Number Analyzed Age Mean (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
$ETCO_2$ <35 mmHg	Caputo, 2012[119] Moderate	R: massive transfusion	105 26 (NR)	*Sen: 97.2% (85.5 to 99.9) *Sp: 66.7% (54.3 to 77.6)	NR
$SLCO_2$ >45 mmHg	Baron, 2004[113] Moderate	R: blood loss	108 28 (11)	Sen: 90% (79 to 96) Sp: 45% (31 to 60)	0.74 (0.65 to 0.84)
$SLCO_2$	Baron, 2007[114] Moderate	R: blood transfusion	86 35 (17)	NR	0.64 (0.49 to 0.79)
$SLCO_2$	Baron, 2007[114] Moderate	R: ICU stay	86 35 (17)	NR	0.71 (0.58 to 0.84)
$SLCO_2$ >62 mmHg	Baron, 2007[114] Moderate	M: mortality	86 35 (17)	Sen: 75% Sp: 86%	0.82 (0.70 to 0.96)

AUROC = area under the receiver operating characteristic curve; CI = confidence interval; ETCO2 = end-tidal carbon dioxide; I = injury type or severity; ICU = intensive care unit; ISS = injury severity score; LSI = life-saving intervention; M = mortality; NR = not reported; OR = operating room; R = resource use; SD = standard deviation; Sen = sensitivity; SLCO2 = sublingual partial pressure of carbon dioxide; Sp = specificity

*Results calculated by reviewers

Key Question 3: Combination Measures

The third Key Question for this review concerns the predictive utility of measures created by combining several variables. Measures in this section include formal scores, triage protocols for routine use, combat settings or mass casualty incidents, and various combinations of variables chosen with different methods such as clinical significance or predictive ability. Utilizing measures in combination may provide more information than a single measure, resulting in better assessment and triage performance. The core question, however, is whether the resources (i.e., time, expertise, or equipment) needed to obtain and use combination measures produces a corresponding benefit. In this case, the desired benefit is an improvement in the ability to identify patients at risk of serious injury.

We included studies of any combination measure that combined two or more relevant variables as long at least one was a measure of circulatory or respiratory compromise (Table 23). We prioritized combinations that combined a measure of the patient’s level of consciousness, determined by the Glasgow Coma Scale (GCS), with physiologic measures. These combinations are listed and discussed first, after which, in the second part of this section, we present the combinations that do not include GCS or a measure of consciousness. We provided more limited information in the text on combinations that add additional factors such as mechanism of injury, and instead included more information and results from these studies in the evidence tables in Appendix D.

Many of the formal scores and triage protocols are commonly referred to by their acronyms, and their constituent measures and scoring are not always specified in the research. We aggregated this information in Table 23, in alphabetic order for reference.

Table 23. Information on combination measures identified in the review

Name **(Full Name)** **Primary Use**	**Components**	**Scoring**
APACHE II[185] (Acute Physiology and Chronic Health Evaluation (revised)) Severity assessment and risk adjustment in intensive care	Temperature MAP HR RR Oxygenation Arterial pH Lab tests (commonly obtained) GCS Severe chronic health problems Age	Range: 0-71 Direction: higher score=greater risk Common threshold: not specified Scoring: 12 components scored 0-4 points Age ≥45 years scored 2-6 points; increases in points at every 10-year increment Severe chronic health problems scored 2 or 5 points
CareFlight Triage[61] Mass Casualty Incident triage	Mental status Radial pulse As evaluated: GCS SBP	Stratification: Immediate, Urgent, Delayed, Unsalvageable Algorithm Walks Obeys commands Breathes with open airway Palpable radial pulse As evaluated Garner 2001[61]: SBP <80 = no palpable radial pulse; GCS motor component <6 = unable to follow commands Vassallo 2017[167]: SBP <90 = no palpable radial pulse; GCS <13 = unable to follow commands
CRAMS[186] (Circulation, Respiration, Abdomen, Motor, Speech) Trauma triage	Capillary refill and SBP Respirations Abdomen and thorax Motor response Speech response (Capillary refill and SBP are scored as a single component)	Range: 0-10 Direction: lower score=more severe trauma Common threshold: major trauma = ≤8 Scoring: 5 components, each scored as 0 (severely abnormal), 1 (mildly abnormal), or 2 (normal)
EMTRAS[187] (Emergency Trauma Score) Mortality risk prediction	Age GCS Base deficit Prothrombin time	Range: 0-12 Direction: higher score=higher risk of death Common threshold: high risk = ≥5 Scoring: 4 components each scored 0-3 Age (years): <40 = 0, 40-60 = 1, 61-75 = 2, >75 = 3 GCS score: 13-15 = 0, 10-12 = 1, 6-9 = 2, 3-5 = 3 Base deficit (mmol/L): >-1 = 0, -1 to -5 = 1, -5.1 to -10 = 2, <-10 = 3 Prothrombin time (% normal): >80 =0, 80-50 = 1, 49-20 = 2, <20 = 3
FTS_{07}[118] (Field Triage Score, revised) Battlefield triage	SBP GCS	Range: 0-2 Direction: higher score=higher risk of death Common threshold: not specified Scoring: 2 components scored 0 points for abnormal and 1 point for normal SBP: abnormal <100 mmHg GCS: abnormal <8

Name (Full Name) Primary Use	Components	Scoring
GAP[138] (GCS, age, pressure) Assess trauma patients/predict mortality	GCS Age SBP	Range: 3-24 Direction: higher score=lower risk of death Common thresholds: high risk = 3-10 points; moderate risk = 11-18 points; low risk = 19-24 points Scoring: GCS: actual value = 3-15 points Age: <60 years = 3 points SBP (mmHg): >120 = 6 points; 60-120 = 4 points
MGAP[96] (Mechanism, GCS, age, pressure) Assess trauma patients/predict mortality	GCS Age SBP Mechanism of injury	Range: 3-29 Direction: higher score=lower risk of death Common thresholds: high risk = 3-17 points; intermediate risk = 18-22 points; low risk = 23-29 points Scoring: Mechanism: blunt = 4 points; penetrating = 0 points GCS score: actual value = 3-15 points Age: <60 years = 5 points; ≥60 years = 0 points SBP (mmHg): >120 = 5 points; 60-120 = 3 points; <60 = 0
Military Triage Sieve[71] Military trauma triage	Respiration RR HR Level of consciousness As evaluated: GCS	Stratification: Priority 1, 2 or 3; Dead Algorithm: Walking Breathing RR (breaths/min): <10 or >29 vs. 10-29 HR (bpm): >120 vs. ≤120 Unconscious As evaluated: Horne, 2013[71], Vassallo, 2017[167]: GCS <13 = unconscious
MPTT[167] (Modified Physiological Triage Tool) Mass Casualty Incident triage	RR HR GCS	Stratification: Priority 1, 2 or 3; Dead Algorithm: Walking Breathing RR (breaths/min): <12 or >22 HR ≥100 bpm GCS <14
PHI[188] (Prehospital Index) Trauma triage/severity score	SBP HR Respirations Level of consciousness Mechanism (penetrating)	Range: 0-24 Direction: higher score=more severe trauma Common threshold: major trauma = 4-24 Scoring: SBP (mmHg): >100 = 0; 86-100 = 1; 75-85 = 2; 0-74 = 5 HR (bpm): ≥120 = 3; 51-119 = 0; <50 = 5 Respirations: normal = 0; labored/shallow = 3; RR <10 or needs intubation = 5 Consciousness: normal = 0; confused/combative = 3; no intelligible words = 5 Penetrating abdominal or chest injuries = 4

Name **(Full Name)** **Primary Use**	**Components**	**Scoring**
PTS[189] (Pediatric Trauma Score) Pediatric trauma triage	Weight Airway SBP Level of consciousness Open wound Skeletal (fractures)	Range: -6 to 12 Direction: lower score=higher mortality risk Common threshold: high risk of death = ≤8 Scoring: 6 components scored -1, +1 or +2 points Weight (kg): ≥20 = +2; 10-20 = +1; <10 = -1 Airway: normal = +2; maintainable = +1; unmaintainable = -1 SBP (mmHg): ≤90 = +2; 50-90 = +1; <50 = -1 Level of consciousness: awake = +2; obtunded/loss of consciousness = +1; coma/decerebrate = -1 Open wound: none = +2; minor = +1; major/penetrating = -1 Skeletal: none = +2; closed fracture = +1; open/multiple fractures = -1
REMS[190] mREMS[142] (Rapid Emergency Medicine Score) (modified Rapid Emergency Medicine Score) Severity assessment REMS non-surgical mREMS trauma	Age MAP or SBP HR RR Oxygen saturation GCS (REMS uses MAP, mREMS uses SBP)	Range: 0-26 Direction: higher score=more severe trauma Common threshold: not specified Scoring: GCS scored 0-6 points and other 5 components scored 0-4 points Age (years): ≤44 = 0; 45-64 = 1; 65-74 = 3; >74 = 4 *MAP (mmHg): 70-109 = 0; 50-69 or 110-129 = 2; 130-159 = 3; <49 or >159 = 4 HR (bpm): 70-109 = 0; 55-69 or 110-139 = 2; 40-54 or 140-179 = 3; ≤39 or >179 = 4 RR (breaths/min): 12-24 = 0; 10-11 or 25-34 = 1; 6-9 = 2; 35-49 = 3; ≤5 or >49 = 4 Oxygen saturation (%): >89 = 0; 86-89 = 1; 75-85 = 3; <75 = 4 GCS: 14-15 = 0; 8-13 = 2; 5-7 = 5; 3-4 = 6 *Modified REMS uses SBP instead of MAP SBP (mmHg): 110-159 = 0; 90-109 or 160-199 = 1; 80-89 or ≥200 = 2; ≤79 = 4
RTS[191] T-RTS[191] (Revised Trauma Score) (Revised Trauma Score for Triage) Trauma triage	GCS SBP RR	RTS Range: 0-7.84 Direction: lower score=more severely injured Common thresholds: severe injury = <6 or <7.5 Scoring: 3 components assigned coded value GCS: 13-15 = 4, 9-12 = 3, 6-8 = 2, 4-5 = 1, 3 = 0 SBP (mmHg): >89 = 4, 76-89 = 3, 50-75 = 2, 1-49 = 1, 0 = 0 RR (breaths/min): 10-29 = 4, >29 = 3, 6-9 = 2, 1-5 = 1, 0 = 0 Score calculated using coded values: RTS = 0.9368 GCS_c + 0.7326 SBP_c + 0.2908 RR_c T-RTS Range: 0-12 Direction: lower score=more severely injured Common thresholds: severe injury = <12 or <8 Scoring: Same components and coded values as in RTS T-RTS = sum of coded values (not weighted)

Name (Full Name) Primary Use	Components	Scoring
SETS[169] (Simplified Emergency Trauma Score) Trauma triage and injury severity rating	Age GCS RR Mechanism of injury	Range: 0 – 100 Direction: higher score=more severe injury Common thresholds: injury rated as low = 0-60; moderate = 61-80; or severe = >80 Scoring: Score = [age - 7(GCS) - RR + 31(ACS Injury) + 180]/3 Uses actual values for RR and GCS, with mechanism of injury scored 0 (absent) or 1 (present) Mechanism of injury based on American College of Surgeons (ACS) list
START[129] **Modified START**[61,192] (Simple Triage and Rapid Treatment) (Modified Simple Triage and Rapid Treatment) Mass Casualty Incident triage	Respirations RR Capillary refill or radial pulse* Mental status START uses capillary refill, modified START uses radial pulse	Stratification: Immediate, Delayed, Unsalvageable Algorithm: Walking Respirations present RR (breaths/min) ≥ 30 or <30 *Capillary refill >2 seconds Follows simple commands *Modified START uses presence of radial pulse instead of capillary refill As evaluated: Garner, 2001[61]: SBP <80 mmHg = no palpable radial pulse; GCS motor component ≤5 =unable to follow commands Gebhart, 2007[193]: GCS ≤14 = unable to follow commands
T-ASPTS[175] (Triage Age-Specific Pediatric Trauma Score) Pediatric trauma triage	GCS SBP HR RR	Range: 0-12 Direction: lower score = more severe injury Common threshold: severe injury = <10 Scoring: SBP, HR and RR scored using age-specific ranges (not specified) GCS: 3 = 0; 4-9 = 1; 10-13 = 2; 14-15 =3 SBP: severe hypotension = 1; mild to moderate hypotension = 2; normal = 3 HR: 0 = 0; bradycardia = 1; tachycardia = 2; normal = 3 RR: intubated = 0; hypoventilation = 1; tachypnea = 2; normal = 3
Triage Sieve[61] Mass Casualty Incident Triage	RR Capillary refill or HR	Stratification: Priority 1, 2 or 3; Dead Algorithm: Walking Breathing RR (breaths/min): <10 or >29 vs. 10-29 Capillary refill: >2 vs. <2 seconds (in cold conditions or poor lighting use HR >120 vs. ≤120 bpm instead of capillary refill)

Name (Full Name) **Primary Use**	**Components**	**Scoring**
ViEWS[194] ViEWS-L[195] (VitalPAC Early Warning Score) (modified VitalPAC Early Warning Score with rapid lactate level) Trauma triage/patient deterioration detection	HR RR SBP Oxygen saturation Temperature Supplemental oxygen Level of consciousness Lactate- -Lactate in ViEWS-L score only	<u>ViEWS</u> Range: 0-21 Direction: higher score=higher risk of death Scoring: 7 components each scored 0-3 points HR (bpm): 51-90 = 0; 41-50 or 91-110 = 1; ≤40 or 111-130 = 2; ≥131 = 3 RR (breaths/min): 12-20 = 0; 9-11 = 1; 21-24 = 2; ≤8 or ≥25 = 3 Temperature (Celsius): 36.1-38.0 = 0; 35.1-36.0 or 38.1-39.0 =1; ≥39.1 = 2; ≤35.0 = 3 SBP (mmHg): ≤111-249 – 0; 101-110 or >250 = 1; 91-100 = 2; ≤90 = 3 Oxygen saturation (%): ≥96 = 0; 94-95 = 1; 92-93 = 2; ≤91 = 3 Supplemental oxygen = 3 Level of consciousness: alert = 0; responds only to voice or pain, or unresponsive = 3 <u>ViEWS-L</u> Adds lactate level to ViEWS score Score = ViEWS score plus lactate level (mmol/L)

APACHE II = Acute Physiology and Chronic Health Evaluation (revised); CRAMS = Circulation, Respiration, Abdomen, Motor, Speech; EMTRAS = Emergency Trauma Score; FTS07 = Field Triage Score (revised); GAP = Glasgow Coma Scale, age, pressure; GCS = Glasgow Coma Scale; HR = heart rate; MAP = mean arterial pressure; MGAP = Mechanism, Glasgow Coma Scale, age, pressure; MPTT = Modified Physiological Triage Tool; mREMS = modified Rapid Emergency Medicine Score; PHI = Prehospital Index; PTS = Pediatric Trauma Score; REMS = Rapid Emergency Medicine Score; RR = respiratory rate; RTS = Revised Trauma Score; SBP = systolic blood pressure; SETS = Simplified Emergency Trauma Score; START = Simple Triage and Rapid Treatment; T-ASPTS = Triage Age-Specific Pediatric Trauma Score; T-RTS = Revised Trauma Score for Triage; ViEWS = VitalPAC Early Warning Score; ViEWS-L = modified VitalPAC Early Warning Score with rapid lactate level

Combinations of Physiologic Measures and Glasgow Coma Scale

Table 24 lists the combination measures identified that include GCS. This table is split into four sections by bold lines. The first section includes the Revised Trauma Score (RTS) and variations designed to be easier to calculate or for use with pediatric patients. The next section below the bold line lists studies of different combinations that are similar to the RTS in that they combine GCS with physiologic measures; which physiology measures are used and how they are combined differ. The third section of the table lists studies that add mechanism or type of injury to the physiologic measures and GCS. The fourth and final sections list studies that evaluate triage protocols, which are the consideration of several measures following a prescribed order or algorithm.

Table 24. Studies that evaluate the predictive utility of combination measures (Key Question 3)

Measure Evaluated	Number of Studies (articles)	References
Revised Trauma Score (RTS)	9 studies (10 articles)	62,95,96,107,109,118,138,142,150,169
Triage RTS	8 studies (9 articles)	95,96,110,112,130,131,133,138,175
Triage Age-Specific Pediatric Trauma Score (ASPTS) Includes SBP, RR, HR, and GCS	1	175
Pediatric Trauma Score (PTS) Includes patient size, airway status, SBP, level of consciousness, open wound, or fracture	1	140
GAP	3	109,138,155
Rapid Emergency Medicine Score (REMS) Consists of GCS, RR, oxygen saturation, MAP, and age Modified REMS (SBP replaces MAP, and different weights placed on GCS and age)	2	131,142
Gglasgow Coma Scale (GCS) and Heart Rate Complexity (HRC)	3 (4 articles)	40,49,81,82
GCS, HRC and HR/vital signs	1 (2 articles)	17,81
GCS and vital signs	2 (3 articles)	17,81,82
GCS and HR	2 (3 articles)	81,82,173
Model (author-derived) using lactate, GCS, HR and SBP	1	63
GCS and manual, semi-automated and automated vital signs **GCS and SBP**	1	70
MGAP	5 (6 articles)	95,96,109,138,142,155
Other measures including mechanism: • SETS (uses GCS, RR, mechanism of injury, and age • Model (author-derived) using GCS, RR, SBP, and anatomic and mechanism criteria • Model (author-derived) using age, chest injury, GCS, and SBP)	3	58,169
APACHE II	1	112
CareFlight triage	2	61,167
EMTRAS	1	134
START triage **Modified START triage** (palpable radial pulse replaces capillary refill)	3	61,129,167
ViEWS (includes SBP, HR, RR, temperature, SpO_2, supplemental O_2, level of consciousness) **ViEWS-L** (ViEWS with lactate)	1	132

Measure Evaluated	Number of Studies (articles)	References
Military Sieve, Modified Military Sieve, Triage Sort	3	71,166,167
Modified Physiological Triage Tool (MPTT)	1	167
Prehospital Index (PHI)	2	43,102
NTTP	3	46,66,91
Current triage criteria: initial out-of-hospital physiologic measures (GCS, SBP, RR, HR, SI) with different combinations of values	2	89,90
Alternative triage guidelines (GCS ≤14; SBP ≤110 or ≥200; RR <10 or >29; HR ≤60 or ≥110)	1	90

APACHE II = Acute Physiology and Chronic Health Evaluation (revised); ASPTS = Age-Specific Pediatric Trauma Score; EMTRAS = Emergency Trauma Score; GAP = Glasgow Coma Scale, age, pressure; GCS = Glasgow Coma Scale; HR = heart rate; HRC = heart rate complexity; MAP = mean arterial pressure; MGAP = Mechanism, Glasgow Coma Scale, age, pressure; MPTT = Modified Physiological Triage Tool; NTTP = national trauma triage protocol; O2 = oxygen; PHI = Prehospital Index; PTS = Pediatric Trauma Score; REMS = Rapid Emergency Medicine Score; RR = respiratory rate; RTS = Revised Trauma Score; SBP = systolic blood pressure; SETS = Simplified Emergency Trauma Score; SI = shock index; SpO2 = peripheral oxygen saturation; START = Simple Triage and Rapid Treatment; ViEWS = VitalPAC Early Warning Score; ViEWS-L = modified VitalPAC Early Warning Score with rapid lactate level

Note: Similar measures are grouped between bold dividing lines.

Revised Trauma Score and Variations

Tables 25 and 26 report the results of the studies that evaluate the RTS as well as the triage RTS (T-RTS) listed in Table 24 for out-of-hospital and ED data. The two studies of variations developed to assess pediatric patients are reported in the section on subquestions about age groups.[140,175]

The RTS is a combination of SBP, RR, and GCS using coded values 0 to 4 assigned to ranges for each measure. The score is calculated as the weighted sum of these values: RTS = 0.9368 GCS_c + 0.7326 SBP_c + 0.2908 RR_c, where subscript c indicates the coded value. This formula combines the three measures in a way that increases its prognostic accuracy but makes it difficult to calculate, requiring the use of a computer, smart phone, or monitor/medical device. The T-RTS is a simple sum of the coded values designed for use in triage.

The included studies often use RTS as reference or comparison for other measures and report AUROC values more frequently than sensitivity or specificity for specific threshold values. In the studies that compared the two versions, the differences were small (e.g., AUROC decreasing from 0.90 for the RTS to 0.88 for the T-RTS[96] or from 0.75 to 0.74).[95] The plot for the ED analysis is in Appendix I.[95,109,110,131,138,142,169]

Table 25. Predictive utility of Revised Trauma Score and Triage Revised Trauma Score: out-of-hospital

Author, Year Risk of Bias	Measure Threshold	Serious Injury Indicator Type: Specific Indicator	Number Analyzed Age Mean (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
Raux, 2011[95] Moderate	**RTS** Lyon cohort	R: ICU LOS >2 days	1,003 39 (18)	NR	0.83 (0.81 to 0.86)
Raux, 2011[95] Moderate	**RTS** National cohort	R: emergency procedure	1,360 38 (17)	NR	0.51 (0.48 to 0.54)
Raux, 2011[95] Moderate	**RTS** National cohort	R: massive hemorrhage	1,360 38 (17)	NR	0.72 (0.69 to 0.73)
Grimme, 2005[62] Moderate	**RTS**	I: organ failure	6,346 33 (range 16 to 81)	NR	0.633 (NR)
Raux, 2011[95] Moderate	**RTS** National cohort	I: severe trauma (ISS >15)	1,360 38 (17)	NR	0.75 (0.73 to 0.78)
Miller, 2017 [142] Moderate	**RTS**	M: in-hospital mortality	429,711 50 (23)	NR	0.959 (0.955 to 0.964)
Raux, 2011[95] Sartorius, 2010[96] Moderate	**RTS** <7.5 National cohort	M: mortality	1,360 38 (17)	Sen: 95% (92 to 97) Sp: 38% (35 to 41)	0.90 (0.88 to 0.92)
Raux, 2017[95] Moderate	**RTS**	M: 30-day all-cause mortality	1,075 39 (18)	NR	0.89 (0.85 to 0.92)
Raux, 2011[95] Moderate	**T-RTS** Lyon cohort	R: ICU LOS >2 days	1,003 39 (18)	NR	0.83 (0.81 to 0.86)
Raux, 2011[95] Moderate	**T-RTS** National cohort	R: massive hemorrhage	1,360 38 (17)	NR	0.73 (0.70 to 0.77)
Raux, 2011[95] Moderate	**T-RTS** National cohort	R: emergency procedure	1,360 38 (17)	NR	0.52 (0.49 to 0.54)
Raux, 2011[95] Moderate	**T-RTS** National cohort	I: severe trauma (ISS >15)	1,360 38 (17)	NR	0.74 (0.71 to 0.76)
Raux, 2011[95] Sartorius, 2010[96] Moderate	**T-RTS** <12 National cohort	M: mortality	1,360 38 (17)	Sen: 96% (93 to 98) Sp: 42% (39 to 45)	0.88 (0.86 to 0.92)

AUROC = area under the receiver operating characteristic curve; CI = confidence interval; I = injury; ICU = intensive care unit; ISS = injury severity score; LOS = length of stay; LSI = life-saving intervention; M = mortality; NR = not reported; R = resource use; RTS = Revised Trauma Score; SD = standard deviation; Sen = sensitivity; Sp = specificity; T-RTS = Revised Trauma Score for Triage

Table 26. Predictive utility of Revised Trauma Score and Triage Revised Trauma Score: emergency department

Author, Year Risk of Bias	Measure Threshold	Serious Injury Indicator Type: Indicator	Number Analyzed Age Mean (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
Woodford, 2012 [107] Moderate	**RTS**	M: mortality	120 42 (range 18 to 82)	Sen: 63% (NR) Sp: 83% (NR)	0.73 (0.53 to 0.94)
Yuen, 2016[169] Moderate	**RTS**	M: mortality	850 48 (25)	NR	0.85 (NR)
Paladino, 2010b [150] Moderate	**RTS**	C: major injury (blood transfusion, hemorrhage, or ISS ≥16)	1,649 35 (range 13 to 95)	NR	0.63 (0.60 to 0.67)
Ahun, 2014[109] Moderate	**RTS** <5.68	M: 24-hour mortality	100 40 (16)	Sen: 50.0% (12.4 to 87.6) Sp: 100.0% (95.9 to 100.0)	0.727 (NR)
Ahun, 2014[109] Moderate	**RTS** <5.97	M: 4-week mortality	100 40 (16)	Sen: 41.7% (15.2 to 72.3) Sp: 95.5% (88.8 to 98.7)	0.680 (NR)
Kondo, 2011[138] Moderate	**RTS**	M: in-hospital mortality	13,691 51 (22)	NR	0.919 (NR)
Kondo, 2011[138] Moderate	**RTS**	M: mortality in ED or OR	13,691 51 (22)	NR	0.966 (NR)
Al-Salamah, 2004[110] Moderate	**T-RTS** <12	M: in-hospital mortality	795 44 (21)	Sen: 84% (NR) Sp: 64% (NR)	0.83 (NR)
Aslar, 2004[112] Moderate	**T-RTS** ≤8	M: 30-day in-hospital mortality	64 36 (19)	*Sen: 68.0% (46.5 to 85.1) *Sp: 94.9% (82.7 to 99.4)	NR
Imhoff, 2014[131] Moderate	**T-RTS**	M: in-hospital mortality	3,680 37 (17)	NR	0.89 (0.889 to 0.891)
Jones, 2014[133] Moderate	**T-RTS** ≤8 <12	M: 30-day mortality	5,363 Median (IQR) Derivation dataset 33 (22 to 51) Validation dataset 34 (21 to 51)	*Sen: 54.0% (49.1 to 58.8) *Sp: 96.1% (95.5 to 96.6) *Sen: 84.2% (80.4 to 87.5) *Sp: 77.2% (76.0 to 78.4)	NR
Kondo, 2011[138] Moderate	**T-RTS**	M: in-hospital mortality	13,691 51 (22)	NR	0.917 (NR)

Author, Year Risk of Bias	Measure Threshold	Serious Injury Indicator Type: Indicator	Number Analyzed Age Mean (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
Kondo, 2011[138] Moderate	**T-RTS**	M: mortality in ED or OR	13,691 51 (22)	NR	0.968 (NR)
Gray, 1997[130] Moderate	**T-RTS** <8 <12	C: major injury composite (ISS ≥15, ICU admission or mortality)	213 Median 33 (range 2 to 95)	Sen: 19% (11.4 to 27.7) Sp: 100% (96.9 to 100) Sen: 60% (49.3 to 69.6) Sp: 90% (84.1 to 95.2)	NR

AUROC = area under the receiver operating characteristic curve; C = composite; CI = confidence interval; ED = emergency department; I = injury; ICU = intensive care unit; IQR = interquartile range; ISS = injury severity score; LSI = life-saving intervention; M = mortality; NR = not reported; OR = operating room; R = resource use; RTS = Revised Trauma Score; SD = standard deviation; Sen = sensitivity; Sp = specificity; T-RTS = Revised Trauma Score for Triage

*Results calculated by reviewers

Other Combinations of Physiologic Measures With Glasgow Coma Scale

In addition to the RTS, other combinations of physiologic measures and GCS have been studied, though less frequently (Table 27). These studies sought either to simplify an existing approach or to validate the addition of specific measures.

GAP (Glasgow Coma Scale, age, and arterial pressure) has been proposed as a simpler version of MGAP (mechanism, Glasgow Coma Scale, age, and arterial pressure). MGAP includes the mechanism of injury (see next section), and has been evaluated as a tool to predict mortality in the ED.[109,138] GAP is calculated by starting with the GCS score (3-15) and adding points for SBP (6 if >120, 4 if 60-120, and 0 if <60) and age (3 if <60 years old; 0 if ≥60). Another simplification of an existing measure for use in triage is the Rapid Emergency Medicine Score (REMS), a simplified version of APACHE II, which is a severity assessment tool for use in intensive care. REMS does not require laboratory results but does require monitors/equipment to measure oxygen saturation and MAP.[131]

Some included studies explored the value of adding measures that required equipment for assessment. One study[69] compared an assessment that could be done with no equipment (described as manual) with one that required a light to assess pupils and a pulse oximetry meter (semi-automated) to automate monitoring of blood pressure, $ETCO_2$, and RR. The study concluded that the manual assessment performed as well as those requiring equipment. Point-of-care lactate analyzers have become available, and another study focused on adding lactate measured in the field to a base combination of vital signs and GCS.[63]

Table 27. Predictive utility of other combinations of circulatory and/or respiratory measures with Glasgow Coma Scale

Measure Threshold Setting	Author, Year Risk of Bias	Serious Injury Indicator Type: Indicator	Number Analyzed Age Mean (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
GAP <19 ED	Ahun, 2014[109] Moderate	M: 24-hour mortality	N=100 40 (16)	Sen: 83% (36 to 97) Sp: 88% (79 to 94)	0.910 (NR)
GAP <21 ED	Ahun, 2014[109] Moderate	M: 4-week mortality	N=100 40 (16)	Sen: 92% (62 to 99%) Sp: 78% (68 to 87)	0.904 (NR)
GAP ED	Kondo, 2011[138] Low	M: short-term mortality	N=13,691 47 (20)	NR	0.965 (NR)
GAP ED	Kondo, 2011[138] Low	M: long-term mortality	N=13,691 47 (20)	NR	0.933 (NR)
GAP ISS>16 subgroup ED	Kondo, 2011[138] Low	M: long-term mortality	N=6,552 47 (20)	NR	0.905 (NR)
GAP ISS >16 subgroup ED	Kondo, 2011[138] Low	M: short-term mortality	N=6,552 47 (20)	NR	0.943 (NR)
GAP ≤21 ED	Rahmani, 2017[155] Moderate	R: no surgery	N=374 42 (18)	Sen: 75% (NR) Sp: 57% (NR)	0.74 (NR)
GAP ≤18 ED	Rahmani, 2017[155] Moderate	M: ED survival	N=374 42 (18)	Sen: 88% (NR) Sp: 85% (NR)	0.93 (NR)
GAP ≤14 ED	Rahmani, 2017[155] Moderate	M: In-hospital survival	N=374 42 (18)	Sen: 98% (NR) Sp: 91% (NR)	0.99 (NR)
REMS ED	Imhoff, 2014[131] Moderate	M: mortality in-hospital	N=3,680 37 (17)	NR	0.91 (SD 0.02)
Modified REMS ED	Miller, 2017[142] Moderate	M: in-hospital mortality	N=429,711 50 (23)	NR	0.967 (0.963 to 0.971)

Measure Threshold Setting	Author, Year Risk of Bias	Serious Injury Indicator Type: Indicator	Number Analyzed Age Mean (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
Author-created model Base (SI, HR, SBP, RR, and GCS) with and without lactate Thresholds SI >0.8, HR >110, SBP <100, RR ≥30, and GCS <15; Lactate >2 OH	Guyette, 2011[63] Moderate	R: emergent operation	N=1168 Median 44 (IQR 27-58)	Base with lactate Sen: 86% (77 to 93%) Sp: 25% (22 to 18%) Base without lactate Sen: 64% (53 to 74%) Sp: 51% (48 to 54%)	Base with Lactate 0.71 (CI NR) Base without lactate 0.68 (NR)
Author-created model Base (SI, HR, SBP, RR, and GCS) with and without lactate Thresholds SI >0.8, HR >110, SBP <100, RR ≥30, and GCS <15; Lactate >2 OH	Guyette, 2011[63] Moderate	R: multiple organ dysfunction	N=1168 Median 44 (IQR 27-58)	Base with Lactate Sen: 99% (92 to 100%) Sp: 25% (23 to 28%) Base without Lactate Sen: 94% (85 to 98%) Sp: 53% (50 to 56%)	Base with Lactate 0.81 (NR) Base without lactate 0.78 (NR)
Author-created model Base (SI, HR, SBP, RR, and GCS) with and without lactate Thresholds SI >0.8, HR >110, SBP <100, RR ≥30, and GCS <15; Lactate >2 OH	Guyette, 2011[63] Moderate	M: mortality	N=1168 Median 44 (IQR 27-58)	Base with lactate Sen: 97% (89 to 100%) Sp: 25% (23 to 28%) Base without lactate Sen: 88% (77 to 95%) Sp: 52% (49 to 55%)	Base with lactate 0.89 (NR) Base without lactate 0.85 (NR)
Manual/Group 1: Radial pulse character, verbal and motor GCS	Holcomb, 2005[69] High	R: prehospital life-saving intervention	N=381 35 (16) Patients with LSI 37 (17) Patients without LSI	NR	0.969 (NR) (multivariate)

Measure Threshold Setting	Author, Year Risk of Bias	Serious Injury Indicator Type: Indicator	Number Analyzed Age Mean (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
Manual/Group 1: Radial pulse character, verbal and motor GCS	Holcomb, 2005[69] High	R: hospital life-saving intervention	N=381 35 (16) Patients with LSI 37 (17) Patients without LSI	NR	0.619 (NR) (multivariate)
Manual/Group 1: Radial pulse character, verbal and motor GCS	Holcomb, 2005[69] High	R: overall LSI	N=381 35 (16) Patients with LSI 37 (17) Patients without LSI	NR	0.804 (NR) (multivariate)
Semi-automated/Group 2: Radial pulse character, eye and motor GCS	Holcomb, 2005[69] High	R: prehospital LSI	N=381 35 (16) Patients with LSI 37 (17) Patients without LSI	NR	0.970 (NR) (multivariate)
Semi-automated/Group 2: Radial pulse character, eye and motor GCS	Holcomb, 2005[69] High	R: hospital LSI	N=381 35 (16) Patients with LSI 37 (17) Patients without LSI	NR	0.616 (NR), $p < 0.05$ (multivariate)
Semi-automated/Group 2: Radial pulse character, eye and motor GCS	Holcomb, 2005[69] High	R: overall LSI	N=381 35 (16) Patients with LSI 37 (17) Patients without LSI	NR	0.807 (NR) (multivariate)
Automated/Group 3: radial pulse character, eye and motor GCS, and SBP	Holcomb, 2005[69] High	R: prehospital LSI	N=381 35 (16) Patients with LSI 37 (17) Patients without LSI	NR	0.975 (NR) (multivariate)
Automated/Group 3: radial pulse character, eye and motor GCS, and SBP	Holcomb, 2005[69] High	R: hospital LSI	N=381 35 (16) Patients with LSI 37 (17) Patients without LSI	NR	0.717 (NR), $p < 0.05$ (multivariate)

Measure Threshold Setting	Author, Year Risk of Bias	Serious Injury Indicator Type: Indicator	Number Analyzed Age Mean (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
Automated/Group 3: radial pulse character, eye and motor GCS, and SBP	Holcomb, 2005[69] High	R: overall LSI	N=381 35 (16) Patients with LSI 37 (17) Patients without LSI	NR	0.846 (NR) (multivariate)

AUROC = area under the receiver operating characteristic curve; CI = confidence interval; ED = emergency department; GAP = Glasgow Coma Scale, age, blood pressure; GCS = Glasgow Coma Scale; HR = heart rate; IQR = interquartile range; ISS = injury severity score; LSI = life-saving intervention; M = mortality; NR = not reported; OH = out-of-hospital; R = resource use; REMS = Rapid Emergency Medicine Score; RR = respiratory rate; SBP = systolic blood pressure; Sen = sensitivity; SI = shock index; Sp = specificity

Addition of Mechanism of Injury

Adding information on how trauma patients were injured has been included in field assessment, based on the idea that the mechanism of injury was relevant information that could be easily collected. Early studies verified that mechanism criteria was associated with severity of injury when considered independently but that this information did not add predictive value when vital signs and GCS were available.[68] The MGAP was developed including a general indicator of type of injury produced, and studies recommended and evaluated MGAP[95,96,109,138] as a predictor of mortality; however, the addition of mechanism added little or no predictive value over the GAP measure. Studies of other combinations of mechanism of injury with physiologic measures and GCS also reported good predictive utility[95,96,109,138,142,155] but not better than that achieved without including mechanism. Details about these studies and their results are available in the evidence tables in Appendix D.

Triage Protocols

Another approach to assessing physiologic indicators is to consider the predictive utility of the overall triage algorithm or protocol in which they are included (Table 28). In order to compare the utility of measures, they need to be varied within the protocol. The studies identified varied the measures for different age groups or tested combinations across age groups. Studies examined the impact of changing the threshold for SBP from 90 to 110 mmHg for trauma patients 16-65 years old and those over 65[46] and assessed the utility of current criteria for people over 55.[89] Another study derived criteria that could increase sensitivity and reduce undertriage, but at the cost of substantial increases in overtriage.[90]

Table 28. Predictive utility of variations and combinations of triage protocols

Author, Year Risk of Bias	Measure and Threshold Setting	Serious Injury Indicator Type: Indicator	Number Analyzed Age Mean (SD)	Sensitivity Specificity (95% CI)	AUROC (95% C)
Brown, 2015a[46] Moderate	NTTP Step 1 + 2; SBP <110 OH	R, I: trauma center need	1,555,944 Median 49	Age 16-65 Sen: 67% (CI NR) Sp: 62% (CI NR)	0.641 (0.64 to 0.642)
Aslar, 2004[112] Moderate	APACHE II score ≥15 ED	M: mortality	64 36 (18.6)	Sen: 80% (59 to 93%) Sp: 95% (83 to 99%) (values calculated)	NR
Vassallo, 2017[167] High	CareFlight Triage	R: Live saving intervention	3654 Age (median) No hemorrhage : 41 (range: 18-83) Hemorrhage group: 29 (range: 18-74)	Sen: 33.5% (31.3 to 35.8) Sp: 98.4% (97.7 to 98.9)	NR
Garner, 2001[61] Low	CareFlight Triage algorithm OH	R: critical injury	1144 Median 33 (IQR 21-53)	Sen: 82% (75 to 88%) Sp: 96% (94 to 97%)	NR
Joosse, 2014[134] Low	EMTRAS (age, GCS, base excess, prothrombin time) ED	M: Mortality, in-hospital	4418 43 (19)	NR NR	0.94 (0.93 to 0.96)
Vassallo, 2017[167] High	Military Sieve	R: Live saving intervention	3654 Age (median) No hemorrhage : 41 (range: 18-83) Hemorrhage group: 29 (range: 18-74)	Sen: 43.8% (41.5 to 46.2) Sp: 93.6% (92.4 to 94.6)	NR
Vassallo, 2017[167] High	Modified Military Sieve	R: Live saving intervention	3654 Age (median) No hemorrhage : 41 (range: 18-83) Hemorrhage group: 29 (range: 18-74)	Sen: 50.9% (48.6 to 53.3) Sp: 87.5% (85.9 to 88.9)	NR

Author, Year Risk of Bias	Measure and Threshold Setting	Serious Injury Indicator Type: Indicator	Number Analyzed Age Mean (SD)	Sensitivity Specificity (95% CI)	AUROC (95% C)
Horne, 2013[71] High	Triage Sieve military UK Triage Sieve RR <12 or >24 and HR >60 and <120 OH	R: Live saving intervention	1213 NR (NR)	Sen: 72.3% (NR) Sp: 77.1% (NR)	NR
Vassallo, 2015[166] Moderate	Triage Sort ED	R: Live saving intervention	345 Age (median) No hemorrhage : 41 (range: 18-83) Hemorrhage group: 29 (range: 18-74)	Sen: 58.6% (51.8 to 65.4) Sp: 88.7% (83.5 to 93.9)	NR
Vassallo, 2017[167] High	Modified Physiological Triage Tool ED	R: Live saving intervention	3654 Age (median) No hemorrhage : 41 (range: 18-83) Hemorrhage group: 29 (range: 18-74)	Sen: 69.9% (67.7 to 72.0) Sp: 65.3% (63.2 to 67.5)	NR
Ocak, 2009[91] Moderate	NTTP - physiologic component - any of: GCS <14, SBP <90, RR <10 or >29 OH	I: Major trauma	302 54(24)	*Sen: 63% (55 to 70) *Sp: 93% (88 to 97)	NR
Haider, 2016[66] Moderate	NTTP with SBP <90 OH	R, I, M: ISS or surgery or ICU or death	505,296 47 (19.7)	Sen: 42% (NR) Sp: 82% (NR)	NR
Haider, 2016[66] Moderate	NTTP with SI>1 OH	R, I, M: ISS or surgery or ICU or death	505,296 47 (19.7)	Sen: 4% (NR) Sp: 80% (NR)	NR
Brown, 2015a[46] Moderate	NTTP Step 1 + 2; SPB <90 OH	R, I: trauma center need	1,555,944 Median 49	Ages16-65 62% (CI NR) / 67% (CI NR) 59% (CI NR) / 69% (CI NR)	0.646 (0.645 to 0.647)

Author, Year Risk of Bias	Measure and Threshold Setting	Serious Injury Indicator Type: Indicator	Number Analyzed Age Mean (SD)	Sensitivity Specificity (95% CI)	AUROC (95% C)
Tamim, 2002[102] Moderate	PHI OH	Composite: Surgical intervention, ICU care, mortality	1291 48 (19)	≥1 Sen: 55% (52 to 57) Sp: 71% (69 to 74) ≥4 Sen: 35% (32 to 38) Sp: 91% (90 to 93)	0.66 (SE 0.02)
Bond, 1997[43] Moderate	PHI OH	I: ISS ≥16	3147 NR	≥4 Sen: 41% (NR) Sp: 98% (NR)	NR
Vassallo, 2017[167] High	START ED	R: Live saving intervention	3654 Age (median) No hemorrhage : 41 (range: 18-83) Hemorrhage group: 29 (range: 18-74)	Sen: 38.7% (36.5 to 41.1) Sp: 96.9% (96.0 to 97.6)	NR
Garner, 2001[61] Low	START OH	R: critical injury	1144 Median 33 (IQR 21-53)	Sen: 85% (78 to 90%) Sp: 86% (84 to 88%)	NR
Garner, 2001[61] Low	Modified START OH	R: critical injury	1144 Median 33 (IQR 21-53)	Sen: 84% (76 to 89%) Sp: 91% (89 to 93%)	NR
Gebhart, 2007[129] Moderate	START protocol model using tabulated score, ≥2 of: GCS <15, RR <30, HR <100 OH	M: mortality	355 41 (21.1)	Sen: 85% (NR) Sp: 63% (NR)	0.86 (NR)
Jo, 2014[132] Moderate	ViEWS-L[132] ED	M: mortality	299 62 Median (IQR 45-73)	Sen: NR Sp: NR	0.84 (95% CI 0.77 to 0.91)

AUROC = area under the receiver operating characteristic curve; CI = confidence interval; GCS = Glasgow Coma Scale; HR = heart rate; I = injury type or severity; ICU = intensive care unit; IQR = interquartile range; ISS = Injury Severity Score; M = mortality; MPTT = Modified Physiological Triage Tool; NR = not reported; NTTP = National Trauma Triage Protocol; OH = out-of-hospital; PHI = Prehospital Index; R = resource use; RR = respiratory rate; SBP = systolic blood pressure; Sen = sensitivity; Sp = specificity; START = Simple Triage and Rapid Treatment; ViEWS-L = modified VitalPAC Early Warning Score with rapid lactate level

Combinations of Physiologic Measures Without Glasgow Coma Scale

Table 29 lists combinations of circulatory and respiratory measures that do not include GCS or a measure of consciousness. Most of these combinations were only evaluated in one or two identified studies.

This table is split into three sections by bold lines. The first section lists studies that evaluated comparatively straight forward combinations of circulatory and respiratory measures. The second section lists more complex combinations and models. The third and last section lists studies that evaluated triage protocols or prediction models, which involved considering several measures following a prescribed order or algorithm.

Table 29. Combination circulatory and respiratory measures (Key Question 3) without assessment of level of consciousness

Measure Evaluated	Number of Studies (articles)	References
Breath index (RR/PP)	2	53,54
Hemorrhage index (HR x RR)/(MAP x PP)	1	53
HR and SBP with lactate or BD	1 (2 articles)	147,148
HR, SBP and SaO_2	1	103
Multiple vital signs	1	80
HRC with vital signs	1 (2 articles)	81,82
New Field Triage Score (FTS_{07})	1	118
Ensemble classifier (model using HR, RR, DBP, SBP, and SaO_2)	1	53
CHAID analysis of multiple variables	1	57
Murphy Factor (injury acuity algorithm)	1	103
Triage Sieve	3	61,71,167

BD = base deficit; CHAID = Chi-square-assisted interaction detection; DBP = diastolic blood pressure; FTS07 = new Field Triage Score; HR = heart rate; HRC = heart rate complexity; MAP = mean arterial pressure; PP = pulse pressure; RR = respiratory rate; SaO2 = oxygen saturation; SBP = systolic blood pressure; SI = shock index; START = simple triage and rapid treatment; ViEWS-L = VitalPAC Early Warning Score with rapid lactate level

Note: Similar measures are grouped between bold dividing lines.

While there were some similarities across these measures, the diversity as well as the lack of multiple studies on these combinations made it difficult to assess their utility. The results are presented in Table 30 below, grouped in the same arrangement as in the table above.

Table 30. Predictive utility of combinations of physiologic measures

Author, Year Risk of Bias	Measure and Threshold Setting	Serious Injury Indicator Type: Indicator	Number Analyzed Age Mean (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
Chen, 2008[53] Moderate	Breath index (RR/PP) OH	R: hemorrhage	627 39 (NR)	Sen: NR Sp: NR	0.67 (0.08)
Chen, 2009[54] Moderate	Breath index (RR/PP), reliable OH	R: major hemorrhage	326 38 (16)	Sen: NR Sp: NR	0.85 (0.77 to 0.91)
Chen, 2008[53] Moderate	Hemorrhage index (HR x RR)/(MAP x PP) OH	R: hemorrhage	627 39 (NR)	Sen: NR Sp: NR	0.73 (0.06)
Paladino, 2008[147,148] Moderate	Lactate >2.5: subgroup with normal vital signs ED	R: major injury	1435 35 (16.9) (range 13 to 95)	Sen: 76% (CI NR) Sp: 49% (CI NR)	NR
Paladino, 2008[147,148] Moderate	Lactate: subgroup with normal vital signs ED	R: major injury	1435 35 (16.9) (range 13 to 95)	Sen: NR Sp: NR	0.64 (0.58 to 0.69), p<0.0001
Paladino, 2008[147,148] Moderate	Author-created model with measures: abnormal lactate or BD; subgroup with normal vital signs ED	R: major injury	1435 35 (16.9) (range 13 to 95)	Sen: 76% (71 to 82%) Sp: 48% (45 to 51%)	NR
Paladino, 2008[147,148] Moderate	BD <-1.3: subgroup with normal vital signs ED	R: major injury	1435 35 (16.9) (range 13 to 95)	Sen: 56% (NR) Sp: 71% (NR)	NR
Paladino, 2008[147,148] Moderate	BD: subgroup with normal vital signs ED	R: major injury	1435 35 (16.9) (range 13 to 95)	Sen: NR Sp: NR	0.68 (0.63 to 0.73), p<0.0001
Van Haren, 2014[103] Moderate	HR >100, SBP<90, SaO_2<95% OH	R: LSI	96 48 (19)	Sen: 44% (NR) Sp: 75% (NR)	0.607, p=0.119
Liu, 2015a[17] Moderate	Vital signs with heart rate complexity ED	M: mortality	108 37 ± 14	Sen: NR Sp: NR	0.86 (NR) (multivariate)
Liu, 2015a[17] Moderate	Vital signs with heart rate complexity ED	R: LSI	108 37 ± 14	Sen: NR Sp: NR	0.86 (NR) (multivariate)
Liu, 2014b[81,82] High	Vital signs and HRC OH	R: LSI	104 40 (16)	Sen: NR Sp: NR	0.81 (NR) (multivariate)

Author, Year Risk of Bias	Measure and Threshold Setting	Serious Injury Indicator Type: Indicator	Number Analyzed Age Mean (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
Liu, 2014a[80] Moderate	Wireless vital sign monitor using HR, RR, and SBP OH	R: LSI ED	305 39 (16)	Sen: NR Sp: NR	0.86 (NR) (multivariate)
Liu, 2014a[80] Moderate	Wireless vital sign monitor using HR, RR, and SBP OH	R: LSI EMS or ED	305 39 (16)	Sen: NR Sp: NR	0.94 (NR) (multivariate)
Cancio, 2008a[118] High	New FTS[118] ED	M: mortality	536 NR (NR)	Sen: NR Sp: NR	0.687 (0.620 to 0.754) (multivariate)
Cancio, 2008a[118] High	New FTS[118] ED	R: massive transfusion	536 NR (NR)	Sen: NR Sp: NR	0.618 (0.569 to 0.666) (multivariate)
Chen, 2008[53] Moderate	Ensemble classifier (nonlinear model of vital signs that allows missing data) OH	R: hemorrhage	627 39 (NR)	Sen: 69% (SD 0.08) Sp: 68% (SD 0.09)	0.76 (SD 0.05)
Chen, 2008[53] Moderate	Ensemble classifier (nonlinear model of vital signs that allows missing data; uses HR, RR, DBP, SBP, and SaO_2) OH	R: hemorrhage	627 39 (NR)	Sen: 90% (NR) Sp: 40% (SD 0.10)	NR
Courville, 2009[57] Low	CHAID testing analysis OH	M: mortality	224,682 NR (NR)	Sen: 60% (CI NR) Sp: 99% (CI NR)	NR
Van Haren, 2014[103] Moderate	Murphy Factor >3 OH	R: LSI	96	Sen: 39% (NR) Sp: 81% (NR)	0.620, p=0.081
Garner, 2001[61] Low	Triage sieve algorithm using capillary refill OH	R: critical injury	1144 Median 33 (IQR 21-53)	Sen: 45% (37 to 54%) Sp: 89% (87 to 91%)	NR
Garner, 2001[61] Low	Triage sieve algorithm using HR OH	R: critical injury	1144 Median 33 (IQR 21-53)	Sen: 45% (37 to 54%) Sp: 88% (86 to 90%)	NR
Horne, 2013[71] High	UK Triage Sieve OH	R: Resource-based definition of Priority 1 casualty	1213 NR (NR)	Sen: 53% (49 to 57%) Sp: 88% (85 to 90%)	NR

Author, Year Risk of Bias	Measure and Threshold Setting	Serious Injury Indicator Type: Indicator	Number Analyzed Age Mean (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
Horne, 2013[71] High	Military Version UK Triage Sieve OH	R: Resource-based definition of Priority 1 casualty	1213 NR (NR)	Sen: 59% (58 to 62%) Sp: 89% (85 to 90%)	NR
Horne, 2013[71] High	Military Version UK Triage Sieve RR <12 or >24 and HR >60 and <120 OH	R: Resource-based definition of Priority 1 casualty	1213 NR (NR)	Sen: 71% (NR) Sp: 79% (NR)	NR

AUROC = area under the receiver operating characteristic curve; BD = base deficit; CHAID = Chi-square-assisted interaction detection; CI = confidence interval; DBP = diastolic blood pressure; ED = emergency department; EMS = emergency medical services; FTS07 = new Field Triage Score; HR = heart rate; HRC = heart rate complexity; IQR = interquartile range; LSI = life-saving intervention; M = mortality; MAP = mean arterial pressure; NR = not reported; OH = out-of-hospital; PP = pulse pressure; R = resource use; RR = respiratory rate; SaO2 = oxygen saturation; SBP = systolic blood pressure; SD = standard deviation; SI = shock index; START = simple triage and rapid treatment; UK = United Kingdom; ViEWS-L = VitalPAC Early Warning Score with rapid lactate level

Note: Similar measures are grouped between bold dividing lines.

Key Questions 1a, 2a, and 3a: Differences Across Age Groups

Each Key Question for this review has a subquestion that asks if the predictive utility of the identified measures varies across age groups (i.e., is it different for children or older adults) and if the evidence supports different measures or different thresholds for specific age ranges. There are ample anecdotal reports, as well as epidemiologic research, documenting that people at the extremes of the age range (the young and the old) experience trauma less frequently than the adult nonelderly population, but that their outcomes are worse. This raises questions about the appropriateness of treatment and about how children and older trauma patients are assessed and triaged.

We identified 10 studies with relevant data specific to pediatric trauma patients[57,77,88,101,111,140,157,171,173,175] and 13 studies with data specific to older trauma patients (ages included vary).[46,72,87,89,90,116,117,123,136,146,151,163,170]

Pediatrics

The 10 pediatric studies included 6 evaluations of circulatory measures (Table 31);[77,88,101,111,157,171] 4 assessments of respiratory measures (Table 32);[77,88,140,171] and 6 reports on combination measures (Table 33).[57,77,88,140,173,175]

The assessments of circulatory measures demonstrated that using the standard thresholds for SBP[77,88,171] and base deficit[111,157] resulted in low sensitivities, indicating they do not identify most children with serious injury. Lactate >2.0 resulted in higher sensitivities compared with the other measures, but the values were still low and they varied across indicators of serious injury and in age subgroups in the one study with subgroup comparisons;[157] however, larger studies are need to confirm these variations.

In the four studies that assessed the predictive utility of RR in children, the results were inconsistent. For example sensitivities range from 2.11[171] to 76.2 percent.[140] This may be because the studies used different indicators of injury or the study populations differed (e.g., the distribution of ages may differ). Additionally, RR in children has even a larger range than in adults and it is also affected by stress as well as pain, both of which are common in trauma.

Overall, the combination measures performed better than individual measures. Reported sensitivities and specificities were higher, with most over 60 percent. The highest were reported in an early study (1996) of HR and GCS combined[173] and a trauma score developed specifically for pediatrics.[175] Using the physiologic measures from the current adult triage guidelines resulted in lower sensitivity (49%) than the customized measures but was still better than individual measures.[77]

Table 31. Predictive utility of circulatory measures (Key Question 1) in pediatric patients

Author, Year Risk of Bias	Measure and Threshold Setting	Type: Serious Injury Specific Indicator	Number Analyzed Age Group Mean Age (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
Engum, 2000[171] Low	SBP ≤90 OH	R: Major trauma (death in ED, ICU admission, major surgery)	N=1,285 Age: 1-15 years 7.2 (range 1-15)	*Sen: 14.78% (11.36 to 18.75) *Sp: 99.01% (98.12 to 99.54)	NR
Newgard, 2009[88] Low	SBP ≤90 OH	Composite: LOS >2 days or death	N=955 ≤14 5.23 (4.57)	*Sen: 24.02% (17.96 to 30.96%) *Sp: 53.99% (50.41 to 57.55T)	NR
Lerner, 2017[77] Low	SBP ≤90 OH	Composite: Trauma center need (non-orthopedic surgery in 24 hours, ICU admission or mortality	N=5,594 ≤15 8 (5)	1-NPV: 87% (under-triage) 1-PPV: 4% (over-triage)	NR
Shah, 2013[101] Moderate	Lactate ≥2.0 OH	R: need for critical care	N=217 <18 11 (median) IQR 6-14	Sen: 64% (NR) Sp: 66% (NR)	NR
Ramanathan, 2015[157] Low	Lactate >4.7 ED	I: ISS >15	N=236 <15 years 9.2 (4.7)	Sen: 26.7% (14.6 to 41.9%) Sp: 95.8% (91.9 to 98.2%)	0.706 (NR)
Ramanathan, 2015[157] Low	Lactate ≥2.0 ED	I: ISS >15	N=236 <15 years 9.2 (4.7)	Sen: 86.7% (73.2 to 95.0%) Sp: 54.5% (47.1 to 61.6%)	0.652 (NR)
Ramanathan, 2015[157] Low	Lactate ≥2.0 ED	I: ISS >15	N=78 Adolescents 13-14 years	Sen: 35.6% (21.9 to 51.2%) Sp: 67.5% (60.4 to 74.1)	NR

Author, Year Risk of Bias	Measure and Threshold Setting	Type: Serious Injury Specific Indicator	Number Analyzed Age Group Mean Age (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
Ramanathan, 2015[157] Low	Lactate ≥2.0 ED	I: ISS >15	N=98 School age 6-12 years	Sen: 40.0% (25.7 to 55.7%) Sp: 58.1% (50.8 to 65.2%)	NR
Ramanathan, 2015[157] Low	Lactate ≥2.0 ED	I: ISS >15	N=42 Toddlers 19 months-5 years NR	Sen: 17.8% (8.0 to 32.1%) Sp: 82.2% (76.0 to 87.3%)	NR
Ramanathan, 2015[157] Low	Lactate ≥2.0 ED	I: ISS >15	N=18 Infants 0-18 months NR	Sen: 6.7% (1.5 to 18.3%) Sp: 92.1% (87.4 to 95.5%)	NR
Ramanathan, 2015[157] Low	Lactate ≥2.0 ED	R: ICU admission	N=126 <15 years 9.2 (4.7)	Sen: 77.9% (67.0 to 86.6%) Sp: 58.5% (50.4 to 66.2%)	NR
Ramanathan, 2015[157] Low	Lactate ≥2.0 ED	R: Intubation	N=126 <15 years 9.2 (4.7)	Sen: 88.2% (72.5 to 96.6%) Sp: 52.5% (45.3 to 59.5%)	NR
Ramanathan, 2015[157] Low	Lactate ≥2.0 ED	R: Major procedure	N=126 <15 years 9.2 (4.7)	Sen: 70.6% (56.2 to 82.5%) Sp: 51.3% (43.9 to 58.7%)	NR
Allen, 2014[111] Moderate	BD <-7 BD <-5 BD <0 ED	R: Blood transfusion	N=1928 <18 years 11 (6)	Sen: 29% (NR) Sp: 95% (NR) Sen: 54% (NR) Sp: 88% (NR) Sen: 94% (NR) Sp: 30% (NR)	NR
Ramanathan, 2015[157] Low	BD <-5.0 ED	I: ISS >15	N=126 <15 years 9.2 (4.7)	Sen: 25.0% (13.2 to 40.3%) Sp: 98.3% (95.1 to 99.6%)	NR
Ramanathan, 2015[157] Low	pH <7.30 ED	I: ISS >15	N=126 <15 years 9.2 (4.7)	Sen: 56.8% (41.0 to 71.6%) Sp: 94.3% (89.9 to 97.2%)	NR

AUROC = area under the operating characteristic curve; BD = base deficit; CI = confidence interval; ED = emergency department; ICU = intensive care unit; GCS = Glasgow Coma Scale; ICU = intensive care unit; ISS = injury severity score; LOS = length of stay; NR = not reported; OH: out-of-hospital; SBP = systolic blood pressure; SD = standard deviation; Sen = sensitivity; Sp = specificity

*Results calculated by reviewers

Table 32. Predictive utility of respiratory predictors (Key Question 2) in studies of pediatric patients

Author, Year Risk of Bias	Measure and Threshold Setting	Type: Serious Injury Specific Indicator	Number Analyzed Age Group Mean Age (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
Engum, 2000[171] Low	RR <10 or >29 OH	R: Major trauma (death in ED, ICU admission, major surgery)	N=1,285 1-15 years 7.2 (range 1-15)	*Sen: 2.11% (0.92 to 4.12%) *Sp: 99.67% (99.04 to 99.93%)	NR
Lerner, 2017[77] Low	RR <10 or >29 OH	Composite:: Trauma center need (non-orthopedic surgery in 24 hours, ICU admission or mortality	N=5,594 ≤15 8 (5)	1-NPV: 69% (under-triage) 1-PPV: 14% (over-triage)	NR
Newgard, 2009[88] Low	RR <10 or >29 OH	Composite: LOS >2 days or death	N=955 ≤14 5.23 (4.57)	*Sen: 44.13% (36.73 to 51.73%) *Sp: 53.09% (49.51 to 56.65%)	NR
Lee, 2014[140] Low	RR Abnormal: not defined ED	R: Receipt of resuscitation in the ED	N= 92 ≤16 Median: 4.75 (range 2 months to 15 years)	Sen: 76.2% (NR) Sp: 66.2% (NR)	NR
Lee, 2014[140] Low	RR Abnormal: not defined ED	Composite: Major trauma	N= 92 ≤16 Median: 4.75 (range 2 months to 15 years)	Sen: 53.8% (NR) Sp: 60.6% (NR)	NR

AUROC = area under the operating characteristic curve; CI = confidence interval; ED = emergency department; I = injury type or severity; ICU = intensive care unit; LOS = length of stay; NPV = negative predictive value; NR = not reported; OH: Out-of-hospital; PPV = positive predictive value; R = resource use; RR = respiratory rate; SD = standard deviation; Sen = sensitivity; Sp = specificity

*Results calculated by reviewers

Table 33. Predictive utility of combination predictors (Key Question 3) in pediatric patients

Author, Year Risk of Bias	Measure and Threshold Setting	Type: Serious Injury Specific Indicator	Number Analyzed Age Group Mean Age (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
Courville, 2009[57] Low	Vitals, GCS, demo-graphics, injury mechanism and days to admission OH	M: Mortality-in hospital	N=224,628 <18 9.7 (NR)	For overall model Sen: 59.9% (NR) Sp: 99.0% (NR)	NR
Lee, 2014[140] Low	Combined criteria (PTS ≤8, GCS ≤10, Abnormal RR) ED	Composite: Major trauma R: Receipt of resuscitation in the ED	N=92 ≤16 Median: 4.75 (range 2 months to 15 years)	Sen: 69.2% (NR) Sp: 53% (NR) Sen: 90.5% (NR) Sp: 83.1% (NR)	NR
Moront, 1996[173] Moderate	HR and GCS OH and ED	R: Correctness of triage	N=3,861 <15 7 (4)	Sen: 97.8% Sp: 95.8%	AUROC analysis mentioned; results not reported
Potoka, 2001[175] Moderate	Pediatric Trauma Score NR	M: mortality I: ISS >20	N=2,248 0-16 9.5 (5.1)	<u>For mortality</u> Sen: 96.7% Sp: 88.83% <u>For ISS</u> Sen: 49.43% Sp: 91.83%	NR
Lerner, 2017[77] Low	Physiologic Measures of Field Triage measures OH	Composite:: Trauma center need (non-orthopedic surgery in 24 hours, ICU admission or mortality	N=5,594 ≤15 8 (5)	*Sen: 49% (43 to 55) *Sp: 82% (81 to 83) 1-NPV: 51% (under-triage) 1-PPV: 18% (over-triage)	NR
Newgard, 2009[88] Low	Pediatric Clinical Decision Tree, (ventilatory assistance, GCS <11, SaO_2 <95%, SBP >96): validation group OH	Composite: LOS >2 days or death	N=955 ≤14 5.23 (4.57)	Sen: 76.5% (66.4 to 86.6) Sp: 71.7% (66.7 to 76.6)	NR

AUROC = area under the operating characteristic curve; CI = confidence interval; ED = emergency department; GCS = Glasgow Coma Scale; HR = heart rate; I = injury type or severity; ICU = intensive care unit; ISS = injury severity score; LOS = length of stay; M = mortality; NPV = negative predictive value; NR = not reported; OH = out-of- hospital; PPV = positive predictive value; PTS = Pediatric Trauma Score; R = resource use; RR = respiratory rate; SaO2 = oxygen saturation; SBP = systolic blood pressure; SD = standard deviation; Sen = sensitivity; Sp = specificity
*Results calculated by reviewers

Older Individuals

We identified 13 studies that addressed the performance of physiologic measures in older people.[46,72,87,89,90,116,117,123,136,146,151,163,170] Key results of the studies that explicitly analyzed the predictive utility of measures in older people are presented in Tables 34, 35, and 36 and are described briefly in the text by type of measure.

Individual Measures of Circulatory and Respiratory Compromise

Four studies evaluated individual measures.[46,89,117,146] For the measures evaluated (SBP, lactate, base deficit, RR, and assisted ventilation), the sensitivities and AUROCs were consistently low. The standard definition of low SBP of under <90 mmHg fails to identify older patients at risk of serious injury or death,[46,89] while higher threshold performs better.[46] One study reported that SBP divided by age in a sample of adults of all ages performed better than SBP alone (results in Appendix D).[116] Similarly, studies documented that lactate and base deficit did not predict mortality in older patients in general[146] or in older patients with normal SBP of >90 mmHg.[117] An additional study also evaluated RR and assisted ventilation and reported similar findings.[89]

Shock Index

Table 35 reports the results of four studies that evaluated SI in older people either on its own or by comparing a modified version in which SI is multiplied by age.[123,136,151,170] Like SBP, SI was less able to identify serious injury in older people. In addition to the studies in Table 35, one study that evaluated SI in a sample of adults of all ages demonstrated that the correlation between SI and several different outcomes decreased when patients were stratified into age groups by decade to the point that in patients over 80, SI was not significantly correlated with any outcomes.[87] Multiplying SI by age increased AUROC values in two studies limited to older people but the increases were small[136,170] and one study reported similar increases when SI age was used in a sample of adults of all ages (results in the evidence tables in Appendix D).[116]

Combination Triage Criteria

Another approach to age differences is to modify triage criteria that combine measures by either changing thresholds, adding criteria, or both. Table 36 reports the results of two studies[72,90] that compared standard to modified criteria for older patients. Both reported that the modified criteria increased sensitivity and AUROC for serious injury. Ichawan et al. created geriatric triage criteria that increased the SBP threshold from 90 to 100 mmHg and GCS from 13 or less to 14 or less and also added more anatomic and cause of injury criteria.[72] This increased sensitivity by over 30 percentage points for ISS >15 with less extreme improvements for other indicators of serious injury. Newgard et al. also increased the GCS threshold to 14, adjusted the vital signs (SBP to <110 or >200 mmHg, respirations to <10 or >24 per minute, and HR <60 or >110 beats per minute), and added high-risk mechanism.[90] This increased sensitivity from 75.9 to 92.1 percent but decreased specificity from 77.8 to 41.5 percent. The authors estimated that the impact would be a reduction in under-triage from 146 to 48 patients, but over-triage would increase from 2,840 to 7,485 in a validation sample of 13,401 patients. A third study examined a related issue and found that when using the same criteria for all adults, trauma teams were less likely to be activated for older patients with severe multi-system injury (adjusted odds ratio 1.37 [95% CI 1.12 to 1.69, p=0.0003] for missed trauma team activation for patients ≥65 years of age vs. <65 years of age).[163]

Table 34. Predictive utility of single physiologic measures in older patients

Author, Year Risk of Bias	Measure and Threshold Setting	Type: Serious Injury Specific Indicator	N Analyzed Age Group Mean Age (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
Brown, 2015a[46] Moderate	SBP alone In NTTP step 1 & 2 <110 OH	R, I: trauma care need	N=438,828 ≥65 Median: 80 (IQR 73-86)	Sen: 13% (NR) Sp: 93% (NR) Sen: 44% (NR) Sp: 71% (NR)	0.532 (0.53 to 0.534) 0.575 (0.572 to 0.577)
Brown, 2015a[46] Moderate	SBP alone In NTTP step 1 & 2 <90 OH	R, I: trauma care need	N=438,828 ≥65 Median: 80 (IQR 73-86)	Sen: 5% (NR) Sp: 99% (NR) Sen: 40% (NR) Sp: 75% (NR)	0.519 (0.517 to 0.52) 0.574 (0.571 to 0.576)
Brown, 2015a[46] Moderate	SBP Derived optimal cutoff <122 OH	R, I: trauma care need	N=438,828 ≥65 Median: 80 (IQR 73-86)	Sen: 22% (NR) Sp: 83% (NR)	NR
Brown, 2015a[46] Moderate	SBP Derived optimal cutoff <118 OH	M: mortality	N=438,828 ≥65 Median: 80 (IQR 73-86)	Sen: 29% (NR) Sp: 86% (NR)	NR
Newgard, 2014[89] Moderate	SBP <90 mmHg OH	I: ISS≥16	N= 44,890 ≥55 Age (median): 77 (IQR 64-85)	*Sen: 4.08% (3.31 to 4.97) *Sp: 98.52% (98.40 to 98.63)	NR
Pal, 2006[146] Low	Lactate >2.0 ED	M: mortality	Total sample N=5,995 NR for older groups 38.8 (range 16-100)	NR	0.65 (NR) age >50 0.63 (NR) age >60 0.62 (NR) age >70 0.72 (NR) all ages
Callaway, 2009[117] Moderate	Lactate 2.5 to 4.0 ED	M: mortality	N=588 Normotensive (SBP >90 mmHg) ≥65 years old 80 (8)	*Sen: 22.32% (15.00 to 31.16%) *Sp: 82.77% (79.07 to 86.06%)	NR

Author, Year Risk of Bias	Measure and Threshold Settting	Type: Serious Injury Specific Indicator	N Analyzed Age Group Mean Age (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
Callaway, 2009[117] Moderate	Lactate >4.0 ED	M: mortality	N=588 Normotensive (SBP>90 mmHg) ≥65 years old 80 (8)	*Sen: 18.75% (12.00 to 27.22%) *Sp: 93.28% (90.64 to 95.36%)	NR
Callaway, 2009[117] Moderate	BD 0 to -6 ED	M: mortality	N=588 Normotensive (SBP>90 mmHg) ≥65 years old 80 (8)	*Sen: 36.94% (27.97 to 46.62%) *Sp: 76.60% (72.50 to 80.35)	NR
Callaway, 2009[117] Moderate	BD <-6 ED	M: mortality	N=588 Normotensive (SBP>90 mmHg) ≥65 years old 80 (8)	*Sen: 15.32% (9.18 to 23.39%) *Sp: 94.47% (92.00 to 96.35%)	NR
Newgard, 2014[89] Moderate	RR <10 or >29 OH	I: ISS ≥16	N= 44,890 ≥55 Age (median): 77 (IQR 64-85)	*Sen: 6.31% (5.36 to 7.38) *Sp: 98.63% (98.51 to 98.73)	NR
Newgard, 2014[89] Moderate	Assisted Ventilation OH	I: ISS ≥16	N= 44,890 ≥55 Age (median): 77 (IQR 64-85)	*Sen: 7.90% (6.84 to 9.08) *Sp: 99.60% (99.53 to 99.66)	NR

AUROC = area under the operating characteristic curve; BD = base deficit; CI = confidence interval; ED = emergency department; I = injury type or severity; ICU = intensive care unit; IQR = interquartile range; ISS = injury severity score; LOS = length of stay; M = mortality; N = number; NR = not reported; NTTP = National Trauma Triage Protocol; OH = out-of- hospital; R = resource use; RR = respiratory rate; SBP = systolic blood pressure; SD = standard deviation; Sen = sensitivity; Sp = specificity

*Results calculated by reviewers

Table 35. Predictive utility of shock index in older patients

Author, Year Risk of Bias	Measure and Threshold Setting	Type: Serious Injury Specific Indicator	N Analyzed Age Group Mean Age (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
DeMuro, 2013[123] Moderate	SI ≥0.8 ≥0.9 ≥1 ED	R: bleeding	N=2,093 ≥65 NR	Sen: 58.8% (NR) Sp: 91.9% (NR) Sen: 41.2% (NR) Sp: 95.7% (NR) Sen: 29.4% (NR) Sp: 98.1% (NR)	NR
Pandit, 2014[151] Moderate	SI ≥1 ED	R: blood transfusion	N=217,190 ≥65 77.7 (7.1)	*Sen: 5.80% (5.44 to 6.17%) *Sp: 97.19% (97.11 to 97.26%)	NR
Pandit, 2014[151] Moderate	SI ≥1 ED	R: exploratory laparotomy	N=217,190 ≥65 77.7 (7.1)	*Sen: 7.54% (6.84 to 8.29%) *Sp: 97.08% (97.01 to 97.15%)	NR
Pandit, 2014[151] Moderate	SI ≥1 ED	M: mortality in-hospital	N=217,190 ≥65 77.7 (7.1)	Sen: 45% (NR) Sp: 97% (NR)	NR
Kim, 2016 [136] High	SI SI*Age ED	M: ED mortality	N=45,880 ≥65 Age (median): 72 (IQR: 68-78)	NR	0.807 (0.780 to 0.834) SI*age vs. 0.771 (0.735 to 0.806) for SI
Zarzaur, 2008[170] Moderate	SI SI*Age ED	R: Blood Transfusion ≥ 4 units in 48 hours	N=2420 ≥55 67 (8.1)	NR	0.805 (0.776 to 0.834) vs. 0.789 (0.758 to 0.819)
Zarzaur, 2008[170] Moderate	SI SI*Age ≥ 52.1 ED	M: Mortality 48-hour	N=2420 ≥55 67 (8.1)	Sen: 72% (NR) Sp: 81% (NR)	0.830 (0.780 to 0.880) vs. 0.789 (0.730 to 0.848)

AUROC = area under the operating characteristic curve; CI = confidence interval; ED = emergency department; M = mortality; N = number; NR = not reported; R = resource use; SD = standard deviation; Sen = sensitivity; SI = shock index; Sp = specificity

*Results calculated by reviewers

Table 36. Predictive utility of combination triage criteria in older patients

Author, Year Risk of Bias	Measure Comparator Setting	Type: Serious Injury Specific Indicator	N Analyzed Age Group Mean Age (SD)	Sensitivity Specificity (95% CI)	AUROC (95% CI)
Ichwan, 2015[72] Moderate	Geriatric Triage Criteria vs. Adult Criteria OH	R: OR within 48 hours	N=33,379 ≥70 years old NR	Sen: 47% (46 to 49) Sp: 42% (41 to 42) vs. Sen: 35% (34 to 37) Sp: 57% (56 to 58)	0.44 (NR) vs. 0.46 (NR)
Ichwan, 2015[72] Moderate	Geriatric Triage Criteria vs. Adult Criteria OH	R: ICU stay	N=33,379 ≥70 years old NR	Sen: 81% (80 to 82) Sp: 48% (47 to 48) vs. Sen: 56% (55 to 57) Sp: 61% (60 to 62)	0.64 (NR) vs. 0.58 (NR)
Ichwan, 2015[72] Moderate	Geriatric Triage Criteria vs. Adult Criteria OH	I: ISS >15	N=33,379 ≥70 years old NR	Sen: 93% (92 to 93) Sp: 49% (48 to 49) vs. Sen: 61% (60 to 62) Sp: 61% (61 to 62)	0.71 (NR) vs. 0.61 (NR)
Ichwan, 2015[72] Moderate	Geriatric Triage Criteria vs. Adult Criteria OH	M: Mortality	N=33,379 ≥70 years old NR	Sen: 90% (89 to 91) Sp: 45% (45 to 46) vs. Sen: 74% (72 to 76) Sp: 60% (60 to 61)	0.68 (NR) vs. 0.67 (NR)
Newgard, 2016[90] Moderate	Alternative Guidelines vs. Current OH	I: ISS ≥16	N=33,298* ≥ 65 NR	Sen: 92.1% (89.8 to 94.5) Sp: 41.5% (40.6 to 42.4) vs. Sen: 75.9% (72.5 to 79.3) Sp: 77.8% (77.1 to 78.5)	0.67 (0.66 to 0.68) vs. 0.77 (0.75 to 0.79)

AUROC = area under the operating characteristic curve; CI = confidence interval; I = injury type or severity; ICU = intensive care unit; ISS = injury severity score; M = mortality; N = number; NR = not reported; OH = out-of-hospital; OR = operating room; R = resource use; Sen: sensitivity; SI = shock index; Sp = specificity; vs. = versus

*Patients in Newgard, 2016, a subset of patients in Newgard, 2014

Discussion

Key Findings

The key findings are based on our quantitative and qualitative syntheses of findings and data across 138 identified articles. In this report we provided an assessment of the strength of evidence for the sensitivity, specificity, and the area under the receiver operating characteristic curve (AUROC), for measures of circulatory and respiratory measures as well as measures that combine these with measures of consciousness. We generated pooled estimates and completed strength of evidence ratings separately for out-of-hospital and emergency department (ED) data to make any differences by setting apparent. We reported pooled estimates both by category (i.e., resource use, injury severity, and mortality) and then totaled across all indicators of risk of serious injury. The key estimates and strength of evidence ratings are provided in Appendix H and summarized in Tables 3, 4, and 5.

Most of the strength of evidence assessments were "low" due to inconsistency in results across studies and imprecision of the estimates, although in some cases study limitations also contributed to the low rating. There were a few "moderate" ratings for measures for which there were more studies or subjects, the results were consistent, and the estimates were more precise. There were no "high" strength of evidence ratings as we are not confident that the results will not change based on the results of larger, better, and more purposefully designed studies of physiologic measures for trauma triage.

Across all the measures, the AUROC values we calculated through meta-analysis generally fell into the ranges considered poor (0.60 to 0.69) or fair (0.70 to 0.79), with only the combination measures assessed with ED data reaching good to excellent (0.8 to 1.0). AUROCs are measures of discrimination that summarize the performance of the measure in terms of both sensitivity (the probability the patient who is seriously injured will be assessed as positive by the measure) and specificity (the probability a patient is not seriously injured will be assessed as negative). The lower AUROC values reflect the fact that in general the measures we identified have high specificities and low sensitivities when used to predict the risk of serious injury and the need for trauma care.

Our analysis of individual measures of circulatory and respiratory compromise (Key Question 1 and Key Question 2) included pooled analyses of systolic blood pressure (SBP), shock index (SI), heart rate (HR), lactate, and respiratory rate (RR), and qualitative summaries of studies of heart rate variability (HRV)/heart rate complexity (HRC), base deficit, and oxygen saturation. Other measures that were the subject of one or two studies were included for completeness but not synthesized.

Focusing on data collected out-of-hospital, the lowest pooled AUROCs were for SBP (0.67) and HR (0.67). The AUROCs were in the fair range for SI (0.72), lactate (0.77), and RR (0.70). The only AUROC that reached the excellent range was for the combination measure known as Glasgow Coma Scale, age, and arterial pressure (GAP), for which the pooled AUROC estimate based on ED data was 0.96.

We also pooled data to estimate sensitivity and specificity results for blood pressure and lactate at different thresholds (>90 or >100 mmHg for blood pressure and >2 or >4 mmol/L for lactate). Using the higher threshold for SBP did increase sensitivity (from 19% to 35% for out-of-hospital and 18% to 35% for ED) with a moderate decrease in specificity (from 95% to 88% for out-of-hospital and from 97% to 89% in ED). The changes were more extreme in the out-of-hospital data (sensitivity was 74% at <90 and 23% at <100; specificity increased from 62% to

93%) than in the ED data (sensitivity was 74% at <90 and 50% at <100; specificity increased from 52% to 86%). However, the out-of-hospital estimates were from fewer studies and patients and the estimates were less stable and less precise. For lactate, defining abnormal with a more extreme value (>4 mmol/L vs. > 2 mmol/L) decreased sensitivity from 74 to 23 percent and increased specificity form 62 to 93 percent.

We identified numerous combination measures (Key Question 3); however, most were analyzed in only one or two articles. The exception was the Revised Trauma Score (RTS) and variations on this score. The RTS has been examined primarily in studies that compare several measures; it was used as a tool for evaluation of these measures more than as a triage or assessment tool with specific cuts offs in the field. Given that the formula for RTS cannot be calculated quickly without a calculator or app, some studies suggested and evaluated revisions that simplified the calculation. These produced minor decreases in AUROCs (from 0.90 for the RTS to 0.88[96] for the simpler version, or from 0.75 to 0.74[95]).

Another combination of potential interest is GAP, which combines the Glasgow Coma Scale, adds points if the patient is under 60 years of age (age is the A in GAP), and scores SBP as above or below 120 mmHg. While the data we reviewed are from a smaller number of studies and the measures were all collected in the ED, the initial indications are that the GAP performs well. Reported AUROCs were over 0.9 and sensitivities ranged from 75 to 98 percent and specificities from 57 to 91 percent across different indicators of serious injury.

We examined the utility of the measures or specific thresholds for pediatric or older trauma patients. The research identified in this review underscores the importance of age. Children, adults, and older people differ physiologically and their responses to trauma differ. While some measures may work across age groups, others may be less useful and new measures or approaches are needed. The available body of research in this area is exploratory and growing. Few studies took steps to separate results by age, although it would seem to be possible. For studies of children, the focus was often on considering whether adult triage thresholds were appropriate or should be changed. The message across studies was that adult triage approaches are generally useful for pediatrics but refinements could increase their predictive utility. For older people, the studies attempted to identify new thresholds with better predictive utility or they incorporated age into the calculation, essentially adjusting the measure.

The included studies that assessed measures in pediatric patients reported that the standard thresholds used for adults for SBP and base deficit resulted in low sensitivities in children. Lactate >2.0 mmol/L resulted in higher sensitivities compared with the other measures, but the values are still low. Performance of this measure varied across indicators of serious injury and in age groups in the one study with subgroup comparisons; however, larger studies are needed to confirm these variations. The results of evaluations of RR were inconsistent, with reported sensitivities ranging from 2 to 76 percent. As in studies of adults or mixed age populations, the studies of combination measures performed better with better results with a trauma score developed specifically for pediatrics. Using the physiologic measures from the current adult triage guidelines resulted in lower sensitivity (49%) than the customized measures but was still better than individual measures, according to one study.[77]

In older adults, studies reported consistently low sensitivities and AUROCs for SBP, lactate, base deficit, RR, and assisted ventilation. SI performed less well in older patients. One study reported that when patients were stratified into age groups by decade, the correlation between SI and outcomes decreased with older age to the point that in patients over age 80, SI was not significantly correlated with any outcomes.[87] Variations of triage criteria modified for older

adults by either changing thresholds or adding additional criteria (e.g., mechanism of injury) may be promising in that they have demonstrated substantial increases in sensitivity (e.g., 76% to 92%[90]), but this magnitude of improvement is not consistent across indicators of serious injury and may come with similar substantial decreases in specificity (e.g., 78% to 42%[90]).

Overall, our analysis demonstrates that physiologic measures have low sensitivity for identifying high-risk trauma patients (i.e., many patients will have normal physiology and prove to have serious injuries—there are higher numbers of false negatives), but have high specificity (i.e., patients with abnormal physiologic measures are likely to have resource needs, serious injuries, and are at higher mortality risk—there are few false positives). There was little evidence to suggest that one physiologic measure is significantly better than another (e.g., SBP versus SI versus lactate) because fewer studies compared these measures directly in head-to-head studies, the head-to-head studies were not amenable to pooling as they use different thresholds and outcomes, and the differences across our pooled estimate were small to moderate. However, combining different categories of physiologic measures (e.g., circulatory and level of consciousness) may increase predictive yield. Overall, less extreme cut-points (e.g., lactate >2 mmol/L, SBP <110 mmHg) raised sensitivity and lowered specificity, demonstrating that sensitivity and specificity have an inverse relationship when selecting dichotomous cut-points in continuous measures.

Findings in Relationship to What Is Already Known

We did not identify any prior systematic reviews that attempted to summarize evaluations of multiple measures of circulatory and respiratory compromise and make comparisons across studies and across measures. We did identify two reviews that focused exclusively on lactate, we reviewed the studies identified in this review, and we included those that met our inclusion criteria. Our analysis differs in that we were able to report the pooled results rather than qualitatively synthesizing the results, and in that we were able to report pooled sensitivities and specificities in addition to AUROCS for lactate thresholds of >2 and >4 mmol/L. This provides a way to explore the impact of changing the threshold and to consider the tradeoffs between sensitivity and specificity.

One of the prior reviews identified five studies that evaluated lactate as a marker for mortality in the ED and concluded that initial lactate does not identify patients at high risk of death.[196] A more recent and comprehensive review assessed ED lactate as predictor of mortality and other outcomes such as intensive care unit (ICU) admission and blood loss. Updated in March 2016, this review identified, assessed, and summarized 28 studies.[197] The review did not attempt to pool the study results, and it did not compare the utility of lactate to other measures. The authors concluded that initial lactate measured in the ED was predictive of mortality, although only three of eight studies reported an AUROC of 0.8 or higher.

Applicability

Our findings were based on a relatively large number of diverse studies, with the majority conducted in the United States and several multi-site studies. Some of the studies were large retrospective analyses of trauma databases, while others were smaller prospective studies designed to evaluate a less common measure or a specific monitoring technology. A small number (3 studies) were conducted in Iraq and Afghanistan in military hospitals that treated mostly military casualties. Table 2 provides an overview of this diversity and details on the studies are included in the evidence tables in Appendix D.

Given the objectives of this review, this diversity is an advantage as well as a challenge. Differences across studies can make synthesis problematic—increasing heterogeneity in pooled estimates and making it difficult to construct a framework for qualitative synthesis. These differences are critical when synthesizing comparative studies because if the studies differ in important ways, the comparisons may not be similar enough to combine. However, the objective of this review was different. Our goal was to identify physiologic measures that can be used to assess whether patients are high risk for serious injury and evaluate their predictive utility. Having data from studies across a wide range of possible situations mirrors the reality of field triage and out-of-hospital assessment. While the diversity across the studies means heterogeneity is high in the pooled estimates, the range is likely to reflect the variation that will be seen in trauma assessment and triage across different locales as well as within the patients served by a trauma system.

An important consideration for applicability is the location of assessment and measurement. We included studies in which the data were collected in the ED if studies clearly identified data as being collected immediately upon presentation to the ED. These data were less applicable to field triage decisions as the patients had already been transported and had undergone initial treatment. However, not including ED data would have prevented us from including certain measures at all (e.g., base deficit would not be included as we did not identify any out-of-hospital studies) or only limited data on others (e.g., information on lactate testing out-of-hospital is available from few studies). Additionally, for some measures the settings were limited to a certain type (e.g., all the studies of HRC were conducted in air ambulances, and some measures were designed specifically for mass casualty situations even though they were tested on data from single trauma incidents), and it was unclear if the results would be similar if the measures were used in different situations or more broadly.

An approach to summarizing the data across studies and then comparing and considering their impact is presented in Table 37. This is a standard approach often used to present the implications of how well a screening test or triage tool performs. The pooled data are modeled to generate positive and negative likelihood ratios (LR+ and LR-). The positive likelihood ratio is Sensitivity/(1-Specificity) and the negative likelihood ratio is (1-Sensitivity)/Specificity. The likelihood ratios are then applied to different hypothetical pretest probabilities and odds to produce post-test odds of the outcome (in this case serious injury) given a negative or positive test. Table 37 shows values derived for SBP at thresholds of <90 and <100 mmHg, and for HR ≥100, SI >1, lactate >2 and >4 mmol/L, and RR <10 or >29.

Table 37. Post-test odds and probability of serious injury given pre-test assumptions

Physiologic Predictor (Test)	**Serious Injury Indicator (Outcome)**	**Pre-test Probability (Hypo-thetical)**	**Pre-Test Odds**	**LR+**	**LR-**	**Post-Test Odds** (if a patient has positive test)	**Post-Test Probability (PPV)** (if a patient has positive test)	**Post-Test Odds** (if a patient has negative test)	**Post-Test Probability (1-NPV)** (if a patient has negative test)
SBP <90	Resource Use	10%	0.11	4.32	0.83	0.48	32%	0.09	8%
SBP <90	Resource Use	20%	0.25	4.32	0.83	1.08	52%	0.21	17%
SBP <100	Resource Use	10%	0.11	3.30	0.80	0.36	27%	0.09	8%

Physiologic Predictor (Test)	Serious Injury Indicator (Outcome)	Pre-test Probability (Hypo-thetical)	Pre-Test Odds	LR+	LR-	Post-Test Odds (if a patient has positive test)	Post-Test Probability (PPV) (if a patient has positive test)	Post-Test Odds (if a patient has negative test)	Post-Test Probability (1-NPV) (if a patient has negative test)
SBP <100	Resource Use	20%	0.25	3.30	0.80	0.83	45%	0.20	17%
HR ≥ 110	Resource Use	10%	0.11	1.37	0.91	0.15	13%	0.10	9%
HR ≥ 110	Resource Use	20%	0.25	1.37	0.91	0.34	25%	0.23	19%
SI >1	Resource Use	10%	0.11	3.13	0.71	0.34	26%	0.08	7%
SI >1	Resource Use	20%	0.25	3.13	0.71	0.78	44%	0.18	15%
Lactate >2*	Resource Use	10%	0.11	1.94	0.29	0.21	18%	0.03	3%
Lactate >2*	Resource Use	20%	0.25	1.94	0.29	0.48	33%	0.07	7%
Lactate >4*	Resource Use	10%	0.11	2.34	0.59	0.26	21%	0.07	6%
Lactate >4*	Resource Use	20%	0.25	2.34	0.59	0.59	37%	0.15	13%
RR <10 or >29	Resource Use	10%	0.11	5.61	0.90	0.62	38%	0.10	9%
RR <10 or >29	Resource Use	20%	0.25	5.61	0.90	1.40	58%	0.23	18%

HR = heart rate; LR+ = positive likelihood ratio; LR- = negative likelihood ratio; NPV = negative predictive value; PPV = positive predictive value; RR = respiratory rate; SBP = systolic blood pressure; SI = shock index

*Lactate >4 is based on Emergency department data; Lactate >2 is out-of-hospital

While the ideal would be for a measure to have both high sensitivity and high specificity, this combination of favorable predictive properties is often difficult or impossible to achieve. Either low sensitivity or low specificity can be problematic in trauma triage, but for different reasons.

For most of the measures we evaluated sensitivities were low. As sensitivity is defined as “true positives” divided by the sum of “true positives” plus “false negatives”, measures with low sensitivity produce a relatively high number of “false negatives”—that is, a high proportion of people who have normal values (a negative test) are actually at high risk of being seriously injured (i.e., the “disease or condition we are using the physiologic measure to detect). With low sensitivity an emergency medical services (EMS) provider cannot be confident that a person is truly negative (NOT seriously injured) based on a normal value for that measure (SBP >100 mmHg or lactate <2 mmol/L).

Specificity is defined as “true negatives” divided by the sum of “true negatives” plus “false positives”, so as the specificity gets higher (closer to 100%) the number of false positives approaches zero. When specificity is high, a positive test, in this case an abnormal value on a measure, is less likely to be a false positive (the patient is not seriously injured) and more likely

to represent a true positive (the patient is seriously injured). Therefore, abnormal values on measures with high specificity should alert an EMS provider that the patient is likely at high risk.

It is important to note that the measures summarized in this report are almost always part of a larger assessment. For example, clinical judgment and experience affect appraisals of the clearly visible injuries, and trauma site characteristics can play a major role in determining appropriateness of trauma center triage. The national triage guidelines include over 20 different criteria representing physiologic, anatomic, mechanism, and special considerations.[12] Additionally, although not all measures were compared individually or in combination in the studies included in this report, trauma triage in practice requires consideration of many measures simultaneously or in combination. Essentially, no single measure or variable is likely to ever be sufficient as the sole criterion for determining the need for trauma center care. Identifying those measures that are best able to quickly and accurately identify patients who do need such care is clinically useful and motivates the search for measures with better discrimination.

Limitations of the Evidence Base

The major limitations of the evidence base are the limited number of head-to-head comparisons and generally low strength of evidence available. As this review illustrates, there are a number of potential physiologic measures that could be used in triage and a range of indicators of serious injury used in this body of research. Our approach to this diversity was to focus on combining information for the same measure across studies and then looking across the measures. If we had limited our examination to head-to-head comparisons we would have had small numbers of studies in each of a larger number of pairwise comparisons. However, there is a risk in comparing measures across studies rather than relying on comparisons within studies. Measures in different studies may produce similar results but for different populations. For example, if estimates of the AUROC for SBP and HR are similar, but based on different studies with different populations, we could erroneously conclude that they will perform similarly across all patients when in truth SBP has this discriminant level for one subtype of patients while HR is similar but in a different subtype of patients.

In order to assess this risk, we examined the results of head-to-head studies as well. We reviewed all the combinations studied, but in many cases there were few head-to-head studies that used similar evaluation approaches (e.g., for respiratory measures there were two studies that compared RR and SpO_2; only one reported AUROCs[94] while the other calculated adjusted odds ratios[131]). Table 38 below provides an example of this by providing information from the out-of-hospital studies that compared the AUROCs for two physiologic measures directly. The results of all head-to-head comparisons are included in the evidence tables in Appendix D.

Table 38. Out-of-hospital head-to-head studies comparing physiologic measures

Comparison Measure 1 Vs. Measure 2	Author, Year	Indicator of Serious Injury	AUROC (95% CI) Measure 1	AUROC (95% CI) Measure 2	Measure Favored; Magnitude of Difference*
SBP vs. HR	Chen, 2010[55]	Major hemorrhage	0.75 (0.65 to 0.84)	0.62 (0.50 to 0.73)	SBP; large
SBP vs. HR	Edla, 2015[59]	Blood transfusion ≥9 pRBC units in 24 hours	0.73 (0.55 to 0.86)	0.72 (0.53 to 0.85)	SBP; small
SBP vs. HR	Grimme, 2005[62]	Organ failure	0.564 (NR)	0.579 (NR)	HR; small
SBP vs. HR	Van Haren, 2014[103]	Life saving intervention	0.544 (NR)	0.535 (NR)	SBP; small
SBP vs. HR	Vettorello, 2013[106]	Blood transfusion or bleeding control	0.911 (0.824 to 0.963)	0.835 (0.734 to 0.909)	SBP; moderate
SBP vs. HR	Woodford, 2012[107]	Mortality	0.55 (0.34 to 0.77)	0.65 (0.44 to 0.86)	HR; moderate
SBP vs. SI	Chen, 2007[52]	Major hemorrhage	0.71 (0.706 to 0.714)	0.77 (NR)	SI; moderate
SBP vs. SI	Grimme, 2005[62]	Organ failure	0.564 (NR)	0.684 (NR)	SI; large
SBP vs. SI	Guyette, 2015[65]	Need for resuscitative care	0.59 (0.53 to 0.66)	0.66 (0.60 to 0.74)	SI; moderate
SBP vs. SI	Haider, 2016[66]	Trauma center need	0.526 (0.524 to 0.527)	0.534 (0.532 to 0.535)	SI; small
SBP vs. SI	Pottecher, 2016[93]	Massive transfusion (≥10 units in 24 hours)	0.61 (0.57 to 0.64)	0.802 (0.74 to 0.87)	SI; large
SBP vs. Lactate	Guyette, 2015[65]	Need for resuscitative care	0.59 (0.53 to 0.66)	0.78 (0.73 to 0.83)	Lactate; large
SI vs. Lactate	Guyette, 2015[65]	Need for resuscitative care	0.66 (0.60 to 0.74)	0.78 (0.73 to 0.83)	Lactate; large
RR vs. SpO_2	Raux, 2006[94]	Mortality	0.691 (0.644 to 0.738)	0.747 (0.704 to 0.790)	SpO_2; moderate

CI = confidence interval; HR = heart rate; NR = not reported; pRBC = packed red blood cell; RR = respiratory rate; SBP = systolic blood pressure; SI = shock index

*Definitions for magnitude of differences in AUROCs: small <0.05, moderate 0.05 to 0.10, large >0.10

The literature available for analysis was dominated by studies that effectively limited their population to trauma patients who are transported by EMS. Most of the studies were based on data from trauma registries. While the specifics for inclusion vary across registries and also across studies that use administrative records in a similar way, standard practice seems to be to include data on patients transported and/or admitted. The implication is that patients assessed by EMS and not transported are either not included at all or included inconsistently.

Another characteristic of the data in these registries is that it is usually collected prospectively but analyzed retrospectively, thus blurring the distinction between prospective and retrospective study designs. In many cases data sources are difficult to determine based on the published reports. Analysis is also complicated by the fact that the registry studies usually have large samples, while the more clearly prospective studies we identified were often exploratory

with small samples. This distinction matters because in other situations we might be able to make assumptions about the potential for differences in bias in prospective and retrospective studies, but in this literature the direction of the potential bias is not clear.

Another deficiency in the evidence is the lack of detail about how the physiologic measure data were collected. Studies rarely reported details that could be important, such as what equipment was used, how and when the measurement was taken, and who was involved. Many of the measures of physiologic compromise can be taken in different ways. For example, blood pressure can be recorded using automated cuffs or recorded by emergency personnel manually. These measurements may be taken at specific times or monitored continuously during assessment and transport. Similarly, lactate may be measured from venous, arterial, or capillary blood. In addition to instrumentation, timing matters. Identifying that measurements were taken either out-of-hospital or in the ED is a start, but with trauma the situation is dynamic and changes occur rapidly. Knowing whether a measurement was first taken on arrival at the scene or if it was after resuscitation or during transport would allow us to examine the impact of timing on the pattern of values and identify whether their ability to predict serious injury varies with the timing of measurement. Finally, information on the training or role of the person doing the assessment was almost never reported. EMS personnel include people with different levels of training, and some studies involved nurses or physicians who traveled with special trauma units or air ambulances. Even in EDs it is not necessarily a given how the data are collected. The impacts of instrumentation, timing, or training on measurement may be small or they may be significant. The concern is that when detail in not provided in the research reports, neither sensitivity analysis nor an analysis of trends is possible, making it harder to determine if the variability seen both across and within studies could be related to measurement differences.

An important limitation of the evidence base is the lack information on subpopulations, particularly children and older adults. Most studies either included all patients or limited their population only to adults, which was defined differently, ranging from over 14 years old to over 18 years old, and to those under 60, or to all ages. Fewer studies specifically focused on children or older adults and those that did were split between studies that only studied one group and those that made comparisons across age groups.

Gaps in the evidence base included the limited number of studies available for some measures or the lack of studies in the field. In some cases, measures have only been evaluated in a small number of studies (e.g., $ETCO_2$). Other measures have only been tested in a particular setting: all the studies of base deficit were based on ED measurement; most studies of HRC were studies in which the patients were transported via helicopter; and most of the lactate studies did not use point-of-care measurement, likely due to the limited availability of the devices, although an assessment of the devices was beyond the scope of this review.

Studies also varied and were inconsistent in defining and using indicators of serious injury. We included a broad range of indictors divided into four categories, created to group the studies: resource use, injury severity or type, mortality, or composites that mixed indicators from two or all three of these groups. The studies tended to select a specific indicator, such as need for a massive transfusion, rather than include multiple indicators, and the definitions varied across studies (e.g., what volume is considered massive and over what time period). While the trauma research community has made efforts to come up with a comprehensive definition (i.e., the consensus-based criteria[25] and lists of life-saving interventions), these are not yet widely used. The result is that many studies may underestimate the utility of measures by requiring that they predict a single or narrowly defined set of indicators for risk of severe injury.

Limitations of the Review Process

There were also limitations to this review resulting from our decisions and processes. These included both conceptual and technical issues.

Evaluating physiologic measures in terms of their ability to estimate need for trauma center care asks a predictive utility question. While we identified and included studies of predictive utility, we also included prognostic studies. These are similar but not identical. The structure of the studies differed in that predictive utility studies usually started with one or more measure and quantified the measure's relationship with an indicator of serious injury such as admission to the ICU or need for blood transfusion. The prognostic studies were often more exploratory and iterative, in that they identified several variables and looked for which variables differed across an outcome. Most of the prognostic studies sought to determine what characteristics are shared by patients who died and what differed from those who survived or what patients needed or didn't need a specific resource such as blood transfusion. There may be underlying differences in these two approaches that affected our results. An important related consideration is that mortality is not the most relevant indicator of severity of injury and need for trauma care, as mortality is usually impacted by the care received. Resource use and injury type or severity occur closer to the time of injury and are not as likely as mortality to be affected by as many intervening factors.

The fact that we included measurements in the ED as well as out-of-hospital was another limitation. However, we attempted to mitigate this by presenting the ED and out-of-hospital results separately to underscore the likelihood that the results for each subgroup were influenced by the setting in which the measures were obtained.

Similarly, we included a wide range of indicators of serious injury, but we grouped them into categories (resource use, injury severity or type, mortality, and composites). We reported results separately by these categories in the plots in the text and reported the specific indicator used in each study in the evidence tables in Appendix D. We computed pooled estimates for studies in each group and a total that combined all groups. These subtotals and overall totals may not be viewed as appropriate, depending on one's assessment of whether the equivalence within each group and across all indicators is considered reasonable.

Our approach to meta-analysis involved first using the random effects DerSimonian-Laird model to pool data and evaluate heterogeneity. As statistical heterogeneity was high, this estimator can result in confidence intervals (CIs) that are too narrow.[198] To address this, we also used bivariate and profile likelihood methods, alternative random effects model, and though the results were similar we reported these more accurate estimates. While this may partially address the statistical heterogeneity, it does not negate the fact that the pooled estimates required combining studies that differ in important ways.

Future Research Needs

This review summarized a sizable body of literature, but also highlighted several areas in which future research is needed. One priority is studies that compare, or at least document, factors that directly affect measurement (instrumentation, timing, etc.). This would allow the impact of these differences on the predictive utility of the measure to be considered.

Increasingly, the amount of technology available to field providers is changing practice. Ideally, some of these technologies could incorporate smart software (e.g., in out-of-hospital monitors) that integrates different measures to better identify seriously injured patients. Since

these measures are dynamic and can be obtained continuously, the monitor could be placed and then followed or trended to see if there is something of concern. Other technological advances may facilitate measurement in the field. This is the case with the development of point-of-care testing for lactate and may be the case with other measures in the future.

Our findings demonstrated the high specificity and low sensitivity of physiologic measures used in trauma. There are different possible reasons for this that could be explored or delineated in future research. It is possible that responses to trauma vary across individuals given their physiologic reserve. Perhaps the changes in physiology observable in the field are not of a magnitude that the measures can ever be effectively sensitive. It may be that our current measurement methods are relatively crude and not able to detect important changes or differences. Technological advances in monitoring may be able to produce measurement that is automated (removing some human error), and more sensitive to smaller changes or to changes that occur more immediately after injury.

An additional priority would be to encourage more research using the consensus-based criteria of the need for trauma care or a standardized list of life-saving interventions. If the indicators of serious injury were consistent, cleaner comparisons could be made both across studies and across measures. This would also permit an assessment of the utility of individual measures in a broader context. For example, this approach to research would make it possible to say whether lactate is limited to predicting need for transfusion or if it predicts other indicators of injury as well.

Our findings suggest, but are not sufficient to conclude, that combination measures have a yet unrealized potential to improve field triage and assessment. Modeling or other simulation studies may be able to add to our understanding as to whether and how individual measures could be combined to improve predictive utility. However, parallel research or device development would also be needed to learn about how these combination measures could be collected and reported so that they would be feasible for EMS personnel to use out-of-hospital.

Another key topic for additional research is the assessment of the utility of measures across age groups. While we did identify some studies that considered the use of physiologic measures for children and older adults, this is still a small subset of the literature and many questions remain. Given the likelihood that many existing studies collected (but did not analyze) data on age, future research could combine age-related data across these studies and obtain large enough samples to meaningfully stratify results and examine age-related subgroup differences.

Implications

For out-of-hospital clinical practice, our findings demonstrated that current circulatory and respiratory measures have low sensitivity but higher specificity. Our findings also suggested equivalence in predictive value across multiple circulatory and respiratory measures. The evidence does not point to necessarily “better” cut-points for measures such as SBP, SI, and RR. In general, more liberal cut-points (e.g., SBP <110 mmHg vs. <90 mmHg) will raise sensitivity and lower specificity—an inevitable trade-off—but the magnitude of this trade-off may differ across tests. However, based on the evidence we identified, no physiologic measures have high enough sensitivity that a negative result (that is normal physiologic values) could be confidently used to conclude that a patient is not at risk of being seriously injured, even with more liberal cut-points.

Conclusions

While specifics vary across measures, settings, and populations, overall the predictive utilities of physiologic measures that are either currently used for trauma assessment and triage, or have been suggested, are moderate and not ideal. Measures of circulatory compromise (SBP, HR, SI, lactate) and respiratory compromise - have been evaluated in multiple studies, some with large numbers of patients. In general, these measures have low sensitivities, high specificities, and AUROCs in the fair-to-good range. Use of these measures should be guided by the understanding that when they are abnormal, they are highly predictive of high risk of serious injury in trauma patients, but that many patients with serious injuries will have normal physiologic measures. Combinations of these measures with assessments of consciousness seem to perform better, but how they would be implemented out-of-hospital needs to be determined, and then they need to be tested under field conditions to confirm their effectiveness and utility. Modification of triage measures for children or older adults is needed, given that these measures perform worse in these age groups than in adults; however, the research has not yet identified better performing variations or replacements.

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Abbreviations and Acronyms

Abbreviation/Acronym	Term
AHRQ	Agency for Healthcare Research and Quality
APACHE II score	Acute Physiology and Chronic Health Evaluation II Score
ASPTS	Age-Specific Pediatric Trauma Score
AUROC	area under the receiver operating characteristic curve
BD	base deficit
bpm	beats per minute
C	Composite
CHAID	chi-square automatic interaction detection
CI	confidence interval
CO_2	carbon dioxide
CRAMS	Circulation, Respiration, Abdomen, Motor, Speech
CT	computed tomography
DBP	diastolic blood pressure
DFA	detrended fluctuations analysis
ECG	Electrocardiogram
ED	emergency department
EMS	emergency medical services
EMT	emergency medical technician
EMTRAS	Emergency Trauma Score
$ETCO_2$	end-tidal carbon dioxide
FTS	Field Triage Score
GAP	Glasgow Coma Scale, age, and arterial pressure
GCS	Glasgow Coma Scale
HF	high frequency
HR	heart rate
HRC	heart rate complexity
HRV	heart rate variability
I	injury type or severity
ICU	intensive care unit
iHat	heart-to-arm time index
IQR	interquartile range
ISS	Injury Severity Score
KQ	Key Question
LF	low frequency
LOS	length of stay
LSI	life-saving intervention
M	Mortality
MAP	mean arterial pressure
MGAP	mechanism, Glasgow Coma Scale, age, and arterial pressure
MPTT	Modified Physiological Triage Tool
mREMS	modified Rapid Emergency Medicine Score
NA	not applicable
NHTSA	National Highway Transportation Safety Administration
NR	not reported
NTTP	National Trauma Triage Protocol
O_2	Oxygen
OH	out-of-hospital
pCO_2	partial pressure of carbon dioxide
PICOTS	population, intervention, comparator, outcome, timing, setting
PHI	Prehospital Index

Abbreviation/Acronym	Term
PP	pulse pressure
PPG	photoplethysmography, photoplethysmogram
PPV	positive predictive value
pRBC	packed red blood cell
PTS	Pediatric Trauma Score
QUIPS	Quality in Prognosis Studies
R	resource use
R-to-R interval	time between heart beats
REMS	Rapid Emergency Medicine Score
RR	respiratory rate
RSA	rate of sinus arrhythmia
RTS	Revised Trauma Score
SampEn	sample entropy
SaO_2	oxygen saturation
SBP	systolic blood pressure
SD	standard deviation
SDNN	standard deviation of the normal-to-normal intervals
SE	standard error
Sen	sensitivity
SETS	Simplified Emergency Trauma Score
SI	shock index
$SLCO_2$	sublingual partial pressure of carbon dioxide
SmO_2	muscle oxygen saturation
SOE	strength of evidence
Sp	specificity
SpO_2	peripheral oxygen saturation
START	Simple Triage and Rapid Treatment
StO_2	tissue oxygen saturation
T-ASPTS	Triage Age-Specific Pediatric Trauma Score
T-RTS	Revised Trauma Score for Triage
TC	trauma center
TEP	Technical Expert Panel
ViEWS	VitalPAC Early Warning Score
ViEWS-L	modified VitalPAC Early Warning Score with rapid lactate level
VLF	very low frequency

Appendix A. Search Strategies

Database: Ovid MEDLINE(R) -

1 exp "Wounds and Injuries"/
2 (prehospital or trauma or traumatic).mp.
3 exp Emergency Medical Services/
4 (EMS or ambulance or transport* or triage).mp.
5 (1 or 2) and (3 or 4)
6 exp Vital Signs/
7 exp Shock/
8 exp "circulatory and respiratory physiological phenomena"/
9 ("systolic blood pressure" or SBP or "mean arterial pressure" or "heart rate" or "shock index").mp.
10 (airway and (intervention or management)).mp.
11 (respira* and (rate or effort)).mp.
12 ("tissue oxygen saturation" or "end-tidal" or "lactate").mp.
13 or/6-12
14 5 and 13
15 limit 14 to humans

Database: EBM Reviews - Cochrane Central Register of Controlled Trials -

1 exp "Wounds and Injuries"/
2 (prehospital or trauma or traumatic).mp.
3 exp Emergency Medical Services/
4 (EMS or ambulance or transport* or triage).mp.
5 (1 or 2) and (3 or 4)
6 exp Vital Signs/
7 exp Shock/
8 exp "circulatory and respiratory physiological phenomena"/
9 ("systolic blood pressure" or SBP or "mean arterial pressure" or "heart rate" or "shock index").mp.
10 (airway and (intervention or management)).mp.
11 (respira* and (rate or effort)).mp.
12 ("tissue oxygen saturation" or "end-tidal" or "lactate").mp.
13 or/6-12
14 5 and 13

Database: EBM Reviews - Cochrane Database of Systematic Reviews

1 ("systolic blood pressure" or SBP or "mean arterial pressure" or "heart rate" or "shock index").mp. [mp=title, abstract, full text, keywords, caption text] (1001)
2 (airway and (intervention or management)).mp. [mp=title, abstract, full text, keywords, caption text] (787)
3 (respira* and (rate or effort)).mp. [mp=title, abstract, full text, keywords, caption text] (2033)
4 ("tissue oxygen saturation" or "end-tidal" or "lactate").mp. [mp=title, abstract, full text, keywords, caption text] (203)

5 or/1-4 (2845)
6 (prehospital or pre-hospital or trauma or traumatic or EMS or ambulance or transport* or triage).ti. (119)
7 5 and 6 (23)

Database: CINAHL Plus with Full Text
S1 (MH "Wounds and Injuries+")
S2 (MH "Trauma+")
S3 (MH "Prehospital Care")
S4 (MH "Emergency Medical Services+")
S5 (MH "Transportation of Patients+")
S6 S1 OR S2
S7 S3 OR S4 OR S5
S8 S6 AND S7
S9 (MH "Cardiopulmonary Physiology+")
S10 (MH "Respiratory Tract Physiology+")
S11 S9 OR S10
S12 S8 AND S11
S13 S12 Limiters - Published Date: 19960101-20161231

Database: Elsevier Embase
((('injury'/exp or prehospital:ab,ti or trauma:ab,ti or traumatic:ab,ti) and ('emergency health service'/exp or ems:ab,ti or ambulance:ab,ti or transport*:ab,ti)) and ('vital sign'/exp or 'shock'/exp or 'cardiovascular function'/exp)) and [embase]/lim not [medline]/lim and ('article'/it or 'article in press'/it or 'review'/it) and (1996:py or 1997:py or 1998:py or 1999:py or 2000:py or 2001:py or 2002:py or 2003:py or 2004:py or 2005:py or 2006:py or 2007:py or 2008:py or 2009:py or 2010:py or 2011:py or 2012:py or 2013:py or 2014:py or 2015:py or 2016:py or 2017:py) and 'human'/de

Appendix B. List of Included Studies

1. Ahun E, Koksal O, Sigirli D, et al. Value of the Glasgow Coma Scale, Age, and Arterial Blood Pressure score for predicting the mortality of major trauma patients presenting to the emergency department. Ulus Travma Acil Cerrahi Derg. 2014;20(4):241-7. doi: 10.5505/tjtes.2014.76399. PMID: 25135017.

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Appendix C. List of Excluded Studies

Table C1. Exclusion code key

Codes	Reason
2	Background or discussion paper only, no data for evidence
3	Not trauma patients (non-human population, patients without known or suspected trauma, transferred patients, chemical exposure, burns)
4	No included measure (the study does not evaluate a measure of respiration, circulation, or combination, measures temperature or coagulation, or evaluates a treatment)
5	No indicator of serious injury (study does not evaluate a measure in terms of predicting any of our indicators of serious injury)
6	No assessment of predictive utility (study does not include a predictive utility measure such as diagnostic accuracy, risk ratios, AUROC)
7	Ineligible setting (in hospital not ED, not immediately upon arrival in ED, studies conducted in the developing world)
8	Ineligible study design (case reports, case series, cross-sectional studies, modeling studies)
9	Ineligible publication type (opinion, editorial, letter, guideline document)
10	Review not meeting our requirements (ineligible study designs, no quality rating, only one database searched, non-systematic review, more updated review available, not in English)
11	Studies outside of search dates (published before January 1996)
12	Indirect studies that do not address one of the subgroups of interest
13	Not English language but may be relevant
14	Population restricted to seriously injured (study sample limited major trauma patients automatically transported to trauma center [ISS >15, BP<90 mmHg, GCS 8 or less])
15	Insufficient data

AUROC = area under the receiver operating characteristic curve; BP = blood pressure; ED = emergency department; GCS = Glasgow Coma Scale; ISS = Injury Severity Score

Excluded Studies With Exclusion Code

Abe T, Takahashi O, Saitoh D, et al. Association between helicopter with physician versus ground emergency medical services and survival of adults with major trauma in Japan. Crit Care. 2014;18(4):R146. doi: 10.1186/cc13981. PMID: 25008159. Exclusion: 14.

Acker SN, Ross JT, Partrick DA, et al. Pediatric specific shock index accurately identifies severely injured children. J Pediatr Surg. 2015;50(2):331-4. doi: 10.1016/j.jpedsurg.2014.08.009. PMID: 25638631. Exclusion: 14.

Afifi RY. Blunt abdominal trauma: back to clinical judgement in the era of modern technology. Int J Surg. 2008;6(2):91-5. doi: 10.1016/j.ijsu.2006.09.005. PMID: 18442804. Exclusion: 9.

Afshar M, Smith GS, Terrin ML, et al. Blood alcohol content, injury severity, and adult respiratory distress syndrome. J Trauma Acute Care Surg. 2014;76(6):1447-55. doi: 10.1097/TA.0000000000000238. PMID: 24854314. Exclusion: 4.

Akkose S, Ozgurer A, Bulut M, et al. Relationships between markers of inflammation, severity of injury, and clinical outcomes in hemorrhagic shock. Adv Ther. 2007;24(5):955-62. PMID: 18029320. Exclusion: 7.

Alter SM, Infinger A, Swanson D, et al. Evaluating clinical care in the prehospital setting: is Rapid Emergency Medicine Score the missing metric of EMS? Am J Emerg Med. 2017;35(2):218-21. doi: 10.1016/j.ajem.2016.10.047. PMID: 27890300. Exclusion: 3.

Andruszkow H, Schweigkofler U, Lefering R, et al. Impact of helicopter emergency medical service in traumatized patients: which patient benefits most? PLoS ONE. 2016;11(1):e0146897. doi: 10.1371/journal.pone.0146897. PMID: 26771462. Exclusion: 14.

Aoki N, Demsar J, Zupan B, et al. Predictive model for estimating risk of crush syndrome: a data mining approach. J Trauma. 2007;62(4):940-5. PMID: 17426552. Exclusion: 14.

Ardagh MW, Hodgson T, Shaw L, et al. Pulse rate over pressure evaluation (ROPE) is useful in the assessment of compensated haemorrhagic shock. Emerg Med (Fremantle). 2001;13(1):43-6. PMID: 11476410. Exclusion: 5.

Arnold TD, Miller M, van Wessem KP, et al. Base deficit from the first peripheral venous sample: a surrogate for arterial base deficit in the trauma bay. J Trauma. 2011;71(4):793-7; discussion 7. doi: 10.1097/TA.0b013e31822ad694. PMID: 21841507. Exclusion: 5.

Arslan A, Flax L, Fraser R, et al. Twenty-four-hour packed red blood cell requirement is the strongest independent prognostic marker of mortality in ED trauma patients. Am J Emerg Med. 2016;34(6):1121-4. doi: 10.1016/j.ajem.2016.03.036. PMID: 27066932. Exclusion: 7.

Asensio JA, Demetriades D, Berne TV, et al. Invasive and noninvasive monitoring for early recognition and treatment of shock in high-risk trauma and surgical patients. Surg Clin North Am. 1996;76(4):985-97. PMID: 8782484. Exclusion: 9.

Asensio JA, McDuffie L, Petrone P, et al. Reliable variables in the exsanguinated patient which indicate damage control and predict outcome. Am J Surg. 2001;182(6):743-51. PMID: 11839351. Exclusion: 14.

Asimos AW, Gibbs MA, Marx JA, et al. Value of point-of-care blood testing in emergent trauma management. J Trauma. 2000;48(6):1101-8. PMID: 10866258. Exclusion: 6.

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Appendix D. Evidence Tables

Table D1. Study characteristics

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Ahun, 2014	Prospective	Turkey, Bursa Urban Trauma system level: NR Study time period: NR	100 analyzed	Initial data collected during hospitalization. Followup during 4-week period to calculate short-term and long-term mortality prediction rates.
Al-Salamah, 2004	Prospective	Canada, Ontario Urban and suburban Trauma system level: NR (trauma hospitals) 1/1/1993 to 2/21/1998 5 years, 3 months	795 analyzed 992 identified 127 excluded - 64 excluded for penetrating trauma - 43 excluded for burns - 20 excluded for missing data	Out of hospital data: OPALS Study database Hospital data: Ontario Trauma Registry Comprehensive Data Set
Allen, 2014	Retrospective	USA, Florida Urban Level I trauma center 1/2000 to 12/2012 13 years	1,928 analyzed	Trauma registry for a single trauma center.
Arbabi, 2004	Retrospective	USA, Washington and Michigan Urban Level I trauma centers 1/1994 to 12/2001 8 years	19,409 analyzed	Trauma registry data at two academic Level I trauma centers.

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used): % of Study Population	Type of Population
Ahun, 2014	Included: Major trauma patients ≥18 years old. Excluded: Pregnant patients and those with psychiatric illnesses.	Adults (≥18): 100%	Civilian
Al-Salamah, 2004	Included: Patients with blunt trauma, with records in the OPALS study database, and were entered into the Ontario Trauma Registry Comprehensive Data Set. The OPALS database includes patients who had an injury caused by any mechanism, ISS >12, and were transported by land ambulance within the study communities. Excluded: Patients with penetrating trauma or burns, or with missing data from the trauma registry.	Adults (≥16): 100%	Civilian
Allen, 2014	Included: Patients <18 years old. Excluded: Patients who were pregnant, incarcerated, or who were not admitted to the trauma or pediatric surgery service.	Pediatrics (<18): 100%	Civilian
Arbabi, 2004	Included: Adult trauma patients (≥18 years old) during study period. Excluded: Patients transferred from an outside hospital, and all burn patients.	Adults (≥18): 100%	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Ahun, 2014	Type of injury Blunt: 98% (98/100) Penetrating: 2% (2/100) Mechanism of injury In-vehicle traffic accident: 68% (68/100) Extravehicular traffic accident: 6% (6/100) Falling from a height: 13% (13/100) Motorbike accident: 11% (11/100) Injury by firearms: 1% (1/100) Sharp object injuries: 1% (1/100)	Ambulance: 99% (99/100) Private vehicle: 1% (1/100) Direct from scene: 80% (80/100) Transferred: 20% (20/100)	Male: 77% (77/100) Race: NR Age (mean): 40 (SD 16)	GAP score MGAP score RTS
Al-Salamah, 2004	Blunt: 100%	Land	Male: 70% Race: NR Age (mean): 44 (SD 21)	RR RTS SBP
Allen, 2014	Blunt: 76% Penetrating: 24%	NR	Male: 70% Race: NR Age (mean): 11 (SD 6)	BD
Arbabi, 2004	Blunt: 84% (16,277/19,409) Penetrating: 16% (3,132/19,409)	NR	Overall Male: 74% Race: NR Age (mean): 41 (SD 17)	SBP

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Ahun, 2014	ED: not specified	NR	NR	RTS calculated using score calculator available at www.trauma.org
Al-Salamah, 2004	ED: on arrival	NR	ED: trauma team	NR
Allen, 2014	ED: on arrival	NR	NR	NR
Arbabi, 2004	Out of Hospital: NR ED: NR	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Ahun, 2014	Scoring system cut-offs used 24-hour mortality GAP: 19 MGAP: 23 RTS: 5.68 4-week mortality GAP: 21 MGAP: 25 RTS: 5.97	Mortality: 24-hour Mortality: 4-week	NR	Moderate
Al-Salamah, 2004	Score cutpoints chosen as values at which there were similar sensitivities and specificities. RTS: <12	Mortality: In-hospital ICU Admission Required intubation in ED	NR	Moderate
Allen, 2014	BD: abnormal < 0 < -5 < -7	Blood transfusion: NR	Partial support by grant N140610670 from the Office of Naval Research and grant 09078015 from the U.S. Army Medical Research and Materiel Command.	Moderate
Arbabi, 2004	SBP <90, <120	Mortality: NR	NR	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Aslar, 2004	Prospective	Turkey, Ankara Urban Trauma system level: NR 3/1/1996 to 1/30/1998 1 year, 11 months	64 analyzed 149 identified 85 excluded - 21 excluded for major head injury - 2 excluded for known acid-base disturbances - 5 excluded for receipt of exogenous sodium bicarbonate prior to arterial blood gas and lactate analysis - 9 excluded for admission for observation only - 1 excluded for age <5 years - 22 excluded for thermal or penetrating injuries - 1 excluded for seizure - 7 excluded as dead on arrival	Prospective collection of ED admission data for a single hospital.
Baron, 2004	Prospective	USA, New York Urban Level I trauma center 7/2001 to 3/2002 9 months	108 analyzed	Primary data collection

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Aslar, 2004	Included: Patients with torso trauma admitted to the ED during the study period Excluded: Patients with major head injury, known acid-base disturbances, those who received exogenous sodium bicarbonate before arterial blood gas and lactate analysis, were admitted for observation only, were under age 5, had trauma caused by thermal and penetrating injuries, seizure, or were pronounced dead on arrival.	Pediatrics (≥5): 100%	Civilian
Baron, 2004	Included: Patients ≥13 years old with penetrating torso trauma. Excluded: Patients transferred from other hospitals and those who died in the ED.	Adults and adolescents (≥13): 100%	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Aslar, 2004	Mechanism of injury: -Traffic accident: 73% (47/64) -Fall: 11% (7/64) -Gunshot: 16% (10/64) Major injury site* Abdomen: 72% (46/64) Chest: 11% (7/64) Vascular: 8% (5/64) Orthopedics: 6% (4/64) NR: 3% (2/64) *Study limited to patients with torso trauma, and excludes those with penetrating trauma or burn injury.	NR	Male: 75% (48/64) Race: NR Age (mean): 36 (SD 19)	APACHE II score BD Lactate pH RTS SI Model: multivariate model with APACHE II score and lactate
Baron, 2004	Type of injury Penetrating: 100% Mechanism of injury Gunshot: 31% (33/108) Stab wound: 69% (74/108) Fall: <1% (1/108)	NR	Male: 90% Race: NR Age (mean): 28 (SD 1)	Base deficit Lactate SLCO2

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Aslar, 2004	ED: on arrival	Lactate: arterial	NR	NR
Baron, 2004	ED: on arrival	Base deficit: arterial Lactate: arterial SLCO2: sublingual PCO2, measurement recorded after equilibration.	SLCO2 measurements by research Team	Base deficit and Lactate: Blood Gas Analyzer (Radiometer Inc., Copenhagen, Denmark) SLCO2: CapnoProbe (Optical Sensors, Minneapolis, Minnesota)

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Aslar, 2004	Cutpoints in univariate analysis: APACHE II score: ≥15 BD: ≤-6 Lactate: ≥4 pH: ≤7.30 RTS: ≤8 SI: >0.9 Predetermined: NR	Mortality: Inpatient within 30 days of admission.	NR	Moderate
Baron, 2004	SLCO2 >45 mm Hg value corresponding to a sensitivity of 90%	Blood loss: best estimate of intracavitary blood loss determined by chest tube drainage, intraoperative blood loss, radiographic evidence of bleeding, change in hematocrit and number of packed RBC transfusions in the first 24 hours of admission. - none - minimal-moderate: <1500 mL - severe: ≥1500 mL	The CapnoProbe sublingual CO2 measurement devices and disposable sensors were supplied by Optical Sensors, Inc., Minneapolis, MN.	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Baron, 2007	Prospective	USA, New York and Maryland Urban Level I trauma centers 3/2003 to 1/2004 11 months	86 analyzed	Primary data collection
Batchinsky, 2007 *Batchinsky, 2007 and Batchinsky, 2009 analyze the same 31 patient ECGs but differ in measures evaluated.	Retrospective	USA, Texas Urban Level I trauma center Study time period: NR	31 analyzed 117 identified 86 excluded - 47 with multiple ectopic beats in the time series - 32 for electromechanical noise - 7 for inadequate data length	Trauma Vitals database (from the US Army Institute of Surgical Research) Data collection by monitor and standard run sheet.
Batchinsky, 2009 *Batchinsky, 2007 and Batchinsky, 2009 analyze the same 31 patient ECGs but differ in measures evaluated.	Retrospective	USA, Texas Urban Level I trauma center Study time period: NR	31 analyzed	Trauma Vitals database, housed at the US Army Institute of Surgical Research. Data collection by monitor and standard run sheet.

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Baron, 2007	Included: Patients ≥16 years old with blunt or penetrating trauma who presented to the ED with hypotension (SBP ≤90 mm Hg). Excluded: Patients with focal neurologic deficits and those transferred from other hospitals.	Adults (≥16): 100%	Civilian
Batchinsky, 2007 *Batchinsky, 2007 and Batchinsky, 2009 analyze the same 31 patient ECGs but differ in measures evaluated.	Included: Patients with ECG recordings free of electromechanical noise severe enough to prevent R-wave identification, free of ectopic beats, and at least 800 heart beats in length. Excluded: No exclusion criteria specified.	NR	Civilian
Batchinsky, 2009 *Batchinsky, 2007 and Batchinsky, 2009 analyze the same 31 patient ECGs but differ in measures evaluated.	Included: ECG recordings free of electromechanical noise severe enough to prevent R-wave identification, free of ectopic beats, and at least 800 heartbeats in length. Excluded: No exclusion criteria specified.	NR	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Baron, 2007	Type of injury Blunt: 51% (44/86) Penetrating: 49% (42/86) Mechanism of injury Motor vehicle crash: 23% (20/86) Pedestrian struck by automobile: 13% (11/86) Motorcycle crash: 5% (4/86) Fall: 5% (4/86) Assault: 2% (2/86) Bicyclist struck by automobile: 1% (1/86) Gunshot wound: 27% (23/86) Stab wound: 22% (19/86) Other: 2% (2/86)	NR	Male: 80% (69/86) Race: NR Age (mean): 35 (SD 17)	Base deficit Lactate SLCO2
Batchinsky, 2007 *Batchinsky, 2007 and Batchinsky, 2009 analyze the same 31 patient ECGs but differ in measures evaluated.	Blunt: 61.3% (19/31) Penetrating: 38.7% (12/31)	Helicopter	Male: 71% (22/31) Race: NR Age (mean): 40 (SD 4)	Heart rate complexity: sample entropy (SampEn)
Batchinsky, 2009 *Batchinsky, 2007 and Batchinsky, 2009 analyze the same 31 patient ECGs but differ in measures evaluated.	Blunt: 61.3% (19/31) Penetrating: 38.7% (12/31)	Helicopter	Male: 71% (22/31) Race: NR Age (mean): 40 (SD 4)	Heart rate complexity metrics - Approximate entropy - Distribution of symbol 2 Heart rate complexity models: combined metrics with and without GCS motor score

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Baron, 2007	ED: on arrival additional measurements up to 48 hours post-hemorrhage	Base deficit: arterial Lactate: arterial SLCO2: handheld capnometer with sublingual CO2 sensor	Physicians and nurses	SLCO2: Capno-Probe System (Nellcor, Pleasanton, California)
Batchinsky, 2007 *Batchinsky, 2007 and Batchinsky, 2009 analyze the same 31 patient ECGs but differ in measures evaluated.	Out of Hospital: during Resuscitation	ECG continuous waveform	NR	Propaq 206EL vital signs monitor (Welch Allyn, Skaneateles Falls, New York)
Batchinsky, 2009 *Batchinsky, 2007 and Batchinsky, 2009 analyze the same 31 patient ECGs but differ in measures evaluated.	Out of Hospital: during Resuscitation	ECG continuous waveform	NR	Propaq 206EL vital signs monitor (Welch Allyn, Skaneateles Falls, New York)

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Baron, 2007	SLCO2 ≥62 mm Hg threshold with optimal combination of sensitivity and specificity	Mortality: not specified ICU stay Blood transfusion	Supported by Nellcor, Pleasanton, CA.	Moderate
Batchinsky, 2007 *Batchinsky, 2007 and Batchinsky, 2009 analyze the same 31 patient ECGs but differ in measures evaluated.	NR	Mortality: Inpatient	Supported by the Combat Critical Care Engineering Program, US Army Medical Research and Materiel Command, Fort Detrick, Maryland.	Moderate
Batchinsky, 2009 *Batchinsky, 2007 and Batchinsky, 2009 analyze the same 31 patient ECGs but differ in measures evaluated.	NR	Mortality	Supported by the Combat Casualty Care Research Program and the Telemedicine and Advanced Technology Research Center, US Army Medical Research and Materiel Command.	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Batchinsky, 2009b	Retrospective	USA, Texas; Iraq, Baghdad Urban vs. rural: NR Trauma system level: NR Study time period: NR	262 analyzed 464 identified	Trauma Vitals database
Beekley, 2010	Prospective	Iraq, Baghdad (U.S. military) Setting: Combat U.S. Army Combat Support Hospital 8/2007 to 12/2007 5 months	147 analyzed	Primary Data Collection and data in the Joint Theater Trauma Registry
Bond, 1997	Retrospective	Canada, Calgary Urban and rural 2 major trauma centers and 2 community acute care centers 5/1/1995 to 10/31/1995 6 months	3,147 analyzed 3,272 identified 125 excluded for incomplete documentation	Primary data collected from medical charts, including EMS patient care record.

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Batchinsky, 2009b	Included: Patients with blunt or penetrating injuries admitted to study EDs. Excluded: Patients whose ECG sections had <800 R-to-R intervals, there were ectopic beats within the analyzed data segments, or the ECG contained electromechanical noise.	NR	NR
Beekley, 2010	Included: US soldiers, US civilians, and foreign nationals with a battle or nonbattle injury brought via litter between 7 AM and 7 PM. Excluded: Patients with detainee status, who were "walking wounded" or with clearly minimal injuries.	Adults (NR): 100%	Military
Bond, 1997	Included: Trauma patients age ≥14 years old who were transported by one EMS provider to any of the 4 study centers. Excluded: Patients <14 years old, those transported by an EMS unit other than that specified, those pronounced dead in the field, and those with incomplete documentation.	Adults (≥14): 100%	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Batchinsky, 2009b	Blunt and penetrating injuries Patients with and without life-saving interventions were clinically indistinguishable with respect to mechanism of injury. Patients who received LSIs were more severely injured based on ISS.	NR	NR Patients with and without life-saving interventions were clinically indistinguishable with respect to age and sex.	HRC artificial neural network (ANN) model using 16 ECG-derived New Vital Signs - Linear time- and frequency-domain metrics - HRC metrics
Beekley, 2010	Primary mechanism Gunshot: 39% Explosion 46% Motor vehicle crash: 7% All others: 8%	Litter (combat casualty)	Male: 93% Race: NR Age (mean): 27 (SD 11)	Base deficit DBP HR Radial pulse character SBP Tissue Oxygenation Saturation ($St0_2$)
Bond, 1997	Type of injury Penetrating: 2% (59/3,147) Blunt: 98% (3,088/3,147) Mechanism of injury Motor vehicle crash: 32% (997/3,147) Falls: 38% (1,190/3,147) Pedestrian vs. auto crashes: 4% (125/3,147) Assault: 13% (422/3,147) Sports injuries: 5% (171/3,147) Burns: 2% (50/3,147) Industrial accidents: 2% (68/3,147) Not classified: 4% (124/3,147)	NR	NR	Prehospital Index (PHI) score

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Batchinsky, 2009b	Out of hospital: timing NR - 27% of patients (70/262) ED: timing NR - 73% (192/262)	ECG: earliest available 800-beat data set from continuous 20-30 minute sections of waveform	NR	ECG waveform analysis: WinCPRS software (Absolute Aliens Oy; Turku, Finland) Artificial neural network (ANN): commercially available feed-forward back-propagation ANN (NeuralWare; Carnegie, Pennsylvania)
Beekley, 2010	ED: on arrival	StO_2: Near-infrared spectroscopy sensor, applied to uninjured extremity.	Research nurses	StO.33 monitor: In-Spectra 650 (Hutchinson Technology, Inc.)
Bond, 1997	Out of hospital: not specified	NR	EMS personnel	NR

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Batchinsky, 2009b	NR	Life-saving intervention: intubation, cardiopulmonary resuscitation, cricothyroidotomy, emergency blood transfusion or decompression of pneumothorax.	NR	High
Beekley, 2010	NR	Life-saving intervention: intubation, cricothyroidotomy, needle decompression of tension pneumothorax, tube thoracostomy, application of tourniquet, application of hemostatic dressing, blood transfusion, cardiopulmonary resuscitation, ED thoracotomy, or emergent transfer to the OR for control of hemorrhage Any blood transfusion within 24 hours Massive transfusion: >10 units in 24 hours	Huchinson Technology provided StO2 monitors and disposable sensors. Authors were government employees.	Moderate
Bond, 1997	Prehospital Index (PHI): ≥4	Major trauma: ISS ≥16	NR	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Bouzat, 2016	Prospective	France, Grenoble Urban Level I trauma center 8/2011 to 2/2013 1 year, 7 months	120 analyzed	Primary collection of data from consecutive patients
Brown, 2011	Retrospective	USA Urban vs. rural: NR (national database) Levels I-IV trauma centers and undesignated hospitals 2002 to 2006 5 years	1,086,764 analyzed 1,477,099 identified 390,355 excluded for incomplete data	NTDB version 7
Brown, 2015	Retrospective	USA Urban vs. rural: NR (national database) Trauma system level: NR 2010 to 2012 3 years	1,555,944 analyzed	NTDB

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Bouzat, 2016	Included: Patients age ≥18 years with SBP <90 who were admitted to the trauma bay for suspected severe trauma based on French Vittel triage criteria. Excluded: Patients with chronic liver disease, pregnant patients, those who received pre-hospital transfusion, pre-hospital infusion of norepinephrine <0.1 mcg/kg/min, or had a body core temperature <35 C.	Adults (≥18): 100%	Civilian
Brown, 2011	Included: Trauma patients age ≥18 years. Excluded: Patients with missing ISS, GCS, SBP or RR data.	Adults (≥18): 100%	Civilian
Brown, 2015	Included: Patients age ≥15 transported from the scene of injury. Excluded: Patients undergoing interfacility transfer or who died on arrival.	Adults (16-65): 72% Elderly (>65): 28%	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Bouzat, 2016	Blunt: 94% (113/120)	NR	Male: 85% (102/120) Race: NR Age (median): 37 (IQR: 27-56)	Lactate SI
Brown, 2011	Blunt: NR Penetrating: % NR	NR	Male: 66% Race: NR Age (mean): 45 (SD 20)	RR SBP Physiologic criteria of the National Trauma Triage Protocol (NTTP), uses GCS, SBP, RR
Brown, 2015	Blunt injury - overall: 89% - adults: 85% - elderly: 99%	NR	Overall Male: 62% Race: NR Age: NR Adults Male: 71% Race: NR Age (median): 37 (IQR 25-50) Elderly Male: 39% Race: NR Age (median): 80 (IQR 73-86)	SBP

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Bouzat, 2016	Out of hospital: not specified - SI ED: on arrival - Lactate: capillary; serum (venous or arterial)	Lactate: capillary (handheld POC) average value of 2 consecutive samples at same collection site (fingertip or ear lobe)	Nurse	Lactate, capillary: lactate scout (Senslab, Leipzig, Germany)
Brown, 2011	Out of hospital: on arrival - GCS (available for 56% of patients) ED: on arrival - SBP, RR - GCS (for 44% with no out of hospital scores) GCS: out of hospital available in 56%; remainder used ED score	NR	NR	NR
Brown, 2015	Out of Hospital: not specified	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Bouzat, 2016	Lactate: normal: <3.5 abnormal: ≥3.5	Significant blood transfusion: ≥4 RBC units transfused within the first 48 hours after trauma Any blood transfusion: any transfusion within the first 48 hours Emergency treatment for hemostasis: embolization and/or damage control surgery (laparotomy, thoracotomy and orthopedic surgery for hemostasis)	NR	High
Brown, 2011	SBP <90 RR <10 or >29	ICU admission ≥24 hours ISS >15 Urgent surgery: ED disposition to the OR Trauma center need: ISS >15, ICU admission ≥24 hours, or urgent surgery (defined as ED disposition to the OR).	NR	Moderate
Brown, 2015	SBP from triage criteria: <90 mm Hg vs. <110 mm Hg SBP optimal cutoffs to maximize sensitivity and specificity - Trauma center need: adults <118, elderly <122 - Mortality: adults <106, elderly <118	Trauma center need: any of ISS>15, ICU admission ≥24 hours, need for urgent surgery, death in the ED Mortality: in hospital	No funding or support was directly received to perform the current study. Dr. Brown receives support from an institutional T32 Ruth L. Kirschstein National Research Service Award training grant (5-T32-GM-008516-20) from the National Institutes of Health. Dr. Sperry receives support from a career development award (K23GM093032) from the National Institute of General Medical Sciences.	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Brown, 2016	Retrospective	USA, Pennsylvania Urban Level I trauma center 1/2009 to 9/2014 5 years, 9 months	6,347 analyzed 8,729 identified 1,354 excluded for no prehospital lactate level 1,028 excluded for not meeting remaining inclusion criteria	Prehospital database and electronic health records from a single trauma center.
Bruijns, 2013	Retrospective	UK, England and Wales Urban vs. Rural: NR Trauma system level: NR 1996 to 2006 11 years	69,367 analyzed 71,882 identified 2,515 excluded as outliers (z score >3 for age, SBP, HR, or RR)	TARN

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Brown, 2016	Included: Patients >15 years old transported by air medical transport by a single transport provider who had a prehospital lactate measurement. Excluded: NR* * Trauma center has a separate burn center and obstetric support; outcome and activation criteria related to burns or pregnancy were not considered.	Adults (>15): 100%	Civilian
Bruijns, 2013	Included: Patients >16 years old. Excluded: Patients with head or spinal injuries other than minor (injury with AIS ≤1); unknown injuries, or who required prehospital intubation or cardiopulmonary resuscitation.	Adults (>16): 100%	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Brown, 2016	Mechanism of injury Penetrating: 5.5% (343/6,347)	Air medical transport	Male: 68% (4,329/6,347) Race: NR Age (median): 44 (IQR: 27-61)	Lactate
Bruijns, 2013	Penetrating: 3%	NR	Male: 56% (38,948/69,367) Race: NR Age (median): 49 (IQR 32-67)	Blood pressure-age index (BP/Age) HR Minpulse (maximum HR - HR) Pulse max index (HR/maximum HR) RR SBP SI SIA (SI x Age)

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Brown, 2016	Out of hospital: not specified	Lactate: venous point-of-care. Sample obtained from peripheral intravenous line start with a 5-cc waste before measurement. For patients with >1 lactate value, the highest value was used. No ground EMS measurements were used for this study.	Out of hospital paramedic/nurse	Lactate Pro meter (Arkray, Japan)
Bruijns, 2013	ED: on arrival	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Brown, 2016	NR	Trauma center need: any of the following: blood transfusion >1 unit in the ED; spinal cord injury; advanced airway placed prehospital or in the ED; thoracotomy within 48 hours of admission; pericardiocentesis within 24 hours of admission; intracranial pressure monitoring; interventional radiology procedure within 4 hours of admission; abdominal/thoracic/vascular/neurologic surgical procedure within 24 hours; death.	No direct funding or support for this study.	Moderate
Bruijns, 2013	Thresholds chosen as values corresponding to 90% specificity in analysis Blood pressure-age index: ≤1.7 HR: ≥104 Minpulse: ≤54 Pulse max index: ≥60% RR: ≥24 SBP: ≤110 SI: ≥0.8 SIA (SI x Age): ≥48 Thresholds chosen as values corresponding to 95% specificity in analysis Blood pressure-age index: ≤1.5 HR: ≥112 Minpulse: ≤44 Pulse max index: ≥70% RR: ≥27 SBP: ≤101 SI: ≥0.9 SIA (SI x Age): ≥55	Mortality: 48-hour	No external funding	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Bruijns, 2014	Retrospective	South Africa, Cape Town* *data from UK registry Urban vs. rural: NR Trauma system level: NR 1996 to 2006 11 years	28,273 analyzed 29,935 cases extracted 1,662 excluded for outlying values (z-score >3) - 594 cases with outlying value for change in RR - 531 cases with outlying value for change in HR - 447 cases with outlying value for change in SI - 1 case with outlying value for age	TARN, a trauma database with data from collaborative hospitals in England and Wales
Callaway, 2009	Retrospective	USA Urban Level I trauma center 1/1/2000 to 12/31/2006 7 years	1,776 analyzed ≥65 years with both lactate and BD: 588/1,776 <65 years with lactate: 1,188/1,776 <65 years with lactate and BD: 1,156/1,188	Trauma registry from a Level I trauma center.
Cancio, 2008	Retrospective	USA, Texas Urban Level I trauma centers Study time period: NR	192 analyzed 182 excluded due to waveform issues (multiple ectopic beats, electromechanical noise, inadequate data set length)	Trauma Vitals (US Army Institute of Surgical Research, Ft. Sam Houston, TX)

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Bruijns, 2014	Included: Patients >16 years old and with recorded values for HR, RR and SBP both prehospital and in the ED. Excluded: Patients with head or spinal injuries other than minor (minor defined as injury with AIS ≤1), had unknown injuries, or who required prehospital intubation or CPR.	Adults (>16): 100%	Civilian
Callaway, 2009	Included: Patients with SBP ≥90 mm Hg upon arrival to the ED, BD or lactate measured at ED admission, and blunt mechanisms of trauma.	Adults: 100% Elderly (≥65 yrs): 33% (588/1,776)	Civilian
Cancio, 2008	Included: Trauma patients transported by one of 2 life flight services to any of the 3 study centers. Excluded: Patients without available ECG of 800 R-to-R intervals (RRIs) in length, who had ectopic beats within the analyzed data segments, or whose ECG quality was inadequate (due to electromechanical noise or disruption of the signal or both).	NR (presumably 100% adult)	Unclear

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Bruijns, 2014	Type of injury: Penetrating: 3% (896/28,273)	NR	<u>Overall</u> Male: 57% (16,214/28,273) Race: NR Age (median): 49 (IQR: 31-67)	HR difference RR difference SBP difference SI difference *Difference is calculated as ED value minus Out of hospital value
Callaway, 2009	Blunt: 100%	NR	<u>Elderly</u> Male: 46% Race: NR Age (mean): 80 (SD 8) <u>Nonelderly Adults</u> Survivors Male: 73% Race: NR Age (mean): 38 (SD 14) Nonsurvivors Male: 78% Race: NR Age (mean): 42 (SD 14)	BD Lactate
Cancio, 2008	Blunt: 85% Not recorded: 3%	Helicopter	Male: 71% Race: NR Age (mean): 37 (SD 5)	HRC metrics: - Sample Entropy (SampEn) - Detrended Fluctuations Analysis (DFA) - SampEn plus DFA HRC plus GCS motor component (HRC metrics SampEn and DFA)

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Bruijns, 2014	Out of hospital: NR ED: NR	NR	NR	NR
Callaway, 2009	ED: on arrival	Lactate: venous	NR	NR
Cancio, 2008	Out of Hospital: during Resuscitation	ECG: continuous waveform	NR	ECG: Pic 50 vital sign monitor (Welch Allyn, Skaneateles Falls NY) ECG R-wave identification: WinCPRS software (Absolute Aliens Oy, Turku, Finland)

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Bruijns, 2014	Cutpoints determined as values corresponding to 90% specificity and 95% specificity.	Mortality: 48-hour	Sponsored by the Plymouth Hospitals Research and Development service; no funding involvement.	Moderate
Callaway, 2009	Previously established thresholds. Hypotension: SBP <90 Lactate (mmol/L): Normal 0-2.4 Moderately elevated 2.5-4.0 Severely elevated >4.0 BD (mEq/L): Normal <0 Moderate 0-6 Severe >6	Mortality: Inpatient	NR	Moderate
Cancio, 2008	NR	LSI: any of the following, performed in the field: cardiopulmonary resuscitation, cricothyroidotomy, endotracheal intubation, needle decompression of the chest, pericardiocentesis, or cardioversion.	Telemedicine and Advanced Technology Research Center (W81XWH-06–2-0065) and the Advanced Capabilities for Combat Medics Task Area of the Combat Critical Care Engineering program (E52-021-2005-USAISR), U.S. Army Medical Research and Materiel Command, Fort Detrick, MD.	High

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Cancio, 2008a	Retrospective	Iraq (U.S. military) Setting: Combat U.S. military Level 3 (combat support hospital) Time study period: NR	536 analyzed 692 identified 156 excluded for missing data	Existing internal performance-improvement database including cases from multiple US Level 3 hospitals in Iraq. Ultimate hospital mortality verified by review of the Joint Theater Trauma Registry.
Cannon, 2009	Retrospective	USA Urban Level I Trauma Center 1996 to 2005 10 years	2,445 analyzed 1,166/2,445 with Out of Hospital data	Collector Trauma Registry
Caputo, 2012	Prospective	USA, New York Urban Level I trauma center 7/11/2011 to 12/16/2011 5 months	105 analyzed 126 trauma team activations 21 excluded - 2 excluded for airway support - 7 excluded for intubated on arrival - 7 excluded for lost vital signs - 5 excluded as missed cases	Primary data collection and data from the electronic medical record
Caputo, 2015	Prospective	USA, New York Urban Level I trauma center 7/2012 to 12/2012 6 months	100 analyzed 113 identified 13 excluded - 9 excluded due inappropriate trauma team activation - 4 excluded due to death before ED arrival	Prospective collection of ED admission data

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Cancio, 2008a	Included: US combat casualties with complete data for SBP, DBP, HR, RR, total GCS, RTS, artificial ventilation, number of pRBC and whole blood units transfused in 24 hours, and in-hospital mortality. Excluded: Patients with incomplete data.	NR (presumably 100% adult)	Military
Cannon, 2009	Included: Patients with a mechanism of injury and an ICD-9 code 800-959, who met trauma system activation criteria, were brought to ED as a type 2 (moderate trauma, mechanism) or type 1 (severe trauma with or without hemodynamic stability) trauma patient, were direct arrivals to the ED from the field, and either died in the ED or were admitted to the hospital. Excluded: Patients transferred to the hospital from an outside institution, those with incomplete records, or who were admitted through the ED but did not require trauma system activation.	NR	Civilian
Caputo, 2012	Included: Patients with penetrating trauma for whom the trauma team was activated. Excluded: Patients with lost vital signs before reaching the trauma bay, those already intubated on arrival, and those with activations for surgical airway support.	NR IQR for age: 19-30	Civilian
Caputo, 2015	Included: Patients age >18 years with penetrating or blunt trauma in which trauma team was activated. Excluded: Patients age <18 years and those with no trauma team activation.	Adults (>18): 100%	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Cancio, 2008a	NR	NR	NR	DBP FTS07 (new Field Triage Score) SI RTS
Cannon, 2009	Penetrating: 26%	Ambulance, helicopter, or private vehicle	Male: 73.7% Race: NR Age (median), patients with ED SI >0.9: 32 Age (median), patients with ED SI ≤0.9: 28	SBP SI
Caputo, 2012	Mechanism of injury Stab wound: 53% Gunshot wound: 47%	NR	Male: 91% Race: NR Age (mean): 26	ET CO2 Lactate SBP
Caputo, 2015	Blunt: 53% Penetrating: 47%	NR	Male: 89% Race: NR Age (mean): 34 (SD NR)	Anion gap BD Lactate

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Cancio, 2008a	ED: on arrival	NR	NR	NR
Cannon, 2009	Out of Hospital: on EMS arrival ED: on arrival	NR	NR	NR
Caputo, 2012	ED: on arrival	ET CO2: measured with nasal cannula with side stream detectors after 30 seconds and establishment of good wave form Lactate: arterial point-of-care	ET CO2: research assistant	ET CO2: Phillips Smart Capnoline Plus (M2526A)
Caputo, 2015	ED: on arrival	Anion gap: arterial blood gas Lactate: arterial	ED clinician	iStat point-of-care blood sampling analyzer (Abbott, Dallas, Texas) using arterial sample. - Lactate (direct) - Anion gap (calculated) - BE (calculated)

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Cancio, 2008a	Thresholds specified in each scoring systems.	Massive transfusion: >10 units of packed RBC or whole blood units in 24 hours. Mortality: in-hospital	Partially funded by the Combat Critical Care Engineering Program, US Army Medical Research and Materiel Command, Ft. Detrick, MD.	High
Cannon, 2009	SI >0.9, predetermined Change in SI ≥0.3, selected during analysis - 0.291 value able to predict increased mortality; Rounded	Mortality: NR	NR	Moderate
Caputo, 2012	Lactate >4 mmol/L: abnormal high ET CO2 <35 mmHg: abnormal low	Operative intervention Massive transfusion	NR	Moderate
Caputo, 2015	Anion gap: >16 mEq/L BD: <-2 mEq/L Lactate: >4 mmol/L	Massive transfusion Operative intervention	No external funding	Low

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Chan, 1997	Retrospective case-control	USA, New York Urban Level I trauma center 1/1/1993 to 5/31/1994 1 year, 5 months	104 analyzed Group 1 (case): n = 52 Group 2 (control): n = 52	Internal hospital trauma registry
Chen, 2007 *Chen 2007, 2008, 2009, and 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	Retrospective	USA, Texas Urban Level I trauma center Study time period: NR	492 analyzed 898 identified	Dataset of trauma patients transported by helicopter from the scene of injury to a single trauma center.
Chen, 2008 *Chen 2007, 2008, 2009, and 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	Retrospective	USA, Texas Urban Level I trauma center Study time period: NR	627 analyzed 898 identified* 271 excluded - 196 excluded for not meeting minimal-data criterion - 75 excluded for receiving blood in the ED but not meeting documented injury criteria	Database of physiologic data collected during transport with additional data collected retrospectively via chart review.

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Chan, 1997	Included: Patients with blunt trauma who were admitted to the hospital who were normotensive on initial ED evaluation. - Group 1 (case): Patients with ≥1 out-of-hospital SBP ≤90. - Group 2 (control): Patients with all out-of-hospital SBP readings >90. Selection by best age and initial ED SBP matches. Excluded: Patients transferred from another institution, those who did not arrive by ambulance, and patients who were discharged from the ED.	NR (presumably 100% adult)	Civilian
Chen, 2007 *Chen 2007, 2008, 2009, and 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	Included: Trauma patients transported by helicopter from the scene of injury to the study trauma center. Excluded: Patients whose records had missing variables for SBP, DBP, HR, RR, or oxygen saturation (SaO2), during the 5-to-7-minute interval of transport; patients who received ≥1 unit of red blood cells without an explicit hemorrhagic injury (laceration of solid organs, abdominal hematoma, hemothorax, explicit vascular injury and operative repair or limb amputation).	NR	Civilian
Chen, 2008 *Chen 2007, 2008, 2009, and 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	Included: Patients with at least one non-zero vital sign (HR, RR, DBP, SBP, or SaO2) available in every 2-minute window during the initial 16 minutes of transport. Excluded: Patients who received blood but did not have documented injuries consistent with hemorrhage.	NR	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Chan, 1997	Blunt: 100%	Ambulance (land vs. air not specified)	Male: 78% (81/104) Race: NR Age (mean): 32 (SD 19)	SBP
Chen, 2007 *Chen 2007, 2008, 2009, and 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	Mechanism of injury Blunt: 90% Penetrating: 10%	Helicopter	NR	Linear classifier system using combinations of 5 vital signs: SBP, DBP, HR RR, oxygen saturation (SaO2)
Chen, 2008 *Chen 2007, 2008, 2009, and 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	Blunt: 89% (555/627) Penetrating: 10% (65/627) NR: 1% (7/627)	Helicopter	Male: 75% (473/627) Race: NR Age (mean): 39 (SD NR)	Classifier to identify major hemorrhage in trauma casualties Composite-variable features Hemorrhage index (HR x RR)/(MAP x PP) HR/PP PP RR/PP SI

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Chan, 1997	Out of Hospital: not specified ED: on arrival	NR	NR	NR
Chen, 2007 *Chen 2007, 2008, 2009, and 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	Out of hospital: during Resuscitation	Vital signs measured automatically by monitor or monitor-calculated using electrocardiogram, photoplethysmogram, and respiratory waveform signals. Average value of 5 seconds of reliable vital-signs data within a 2-minute time window.	NR	Vital signs: Propaq 206EL vital-signs monitor
Chen, 2008 *Chen 2007, 2008, 2009, and 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	Out of Hospital: during Resuscitation	Automated measurement by monitor: ECG, photoplethysmogram respiratory, waveform, SBP, MAP, DBP Monitor-calculated: HR, SaO2, RR	NR	Propaq 206EL vital-sign monitor

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Chan, 1997	Hypotension: SBP ≤90 mmHg Normotension: SBP >90 mmHg	Mortality: not specified ICU admission Blood transfusion: received transfusion in the first 12 hours	NR	High
Chen, 2007 *Chen 2007, 2008, 2009, and 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	Major hemorrhage: Transfusion of ≥1 unit of red blood cells and an explicit hemorrhagic injury (laceration of solid organs, hematoma in the abdomen, explicit vascular injury and operative repair, or limb amputation).	Supported by the Combat Casualty Care and the Military Operational Medicine research programs of the U.S. Army Medical Research and Materiel Command (USAMRMC), Fort Detrick, Maryland.	High
Chen, 2008 *Chen 2007, 2008, 2009, and 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	Vital-sign variables calculated by 3 methods, based on 2-minute time windows: - best-quality 5-second data - first 5-second data - all data combined Predetermined: NR	Hemorrhage: Received blood in the ED and had documented injuries consistent with hemorrhage. Injuries consistent with hemorrhage defined as at least one of: laceration of solid organs; internal bleeding as indicated by abdomino-pelvic hematoma or hemothorax; or explicit vascular injury and operative repair or limb amputation.	Partially supported by the Combat Casualty Care Directorate of the US Army Medical Research and Materiel Command, Fort Detrick, Maryland.	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Chen, 2009 *Chen 2007, 2008, 2009, and 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	Retrospective	USA, Texas Urban Level I trauma center Study time period: NR	326 analyzed 898 identified* 473 excluded for not having reliable vital signs 99 excluded for out of hospital intubation	Database of physiologic data collected during transport with additional data collected retrospectively via chart review.
Chen, 2010 *Chen 2007, 2008, 2009, and 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	Retrospective	USA, Texas Urban Level I trauma center 8/2001 to 4/2004 2 years, 9 months	344 analyzed 898 identified* 554 excluded - 399 excluded for no suitable PPG waveform data available - 121 excluded for blood transfusion without an explicitly hemorrhagic injury - 34 excluded for ≥1 other basic vital signs unavailable	Database of physiologic data collected during transport with additional data collected retrospectively via chart review.

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Chen, 2009 *Chen 2007, 2008, 2009, and 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	Included: Patients with at least 5 seconds of consecutive reliable RR data. Excluded: Patients with out of hospital intubation or who did not have at least 5 seconds of reliable HR, SBP, and DBP data. Thoracic injury subgroup: Patients with injuries to the thorax identified by a search of abbreviated injury-scale codes in the database.	NR	Civilian
Chen, 2010 *Chen 2007, 2008, 2009, and 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	Included: Patients who had within the first 25 minutes of transport: ≥45 seconds continuous, clean PPG waveform data; ≥45 seconds continuous, nonzero HR, RR, and SpO2 data; and at least one SBP and DBP measurement. Excluded: Patients without clean PPG waveform data or missing any one of the basic vital signs.	NR	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Chen, 2009 *Chen 2007, 2008, 2009, and 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	Blunt: 87% Penetrating: 13%	Helicopter	Male: 76% (247/326) Race: NR Age (mean): 38 (SD 16)	Breath index (RR/PP) DBP Hemorrhage index (HR x RR)/(MAP x PP) HR MAP PP RR SBP SI standard measurement vs. reliable automated
Chen, 2010 *Chen 2007, 2008, 2009, and 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	Blunt: 90%	Helicopter	Male: 77% Race: NR Age (mean): 37 (SD 15)	HR Respiration-induced waveform variation metrics SBP

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Chen, 2009 *Chen 2007, 2008, 2009, and 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	Out of Hospital: during Resuscitation	Automated by monitor: ECG, respiratory waveform; and SBP, DBP, and MAP using standard oscillometric device. Algorithms: Standard RR: average of non-zero RR Reliable RR: investigational Reliable vital signs: calculated average of reliable data during patient transport	NR	Propaq 206EL vital-sign monitors (Protocol Systems)
Chen, 2010 *Chen 2007, 2008, 2009, and 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	Out of Hospital: during Resuscitation	Automated measurement by monitor: HR (ECG-derived) Photoplethysmogram Respiratory waveform SBP Automated algorithm-calculated: Reliable HR Reliable SBP	NR	Propaq 206EL transport monitor (Protocol Systems, Beaverton, Oregon)

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Chen, 2009 *Chen 2007, 2008, 2009, and 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	Reliable RR: independent algorithm rating ≥2	Major respiratory interventions: ED intubation or subsequent tube thoracotomy. Major hemorrhage: Blood transfusion in the hospital with documented injuries that were consistent with hemorrhage, as determined by chart review (laceration of solid organs, thoracic or abdominal hematomas, explicit vascular injury and operative repair, or limb amputation).	NR	Moderate
Chen, 2010 *Chen 2007, 2008, 2009, and 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	Major hemorrhage: ≥1 unit of packed red blood cell (PRBC) transfusion within 24 h after hospital arrival and had a documented injury that was explicitly hemorrhagic, which was one or more of the following: laceration or fracture of a solid organ; thoracic or abdominal hematomas; explicit vascular injury that required operative repair; or limb amputation.	Partially supported by the Combat Casualty Care Research Area Directorate of the US Army Medical Research and Materiel Command, Fort Detrick, MD.	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Cherry, 2007	Retrospective	USA, Pennsylvania Urban vs. rural: NR Level I trauma center 1/1/2004 to 12/31/2004 1 year	494 analyzed 1,969 identified	Trauma registry for a single trauma center.
Cooke, 2006a	Retrospective unmatched case-control	USA, Texas Urban Level I trauma center Study time period: NR	30 analyzed 15 Died 15 Lived Died: 93 identified 66 excluded for incomplete data, no recorded ECG, or head AIS >2 11 excluded for poor quality of ECG signal	Trauma Vitals database, developed by the U.S. Army Institute of Surgical Research.

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Cherry, 2007	Included: Trauma patients who met criteria for trauma team activation. Excluded: Patients with penetrating injuries, traumatic arrests, and interfacility transfers.	NR	Civilian
Cooke, 2006a	Died (cases) Included: Patients who died from their injuries. Excluded: Patients with incomplete data, no ECG recorded, poor quality of ECG signal, or who had an AIS head score >2. Lived (controls) Included: Patients who lived. Excluded: Similar exclusion criteria.	NR	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Cherry, 2007	Blunt: 100%	NR	Overall: Male: NR Race: NR Age (mean): NR* Level 1 activation: Age (median): 41 (IQR 25 to 55) Level 2 activation: Age (median): 43 (IQR 28 to 58) Level 3 activation: Age (median): 42 (IQR 28 to 57) * Mean age not reported for overall population, but medians and IQRs reported by subgroups.	SBP
Cooke, 2006a	Blunt: 66.5%	Helicopter	Male: 87% (26/30) Race: NR Age (mean): 39 (SD 3)	Heart rate variability Intubation status

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Cherry, 2007	ED: on arrival	NR	NR	NR
Cooke, 2006a	Out of Hospital: during Resuscitation	ECG recorded by vital signs monitor, collected by digital assistant	NR	ECG recording: ProPaq 206EL vital signs monitor (WelchAllyn, Beaverton, Oregon) ECG collection: iPAQ personal digital assistant (Talla-tech RPDA, Tallahassee, Florida) ECG filtering and cleaning: customized software ECG analysis: WinCPRS (Absolute Aliens, Turku, Finland)

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Cherry, 2007	SBP <90 mm Hg	Mortality: NR	NR	Moderate
Cooke, 2006a	Clean ECG signal: first 2 minutes of continuous data able to identify individual R waves for each cardiac cycle with certainty. 2-minute data sets for analysis determined based on availability of clean ECG signals.	Mortality: NR	Supported by the United States Army Medical Research and Materiel Command Combat Casualty Care Research Program (STO III ME 2001 02) and the United States Special Operations Command (MIPR 051-80482).	High

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Courville, 2009	Retrospective	USA Setting: NR (national database) Trauma level: NR 2001 to 2005 5 years	224,682 analyzed 245,490 identified <18 years old 676 excluded for no valid mortality indicator 19,907 excluded for missing time or admission >1 day after injury 245 excluded: NR CHAID model cohort randomly divided - training data: 112,342 - testing data: 112,286	NTDB, version 6.2
Cudnik, 2012	Prospective	USA, Ohio Urban and rural Level I trauma centers 10/2009 to 9/010 1 year	557 analyzed	Primary data collection of out-of-hospital data from EMS. Hospital data from each institution's trauma registry.
Davis, 1996	Retrospective	USA, California Urban Trauma system level: NR 7/1/1990 to 8/31/1995 5 years, 2 months	2,954 analyzed 5,264 in registry	Trauma registry for a single hospital. (UCSF/Fresno Valley Medical Center)
DeMuro, 2013	Retrospective	USA, New York Suburban Trauma system level: NR (regional trauma center) 1/1/2000 to 12/31/2010 11 years	4,277 analyzed 4,292 identified 16 excluded for incomplete data	Trauma One database, an electronic retrospective database/chart review for one hospital. Data reported to National Trauma Data Bank as well as state and local reporting

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Courville, 2009	Included: Patients <18 years old. Excluded: Patients without a valid mortality indicator (hospital disposition status other than dead or alive), and those admitted >1 day after injury or with missing data on time between injury and admission.	Children (<18): 100%	Civilian
Cudnik, 2012	Included: Patients age ≥16 years who were transported by medical helicopter (by a single air transport agency) directly from the scene of injury to one of the two trauma centers. Excluded: NR	Adults (≥16): 100%	Civilian
Davis, 1996	Included: Patients with an arterial blood gas obtained within 1 hour of admission. Excluded: Patients <5 year old, with trauma caused by thermal injury, or with seizure or diabetic ketoacidosis.	Children and adults (≥5): 100%	Civilian
DeMuro, 2013	Included: Patients 16 years or older who had sustained trauma. Excluded: Patients who were transferred from another hospital and those who suffered traumatic brain injury as determined by chart review of discharge codes.	Adults (≥16): 100% Elderly (≥65): 49% (2,093/4,277)	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Courville, 2009	Blunt: 86% Penetrating: 8% Burn: 3%	NR	Male: 65% Race (% of reported, n=207,077) - White: 60% - Black: 17% - Hispanic: 11% - Asian/Pacific Islander: 1% - Native American: 0.6% - Other: 3% Age: NR	Airway status Chi-square-assisted interaction detection (CHAID) model
Cudnik, 2012	Type of injury Penetrating: 3% Blunt: 97%	Helicopter	Male: 67% Race - White: 95% Age (median): 39 (IQR 24-52)	Model (derived by multivariate analysis) consisting of: age >44, SBP <90, flail chest injury, GCS <14
Davis, 1996	Blunt: 71%	NR	Male: 77% Race: NR Age (mean): 32 (SD 0.3)	BD
DeMuro, 2013	Blunt: 93% (3,971/4,276) Penetrating: 7% (305/4,276)	NR	NR	SI

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Courville, 2009	Out of Hospital: NR ED: on admission	NR	NR	NR
Cudnik, 2012	Out of Hospital: on arrival	NR	EMS on arrival	NR
Davis, 1996	ED: on arrival	BD: arterial	NR	NR
DeMuro, 2013	ED: on arrival	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Courville, 2009	Airway and sedation status: - breathing spontaneously, not intubated or chemically sedated - chemically sedated - intubated - intubated and chemically sedated CHAID model: age, sex, race, days from injury to admission, ED vital signs (SBP, temp, RR), ED airway and sedation status, ED and field GCS, mechanism	Mortality: in-hospital	No outside pharmaceutical or industry support. None of the authors received financial support for the study.	Low
Cudnik, 2012	Predetermined, based on the State of Ohio Trauma Triage Criteria - SBP <90 mmHg - GCS <14 Predetermined: NR - Age >44 years	Mortality: in-hospital death from any cause	Ohio Department of Public Safety Trauma Grants Program Award (#DPS01–0000017362)	Moderate
Davis, 1996	BD Mild: -3 to -5 Moderate: -6 to -9 Severe: ≤ -10	Blood transfusion: PRBC transfusion within 24 hours of admission. Mortality: NR	NR	Moderate
DeMuro, 2013	SI: evaluated at cutpoints in increments of 0.1 from 0.1 to 2.0. - standard cutoff examined: >0.9 vs. ≤0.9	Bleeding: transfusion of ≥2 PRBC units within 24 hours of admission, or any injury requiring surgery or interventional radiology for hemostasis within 24 hours of admission.	NR	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Dinh, 2014	Retrospective	Australia, New South Wales Urban Major trauma center 1/2007 to 12/2011 5 years	3,027 analyzed 3,393 identified 366 excluded for not directly transferred from scene	Trauma registry data for a single trauma center.
Dunham, 2017	Retrospective	South Africa, Pietermaritzburg Urban vs. rural: NR Trauma system level: NR 2010 to 2015 6 years	1,863 analyzed 9,573 trauma admissions 5,132 excluded for non-penetrating trauma 2,465 excluded for no recorded BD 113 excluded for incomplete vital signs dataset	Trauma database for 2 trauma centers
Dunne, 2005	Prospective	USA, Maryland Urban Level I trauma center 1998 to 2000 3 years	13,526 analyzed for lactate 15,179 in study 1,563 without lactate measurement	Trauma database at Level I trauma center
Eastridge, 2007	Retrospective	USA Urban vs. rural: NR (national database) Trauma system level: NR Study time period: NR	729,736 analyzed 870,634 identified 140,898 excluded for GCS score ≤8 and BD <5	NTDB version 5.0

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Dinh, 2014	Included: Patients ≥15 years old who had trauma team assessment and management in the ED, and who were transported directly to the hospital by air or ground ambulance. Excluded: Patients who arrived by private vehicle, were transported from other hospitals, were dead on arrival (absent vital signs and GCS score of 3), or who were still inpatients on 12/31/2011.	Adults (≥15): 100% Elderly (≥65): 17% (525/3,027)	Civilian
Dunham, 2017	Included: Patients ≥16 years old with penetrating mechanism of traumatic injury and who had a complete dataset for HR, SBP, GCS and BD recorded at admission. Excluded: No exclusion criteria specified.	Adults (≥16): 100%	Civilian
Dunne, 2005	Included: Patients admitted to the trauma center. Excluded: No exclusion criteria specified.	NR	Civilian
Eastridge, 2007	Included: Patients with ED SBP and mortality data. Excluded: Patients with severe head injury or TBI, based on GCS score ≤8 and BD < -5.	NR	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Dinh, 2014	Type of injury Penetrating: 4% Mechanism of injury Falls: 27% Motor vehicle crash: 24% Motorbike crash: 10% Pedestrian: 14% Cyclist: 10% Assault: 9% Other: 6%	Helicopter or ground ambulance	Male: 66% Race: NR Age (mean): 43 (SD 20)	HR RR SBP Vital signs: SBP, HR, and RR
Dunham, 2017	Penetrating: 100%	NR	Male: 90% (1,679/1,863) Race: NR Age (mean): 29 (SD 11)	BD HR SBP SI
Dunne, 2005	Blunt: 77% - Motor vehicle crash: 48% - Falls: 23% - Pedestrian struck: 5% - Other: 1% Penetrating: 23%	NR	Overall study population (n=15,179) Male: 71% Race - Caucasian: 59% - Non-Caucasian: 41% Age (mean): 37 (SD 19)	Lactate
Eastridge, 2007	NR	NR	NR	SBP

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Dinh, 2014	ED: on arrival	NR	NR	NR
Dunham, 2017	ED: on arrival	NR	NR	NR
Dunne, 2005	ED: on arrival	NR	NR	NR
Eastridge, 2007	ED: not specified	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Dinh, 2014	Abnormal vital signs: - HR <50 or >110 - RR <10 or >24 - SBP <90 or >180	Major trauma: ICU admission at any point in hospitalization, ISS >15, or in-hospital death.	Funding NR Conflict of interest declared: None.	Moderate
Dunham, 2017	BD classification of hemorrhagic shock class group: 1: >-2.0 2: -2.0 to -5.9 3: -6.0 to -9.9 4: ≤ -10.0	Mortality: timing not specified	NR	High
Dunne, 2005	Lactate >6.0 mmol/L	Mortality	NR	Moderate
Eastridge, 2007	SBP ≤90 vs ≤110 mmHg for hypotension	Mortality: overall	NR	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Edla, 2015b	Retrospective	USA, Texas and Massachusetts Urban and rural Level I trauma centers Dataset 1 (Texas): 8/2001 to 4/2004 2 years, 9 months Dataset 2 (Massachusetts): 2/2010 to 12/2012 2 years, 11 months	402 analyzed Dataset 1: 273 analyzed Dataset 2: 129 analyzed 999 identified 597 excluded - 43 excluded for death in field - 90 excluded for transfusion without hemorrhagic injury - 464 excluded for incomplete vital signs	Datasets from Memorial Hermann Life Flight (Houston, Texas) and Boston Medflight (Bedford, Massachusetts) air ambulances.
Engum, 2000	Prospective	USA, Indiana Urban Level I Trauma Center Study dates: NR 3 years	1,285 analyzed	Pediatric Trauma Service Trauma Registry
Folkert, 2015	Retrospective	USA, Pennsylvania Urban Level I trauma center 1/1/2006 to 12/31/2010 5 years	132 analyzed	Retrospective analysis of trauma registry data for a single institution
Franklin, 2000	Retrospective	USA, Kentucky Urban and rural Level I trauma center 7/1993 to 10/1998 5 years, 4 months	4,194 analyzed 6,976 identified 2,539 excluded for no available prehospital data 193 excluded for immediate death in ED	Trauma registry for a single trauma center and primary data collection from medical records.

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Edla, 2015b	Included: Patients ≥18 years old with a complete set of reliable investigational metrics: HR, SBP, PP, and 3 heart rate variability metrics. Automated computer algorithm used to identify reliable vital signs. Excluded: Patients who died before hospital admission, those who received PRBC transfusion without an explicitly hemorrhagic injury (documented solid organ injury, thoracic or abdominal hematoma, or vascular injury requiring a procedure for hemostasis), and those with an incomplete set of reliable vital signs.	Adults (≥18): 100%	Civilian
Engum, 2000	Included: Patients age 0-15 years evaluated by the pediatric trauma service. Excluded: No exclusion criteria specified.	Children (≤15): 100%	Civilian
Folkert, 2015	Included: Patients who were hemodynamically stable on presentation to ED (HR <101 and SBP >90) with isolated penetrating trauma to the extremities and had venous lactate measured during initial evaluation. Excluded: Patients <16 years old, who were pregnant, prisoners, and those with injuries in body regions other than the extremities.	Adults (≥16): 100%	Civilian
Franklin, 2000	Included: Patients who had emergent trauma consultation in the ED or were admitted to the trauma service for >24 hours. Excluded: Patients with burn injuries, those with no available prehospital data, and patients who died immediately in the ED.	NR	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Edla, 2015b	Blunt: 89% Penetrating: 10% NR: 1%	Helicopter	Male: 76% Race: NR Age (mean): 39 (SD 16)	HR HRV metrics - Rate of sinus arrhythmia (RSA) - Sample entropy (SampEn) - Standard deviation of the R-to-R intervals (SDNN) Pulse pressure (SBP-DBP) RR SBP
Engum, 2000	Injury type or mechanism (injury triage criteria distribution) Pedestrian struck >20 mph: 22% Second or third degree burn involving >15% total body surface area: 6% Penetrating injury to head, neck, chest, abdomen, or groin: 5% Rollover of vehicle: 5% Fall from >20 feet: 3% Ejection from vehicle: 1%	NR	Male: 63% Race: NR Age (mean): 7 (range 1-15)	SBP RR
Folkert, 2015	Penetrating: 100% Mechanism of injury Gunshot: 74% Stab: 23% Other: 3%	NR	Male: 91% Race: African American: 89% Caucasian: 8% Other: 3% Age (median): 25 (IQR 20-34)	Lactate
Franklin, 2000	Identified patients (database) Blunt: 83% Patients with prehospital or ED hypotension Blunt: 73% Penetrating: 27%	NR	Identified patients (database) Male: 72% Patients with prehospital hypotension (*including patients with immediate ED death*) Male: 67% Race: NR Age (mean): 41	SBP

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Edla, 2015b	Out of Hospital: during Resuscitation	Vital signs by patient monitor with reliable measurements determined by automated computer algorithms. HRV metrics calculated from ECG from patient monitor	NR	Propaq 206 vital signs monitors (Welch-Allyn, Beaverton, Oregon) Sample entropy (SampEn) computed using PhysioTools software "sampen.m"
Engum, 2000	NR	NR	NR	NR
Folkert, 2015	ED: on admission	Lactate: venous	NR	Lactate: UniCel DxC 600/800 analyzer
Franklin, 2000	Out of hospital: not specified ED: on arrival	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Edla, 2015b	HRV normal ranges - RSA (cpm) 19-26 SDEn (ms) 23-53 SampEn: 0.9-1.4 Routine vital signs	Blood transfusion with different thresholds: blood transfusion within 24 hours with hemorrhagic injury defined as a documented solid organ injury, thoracic or abdominal hematoma, or vascular injury requiring a procedure for hemostasis. - thresholds (number PRBC units transfused): ≥1, ≥5, ≥9	NR	Moderate
Engum, 2000	RR <10 or >29 SBP ≤ 90 mm Hg Predetermined	Major trauma: death in the ED, pediatric ICU admission, or requiring a major surgical procedure (craniotomy, neck exploration, thoracotomy, median sternotomy, exploratory laparotomy, and limb-threatening vascular procedures). Minor trauma: discharged from ED, admission to ward, or a requiring minor surgical procedure.	NR	Moderate
Folkert, 2015	Lactate: elevated >2.2 mmol/L laboratory-defined cut point as upper limit of reference range by assay manufacturer	Clinically significant bleeding: need for packed red blood cell transfusion or intervention to control bleeding (surgery or angioembolization), presenting hemoglobin of <7 mg/dL or a decrease in hemoglobin ≥2g/dL in 24 hours.	Supported by the United States National Heart, Lung, and Blood Institute, Award Number K12 HL 109009.	Moderate
Franklin, 2000	Hypotension: SBP <90 mmHg	ICU admission: ED disposition to ICU Urgent operation: abdominal, thoracic, or vascular/amputation procedure ED disposition to OR Mortality: ED Mortality: late (in-hospital excluding ED) Mortality: overall in-hospital (ED or late)	NR	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Garner, 2001	Retrospective	Australia, New South Wales Urban and rural Level I and II trauma centers 1/1994 to 12/1994 1 year	1,144 analyzed 1,192 identified 48 excluded for missing or incomplete ambulance case sheets	Trauma registries for 2 trauma centers.
Gebhart, 2007	Retrospective	USA, Ohio Urban Level II trauma center	355 analyzed 357 identified	Trauma database for a single trauma center.
Gray, 1997	Retrospective	UK, England Urban Trauma system level: NR 1/1/1993 to 6/7/1995 2 years, 5 months	213 analyzed 293 direct admissions identified 80 excluded for incomplete data	Resuscitation records and Major Trauma Outcome Study (MTOS) database
Grimme, 2005	Retrospective	Germany Urban and rural 70-80 trauma centers 1/1/1993 to12/31/2001 9 years	6,346 analyzed	German Trauma Registry

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Garner, 2001	Included: Patients ≥14 years old with traumatic injury and an ED stay longer than 4 hours or inpatient admission, and who were transported directly from the incident scene. Excluded: No exclusion criteria specified.	Adults (≥14): 100%	Civilian
Gebhart, 2007	Included: Random selection of trauma patients in database. Excluded: Patients without recorded GCS score.	NR (presumably 100% adult)	Civilian
Gray, 1997	Included: Patients admitted to the ED who were entered into the trauma database and had CRAMS score and physiologic components of the T-RTS recorded. Excluded: Patients who were secondary transfers and those with incomplete data.	Mixed; percentages not provided range: 2-95	Civilian
Grimme, 2005	Included: Patients with documentation in the German Trauma Registry, including patients who died in the ED or who had minor injuries; and who had clinical documentation by admitting physician. Excluded: No exclusion criteria specified.	Adults (≥16): 100%	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Garner, 2001	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%	Ambulance (land vs. air not specified)	Male: 65% Race: NR Age (median): 33 (IQR 21-53)	Capillary refill HR RR SBP START modified START Triage Sieve CareFlight Triage
Gebhart, 2007	NR	NR	Male: 59% (210/355) Race: NR Age (mean): 41 (SD 21)	START triage protocol (using tabulated scoring)
Gray, 1997	NR	NR	Male: NR Race: NR Age (median): 33 (range: 2-95)	CRAMS scale T-RTS
Grimme, 2005	Type of Injury (more than one type of injury may be reported) Blunt trauma: 96.2% Penetrating trauma: 5.6% Mechanism of Injury Motor vehicle accident: 64.9% Fall from a height: 12.2% Suicide: 4.1% Other: 18.8%	Helicopter or Land	Male: 76% Race: NR Age (mean): 33 (range 16-81)	HR RR RTS SBP SI

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Garner, 2001	ED: on arrival	NR	NR	NR
Gebhart, 2007	ED: on arrival	NR	NR	NR
Gray, 1997	ED: on admission	NR	NR	NR
Grimme, 2005	Out of Hospital: on EMS arrival	NR	EMS on arrival	NR

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Garner, 2001	All triage algorithms: transport by ambulance used as stand-in indicator of inability to walk modified START: SBP <80 used as stand-in for no palpable pulse	Critical injury: life-saving intervention determined as a nonorthopedic operative procedure within 6 hours of admission, fluid resuscitation >1,000mL with SBP <90, invasive central nervous system monitoring and positive head CT scan, airway or ventilatory assistance (excluding for sedation), or decompression of a pneumothorax.	NR	Moderate
Gebhart, 2007	START tabulated score thresholds: ≤1; ≥2	Mortality: inpatient	NR	Low
Gray, 1997	CRAMS score <9 T-RTS <12 (optimal cutoff), <8 Optimal cut-offs where ratio of sensitivity specificity are closest to 1.	Major injury (composite): ISS ≥15, ICU admission or death.	NR	Moderate
Grimme, 2005	SI: 0.3-0.79, 0.8-1.29, ≥1.3 SBP: <100. 100-120 HR <60 bpm: bradycardia RR: 10-17, 18-24	Mortality: NR	NR	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Guyette, 2011	Prospective	USA, Pennsylvania Urban Level I trauma center 4/2008 to 10/2009 1 year, 6 months	1,168 analyzed 2,190 identified 1,022 excluded - 736 excluded for no lactate obtained - 198 excluded due to sample from bilateral extremity injury, crush or burn - 88 excluded due to age <18 years	Prospective collection data on of transported, admitted trauma patients
Guyette, 2012	Prospective	USA, Pennsylvania Urban Level I trauma center 4/2009 to 11/2009 8 months	150 analyzed	Primary data collection from prehospital and hospital electronic medical records for 1 trauma center and 6 air medical transport helicopters.

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Guyette, 2011	Included: Trauma patients age ≥18 with serum lactate obtained by out of hospital providers, who were admitted to the hospital. Excluded: Patients whose lactate sample was taken from an extremity with a crush injury, amputation or fracture.	Adults (≥18): 100%	Civilian
Guyette, 2012	Included: Patients ≥18 years old who were transported to the trauma center by a helicopter equipped with the near-infrared spectroscopy StO2 monitor, and were admitted to the trauma service. Excluded: Patients with bilateral forearm injuries, known pregnant females, and prisoners. Patients transported from other hospitals were not excluded.	Adults (≥18): 100%	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Guyette, 2011	Type of injury -Penetrating: 4% Mechanism of injury -Fall: 25% -Motor vehicle crash: 62% -Stab/shot: 4% -Other: 9% Site of injury (more than one site of injury may be reported) -Head/neck: 50% -Face: 22% -Chest: 30% -Abdomen: 20% -Extremity: 84%	Helicopter	Male: 68% Race: NR Age (median): 44 (IQR 27-58)	HR Lactate SBP Predictor models using different combinations of: age, sex, SBP, HR, RR, GCS and lactate
Guyette, 2012	Type of injury Penetrating trauma: 4% (6/150) Mechanism of injury Fall: 25% (38/150) Motor vehicle collision: 62% (93/150) Stab/shot: 4% (6/150) Other: 9% (13/150)	Helicopter	Male: 60% (90/150) Race: NR Age (mean): 47 (SD 20)	DeO2 ReO2 SBP

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Guyette, 2011	Out of Hospital: not specified	Lactate: venous and capillary	EMS on arrival	Point of care serum lactate meter (Lactate Pro, FACT, Canada)
Guyette, 2012	Out of hospital: during Resuscitation	DeO2 and ReO2: near-infrared spectroscopy StO2 monitor applied to thenar eminence, vascular occlusion test was performed and slopes calculated for deoxygenation and reoxygenation phases. DeO2 using Pearson's coefficients of regression (r2) for the first 25% of descent and ReO2 slope using entire recovery period. SBP: automated continuous	Helicopter flight crew members	StO2: near-infrared spectroscopy StO2 (InSpectra StO2; Hutchinson Industries; Hutchinson, MN) SBP: LIFEPAK 12 monitors (PhysioControl; Redmond, WA)

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Guyette, 2011	HR >110 Lactate >2 RR ≥30 SBP <100 SI >0.8	Mortality: inpatient Emergent surgery: any of the following procedures for hemorrhage control in the first 24 hours of hospitalization: thoracotomy, laparotomy, pelvic fixation, and embolization. Multiple organ dysfunction: MOD score >6; MOD score is the sum of the following ordinal subscales: (a) the respiratory system (PaO_2/FIO_2 ratio); (b) the renal system (serum creatinine concentration); (c) the hepatic system (serum bilirubin concentration); (d) the hematologic system (platelet count); (e) the central nervous system (GCS); and (f) the cardiovascular system (heart rate X central venous pressure/mean arterial pressure)	Partially supported by the Fogarty International Center NIH Grant No. 1 D43 TW007560-01.	Moderate
Guyette, 2012	Lowest SBP: lowest recorded value for SBP	Need for in-hospital life-saving intervention: emergent operation or emergent transfusion in the first 24 hours of hospitalization. Emergent operation defined as any of these procedures in the first 24 hours of hospitalization for hemorrhage control: thoracotomy, laparotomy, pelvic fixation or embolization. Emergent transfusion defined as any blood transfused in the first 24 hours of hospitalization. The trigger for transfusion is hypotension (SBP <90) not responsive to 2L of crystalloid, or at the discretion of the command physician (prehospital) or trauma surgeon (trauma bay).	Supported in part by USAF FA7014-07-C-0053 and NHLBI HL07820.	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Guyette, 2015	Prospective	USA and Canada Urban and Rural Level I and II trauma centers 3/2011 to 8/2012 1 year, 6 months	387 analyzed 1,251 identified 737 excluded for no lactate sample taken 22 excluded for no analyzable lactate result 105 excluded for SBP ≤70	Resuscitation Outcomes Consortium, selected sites. Database: centralized web-based data collection system at Resuscitation Outcomes Consortium Data Coordinating Center
Haider, 2016	Retrospective	USA Setting: NR (national database) Trauma system level: NR 2011 to 2012 2 years	505,296 analyzed	National Trauma Databank

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Guyette, 2015	Included: Patients with blunt or penetrating trauma transported by ground EMS with an out of hospital SBP 71-100 mmHg. Excluded: Patients <15 years old, obvious isolated penetrating head injury, drowning, asphyxia caused by hanging, burns on >20% of total body surface area, or those with prisoner status.	Adults (≥15): 100%	Civilian
Haider, 2016	Included: Trauma patients ≥18 years old. Excluded: Patients who were transferred, did not have vital signs on arrival, those with missing data for EMS vital signs (SBP, HR, RR, GCS), or with missing ISS score.	Adults (≥18): 100%	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Guyette, 2015	Penetrating: 28.7% (111/387)	Land	Male: 69% (267/387) Race* - Non-white or Hispanic: 60% (214/358) Age (mean): 39 (SD 17) * Race or ethnicity not reported for 29 patients	Airway/bag valve mask attempt Lactate SBP SI
Haider, 2016	NR	NR	Male: 65.2% Race: NR Age (mean): 47 (SD 20)	SBP SI National trauma triage protocol (NTTP) physiologic criteria (Step 1) - current, using SBP - investigational model using SI instead of SBP

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Guyette, 2015	Out of Hospital: on arrival	Lactate: venous POC	EMS on arrival	Lactate POC: Lactate Pro (Arkray, Japan)
Haider, 2016	Out of Hospital: not specified	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Guyette, 2015	Lactate cut point: Predetermined to equal the value yielding the same specificity as EMS SBP ≤90. "P-LAC decision rule" - ≥2.5 for overall group - NR for early vs late lactate subgroups For multivariate analysis: 2.5 and 4.0 "knots" = cutoff points selected from prior studies Early lactate: lactate measured <15 minutes after 911 call Late lactate: measured >15 minutes after 911 call	Need for resuscitative care: Any of the following within 6 hours of ED arrival: blood transfusion of ≥5 units; intervention for hemorrhage (including thoracotomy, laparotomy, pelvic fixation or interventional radiology embolization); or death (including death before ED arrival).	The Resuscitation Outcomes Consortium is supported by a series of cooperative agreements to nine regional clinical centers and one Data Coordinating Center from the National Heart, Lung and Blood Institute in partnership with the US Army Medical Research & Material Command, The Canadian Institutes of Health Research (CIHR) - Institute of Circulatory and Respiratory Health, Defense Research and Development Canada, the Heart, Stroke Foundation of Canada and the American Heart Association. These are: 5U01 HL077863V - University of Washington Data Coordinating Center, HL077866 - Medical College of Wisconsin, HL077867 - University of Washington, HL077871 - University of Pittsburgh, HL077873 - Oregon Health and Science University, HL077881 - University of Alabama at Birmingham, HL077887 - University of Texas SW Medical Ctr/Dallas, HL077908 - University of California San Diego	Moderate
Haider, 2016	SBP <90 SI >1.0	Trauma center need: ISS>15, ED disposition to emergency surgery, ICU LOS >1 day, or death in ED.	Authors declare no conflicts of interest.	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Hamada, 2014	Retrospective	France, Ile de France (Paris) Urban Major trauma center 1/1/2011 to 9/30/2012 1 year, 9 months	825 analyzed 998 identified 173 excluded for no direct admission in first 24 hours	Medical records of 2 hospitals.
Henry, 1996	Prospective	USA, New York Suburban and rural Trauma system level: NR 1/25/1994 to 6/30/1994 5 months	1,545 analyzed 1,601 with data collected 56 excluded: - 34 excluded for motorcycle injuries - 22 excluded for unavailable medical records	Primary data collection by EMS personnel. Hospital data by review of medical records.
Holcomb, 2005	Retrospective	USA, Texas Urban Level I trauma center 5/2002 to 4/2004 2 years	381 analyzed 920 identified 137 excluded for head injury 339 excluded for pulse character not recorded (data collected 8/2001 to 5/2002) 63 excluded for SpO2 of 0% or unable to record value, or were dead at admission	Trauma Vitals Database, for transport to a single trauma center (Memorial Hermann Hospital)
Holcomb, 2005b	Prospective	USA, Texas Urban Level I trauma center 8/1/2001 to 3/7/2002 7 months	216 analyzed	Primary data collection

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Hamada, 2014	Included: Patients admitted for suspicion of major trauma. Excluded: Patients who were not directly admitted within 24 hours after trauma.	Overall: NR (mean age 37) Elderly (≥65): 7% (66/825)	Civilian
Henry, 1996	Included: Patients who were victims of motor vehicle crashes who received spinal immobilization by EMS and were transported to any of 12 ambulance receiving hospitals. Excluded: Patients not transported by EMS, those with motorcycle crashes, or with unavailable medical records.	NR	Civilian
Holcomb, 2005	Included: Trauma patients transported from the scene by life flight helicopter service. Excluded: Patients with head injuries (head AIS score ≥3), those without data for pulse character, or who had an SpO2 of 0% or value was not able to be recorded by the monitor, and those who were dead at admission to the hospital.	NR	Civilian
Holcomb, 2005b	Included: Patients transported directly from the incident scene who had an injury necessitating admission to the hospital. Excluded: Patients discharged home from the emergency department.	Adults (>18): 79% Children (2-18): 21%	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Hamada, 2014	Type of injury Blunt: 93.1% Penetrating: 6.9% Mechanism of injury Firearm: 2% Stabbing: 5% Pedestrian/cyclist: 11% Car crash: 19% Motorbike: 28% Fall: 28% Other: 7%	NR	Male: 79% Race: NR Age (mean): 37 (SD 17)	Airway support (assisted ventilation) SpO2 SBP
Henry, 1996	Type of injury: NR Mechanism of injury Motor vehicle crash: 100%	Land and Helicopter	Male: 47% Race: NR Age (median): 30 (range 0 to 93)	RR SBP
Holcomb, 2005	Blunt: 88% Penetrating: 12%	Helicopter	Male: 72% Race: NR Age (mean): 36 (SD 15)	SBP Models using vital signs and scores which differed based on method of measurement - manual (group 1) - semi automated (group 2) - automated (group 3)
Holcomb, 2005b	Blunt: 90% Penetrating: 10%	Helicopter	Male: 73% Race: NR Age (mean): 33 (SD 17)	Capillary refill HR RR SBP SBP plus GCS motor

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Hamada, 2014	Out of hospital: worst value Obtained	NR	NR	NR
Henry, 1996	Out of Hospital: on EMS arrival	Not specified	EMS on arrival	NR
Holcomb, 2005	Out of Hospital: during Resuscitation	Group 1 (manual): no equipment Group 2 (semi automated): light source and minimal instruments Group 3 (automated): automated, vital signs monitor	Flight medic and nurse	Vital signs monitors: Propaq 206EL (Welch Allyn, Skaneateles Falls, NY) or PIC 50 defibrillator/vital signs monitor (Welch Allyn)
Holcomb, 2005b	Out of Hospital: during Resuscitation	Vital signs: automated using portable patient monitor	Flight medical personnel	Propaq 206 monitor (Welch Allyn, Beaverton, Oregon)

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Hamada, 2014	SpO2 <90% SBP <90 mmHg	Major trauma: ISS >15	Authors declare no conflicts of interest.	Moderate
Henry, 1996	RR <10 or >29 breaths per minute SBP <90 mmHg Predetermined, American College of Surgeons Trauma Triage Criteria	Major nonorthopedic operative interventions or death - Major non-orthopedic operative intervention: craniotomy. laparotomy, thoracotomy, or spinal stabilization - Death: in-hospital ISS ≥ 16 Hospital LOS >2 days	Funded by the New York State Department of Health Regional Trauma Quality Assurance Demonstration Project	Low
Holcomb, 2005	SBP <99	LSI defined using a consensus recommendation of a multidisciplinary panel of trauma experts	Supported by the United States Army Medical Research and Materiel Command Combat Casualty Care Research Program (E52-0021-2005-USAISR) and the United States Special Operations Command (MIPR 051-80482).	High
Holcomb, 2005b	Capillary refill Delayed: >2 seconds SBP Hypotensive: <90 mmHg GCS motor score Abnormal: <6	LSI: pre-hospital or hospital intubation, chest tube, needle thoracentesis, cricothyroidotomy, pericardiocentesis, CPR, defibrillation, blood transfusion, operative intervention or arteriogram.	Supported by grants from the U.S. Army Combat Casualty Care Program and the Defense Advanced Research Projects Agency.	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Horne, 2013	Retrospective	Iraq and Afghanistan (UK military) Setting: Combat 2005 to 2010 6 years	1,657 analyzed (overall dataset) 1,213 with complete data for comparative analysis	Joint Theatre Trauma Registry; Royal Centre for Defence Medicine, Birmingham UK
Ichwan, 2015	Retrospective	USA, Ohio Urban and rural (statewide) Trauma system level: NR (both trauma and nontrauma centers) 2006 to 2011 6 years	101,577 analyzed 133,962 identified 30,342 excluded for non-EMS transport 2,043 excluded for missing data to calculate ISS	Ohio Trauma Registry, includes EMS run sheet data
Imhoff, 2014	Retrospective	USA, Kansas Urban Level I Trauma Center Study dates: NR 4 years	3,680 analyzed	Trauma registry for a single trauma center; chart review.
Jo, 2014	Retrospective	South Korea Urban Trauma system level: NR (regional trauma center) 4/1/2010 to 3/31/2011 1 year	299 analyzed 502 identified 203 excluded for no initial lactate level	Internal hospital data

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Horne, 2013	Included: All military or civilian trauma patients with pre-hospital data. Excluded: No exclusion criteria specified. Comparative analysis dataset: Excluded patients with an incomplete set of physiologic data in which the data present did not automatically classify the patient as Priority 1.	NR	Military (may include some Civilians)
Ichwan, 2015	Included: Patients age ≥16 years with EMS transport from the scene. Excluded: Patients who were not transported by EMS or had absent data to calculate ISS.	Adults (≥16): 100% Elderly (≥70): 33%	Civilian
Imhoff, 2014	Included: Patients ≥14 years old with trauma. Excluded: Patients who were transferred from other hospitals, those with burns or drowning-related injuries, or had insufficient vital sign documentation to calculate the REMS score.	Adults (≥14): 100%	Civilian
Jo, 2014	Included: Patients ≥15 years old with blunt trauma, ISS ≥9 and serum lactate level taken on ED arrival. Excluded: No exclusion criteria specified.	Adults (≥15): 100%	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Horne, 2013	NR	NR	NR	Triage Sieve, UK - Civilian version - Military version
Ichwan, 2015	Blunt: 90% Penetrating: 9% Burns: 1% Asphyxial: <1%	Land vs. air: not specified - Interhospital transfer: 14%	Male: 55% Race - White: 79% - Black :14% - Hispanic: 1.4% - Indian/Alaskan/Native: 0.1% - Asian/Pacific Islander: 0.6% - Other: 0.8% - Undocumented: 4.5% Age (mean): 55 (SD 23)	Adult trauma triage criteria Geriatric trauma triage criteria: uses different thresholds for SBP and GCS, and additional anatomic and cause of injury criteria
Imhoff, 2014	NR	NR	Male: 74% Race - White 62% - Black: 23% - Other: 15% Age (mean): 37 (SD 17)	HR MAP Oxygen saturation REMS RR RTS SI
Jo, 2014	Type of injury - Blunt: 100% Mechanism of injury -Motor vehicle crash: 56% -Fall: 11% -Other: 33%	EMS: 67% (land vs. air not specified) Interhospital transfer: 18% Other: 15%	Male: 69% (207/299) Race: NR Age (median): 62 (IQR 45-73)	ViEWS-L (VitalPAC Early Warning Score-Lactate)

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Horne, 2013	Out of Hospital: not specified	NR	NR	NR
Ichwan, 2015	Out of hospital: on arrival - GCS ED: on admission - RR, SBP - GCS (used if missing out of hospital value)	NR	NR	NR
Imhoff, 2014	ED: not specified	NR	NR	NR
Jo, 2014	ED: on arrival	Lactate: arterial	ED clinician	Lactate: Stat Profile Critical Care Xpress Analyzer (Nova Biomedical, Waltham, Massachusetts)

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Horne, 2013	Triage Sieve protocol, military version - GCS <13 in lieu of unconscious status	Priority 1 casualty: Resource based definition; list of LSI including (but not limited to): intubation, surgical airway, thoracostomy, operative intervention for bleeding control, >4 units blood product transfusion, proximal amputation, laparotomy, thoracotomy, pericardial window, or CPR/ACLS activation.	Conflict of interest: authors declare no conflict of interest.	High
Ichwan, 2015	Triage criteria - differences in Adult vs. Geriatric - SBP <90 vs. <100 - GCS ≤13 vs. ≤14 if known or suspected traumatic brain injury - Other differences in anatomic and cause of injury criteria.	Need for trauma center care: ISS >15, OR visit within 48 hours, ICU admission or in-hospital mortality.	Study funded through a 2013 Trauma Grant from the Ohio Department of Public Safety. Author support: Ohio State University College of Medicine Roessler Scholarship (Ichwan), and the National Institute on Aging 1K23AG038351-01 (Caterino).	Moderate
Imhoff, 2014	NR	Mortality: in-hospital	No specific grant for this research from any funding agency in the public, commercial or non-for-profit sectors.	Moderate
Jo, 2014	NR	Mortality: in-hospital	Conflict of interest: authors declare no conflict of interest.	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Jones, 2014	Retrospective	Norway, Oslo Urban Trauma system level: NR (major trauma hospital) Overall 8/1/2000 - 7/31/2008 8 years Derivation data set: 8/1/2000 to 7/31/2006 Validation data set: 8/1/2006 to 7/31/2008	5,363 derivation data set 2,517 validation data set Derivation data set 5,409 identified - 46 excluded for missing information on variables of interest Validation data set 2,521 identified - 4 excluded for missing information on model predictors	Hospital trauma registry. Survival status obtained from patient records and the Norwegian Population Registry.
Joosse, 2014	Retrospective	The Netherlands Urban and rural 2 Level I trauma centers Center A (urban) 2004 to 2010 7 years Center B (rural) 2006 to 2011 6 years	4,418 analyzed - 3,001 in Center A - 1,417 in Center B	Trauma registries for two trauma centers.
Khasawneh, 2014	Retrospective	USA Rural Trauma system level: NR 1/2011 to 7/2012 1 year, 7 months	325 analyzed - 23 with StO2 <65% - 302 with StO2 ≥65 632 identified 307 excluded due to no StO2 value	Prospective collection of internal data

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Jones, 2014	Included: Patients who arrived within 24 hours after injury, including local hospital transfers, who had trauma team activation; and patients with ISS ≥10, head AIS≥3 and /or penetrating injuries towards the head, neck, torso, and/or proximal to elbow or knee. Excluded: Patients with isolated single extremity fractures in which the trauma team was not activated. Patients classified as dead on ED arrival were not excluded.	Children and Adults Derivation data set Age 0-14: 10% (535/5,363) Age 15-64: 77% (4,141/5,363) Age 65-84: 11% (578/5,363) Age ≥85: 2% (109/5,363)	Civilian
Joosse, 2014	Included*: Trauma patients admitted to the hospital, those who died in the ED, and those referred immediately after trauma. Excluded: Patients <16 years old, those who were declared dead on arrival, or were discharged home directly from the ED. * Center A: All patients treated at the trauma resuscitation room. * Center B: Patients triaged as "code red" (judged as potentially severe trauma patients).	Adults (≥16): 100%	Civilian
Khasawneh, 2014	Included: Highest tier triage trauma patients with StO_2 measures.	Adults (≥18): 100%	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Jones, 2014	Derivation data set Blunt: 90.9% Penetrating: 9.1% Validation data set: NR	Land and Helicopter	Derivation dataset Male: 71.7% Race: NR Age (median): 33 (IQR 22-51) Validation dataset Male: NR Race: NR Age (median): 34 (IQR 21-51)	Intubation status RR SBP T-RTS
Joosse, 2014	Blunt: 92% Penetrating: NR	NR	Male: 72% Race: NR Age (mean): 43 (SD 19)	Emergency Trauma Score (EMTRAS): uses age, GCS, base excess, and prothrombin time
Khasawneh, 2014	Blunt: 87%	NR	Male: 74% Race: NR Age (mean): 46 (SD NR)	StO_2

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Jones, 2014	ED: not specified GCS and RR for patients intubated and in general anesthesia on ED arrival: Out of hospital, immediately before intubation	NR	Hospital staff and trauma registrars	NR
Joosse, 2014	ED: on arrival	Base excess: arterial blood gas GCS: most recent value before intubation, if indicated	NR	NR
Khasawneh, 2014	ED: on arrival	StO_2 oxygenation monitor, measured from patient's thenar eminence	NR	InSpectra StO_2 oxygenation monitor (Hutchinson Technology Inc., Hutchinson, Minnesota)

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Jones, 2014	RR: <10 or >29 SBP: <90 T-RTS: <8, <12	Mortality: 30 days after injury	Co-author (N. O. Skaga) received financial support from The Norwegian Air Ambulance Foundation and the South-Eastern Norway Regional Health Authority.	Moderate
Joosse, 2014	NR	Mortality: in-hospital	Conflict of interest: authors declare no conflict of interest.	Low
Khasawneh, 2014	StO_2: <65	Transfusion: any blood product with 24 hours after injury Massive transfusion Mortality Surgical intervention	No external funding. No support of any kind was received from Hutchinson Technology, the manufacturer of the oxygenation monitor.	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Kim, 2016	Retrospective	South Korea Urban vs. rural: Nationwide Trauma system level: NR (20 tertiary academic hospitals) 1/2008 to 12/2013 6 years	45,880 analyzed 1,179,157 total injured patients 1,067,726 excluded for age <65 or unknown 591 excluded for death on arrival 8,297 excluded for traumatic brain injury 14,819 excluded for non-traumatic injury 8,048 excluded for missing vital signs 33,796 excluded for time to ER >6 hours or unknown	Emergency Department-based Injury In-depth Surveillance (EDIIS) database of Korea
King, 1996	Retrospective	USA, Ohio Urban Level I trauma center 8/1/1992 to 7/31/1994 2 years	1,101 analyzed 1,738 identified 289 excluded for GCS ≤8 107 excluded for minor injury 158 excluded for age ≤14 83 excluded for incomplete documentation	Trauma registry for a single trauma center.
King, 2009	Retrospective	USA, Florida Urban Level I trauma center 12/2007 to 11/2008 1 year	75 analyzed 95 enrolled 12 excluded for short recording time (<200 QRS complexes) 2 excluded for technical problem with the recording (missing leads, extreme artifact, or a recording unable to be interpreted meaningfully due to noise 6 excluded for incomplete data from medical record or trauma registry	Primary data collection (prospective collection during helicopter transport) and medical records.

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Kim, 2016	Included: Injured patients age ≥65 years. Excluded: Patients who were dead on arrival to ED, who had isolated traumatic brain injury, those who had non-traumatic injuries (such as burn, drowning, or drug intoxication), lacked data on vital signs, those with injury occurring <6 hours prior to ED arrival or with unknown time parameter.	Elderly (≥65): 100%	Civilian
King, 1996	Included: Patients who required evaluation by the trauma service for trauma alert or trauma consult as indicated based on internal triage criteria. Excluded: Patients ≤14 years old, those with minor trauma not requiring consultation or admission (i.e. single system injuries such as extremity sprains or contusions, with stable vital signs), who had severe head injury (GCS score ≤8), and those with incomplete records or documentation.	Adults (≥15): 100%	Civilian
King, 2009	Included: Patients with trauma requiring out of hospital helicopter transport to the level I trauma center. Excluded: Patients who had measurement artifact or technical problems with ECG recordings.	NR	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Kim, 2016	Mechanism of injury Traffic accident: 25.5% (11,709/45,880) Falling: 54.6% (25,038/45,880) Blunt force: 11.5% (5,286/45,880) Penetrating: 7.6% (3,503/45,880) Other: 0.7% (344/45,880)	EMS from field: 40% (18.285/45,880) EMS interhospital: 5% (2,468/45,880) Ambulatory: 48% (21,899/45,880) Unknown: 7% (3,228/45,880)	Male: 46% (21,223/45,880) Race: NR Age (median): 72 (IQR: 68-78)	Age shock index (Age SI): Age x SI Modified shock index (MSI): HR/MAP SI
King, 1996	Blunt: 84% (925/1,101) Penetrating: 16% (176/1,101)	Ambulance or helicopter	Male: 71% Race: NR Age (mean): 37 (SD 18)	HR SBP SI
King, 2009	NR	Helicopter	Male: 63% (47/75) Race: NR Age (mean): 47 (SD 20)	Heart rate variability HR SBP

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Kim, 2016	ED: on arrival	NR	NR	NR
King, 1996	ED: on arrival	NR	NR	NR
King, 2009	Out of Hospital: during Resuscitation	ECG: digital Holter monitor Heart rate variability: standard deviation of the normal-to-normal R-R interval (SDNN) HR: NR SBP: NR	NR	ECG recording: 2-Channel SEER Light recorder (GE Healthcare, Milwaukee, Wisconsin) ECG analysis: Mars Holter monitor system (GE Healthcare) and proprietary software

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Kim, 2016	Hemodynamic instability: Age SI ≥50 Modified SI ≥1.3 SI ≥1	Mortality: in-hospital Mortality: ED	NR	High
King, 1996	Thresholds chosen as value that maximizes sensitivity and specificity.	Early mortality: 24-hour ISS ≥16 ICU admission: ICU stay ≥1 day Blood transfusion ≥2 units	NR	Moderate
King, 2009	Heart rate variability SDNN cutoffs: 24 msec, 39 msec, 55 msec - 24 msec chosen to attain ≥80% sensitivity	Serious injury: Two out of three trauma surgeons classified patient as seriously injured through blinded review of patient charts and final diagnoses. Any death was considered serious injury. Life-saving intervention in OR: Two out of three trauma surgeons classified surgery as "life-saving" through blinded review.	Partially supported by the Office of Naval Research grant N140610670.	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Kondo, 2011	Prospective	Japan Urban vs. rural: NR (national) Level I trauma center equivalent (114 hospitals) 2004 to 2009 6 years	13,691 analyzed for validation 42,336 in database 3,217 excluded for age <16 280 excluded for cardiac arrest 1,519 excluded for burn injury 185 excluded for other cause of trauma 1,403 excluded for unknown cause of trauma 8,578 excluded for incomplete important data 13,463 used for score derivation	Japan Trauma Data Bank (JTDB)
Kuo, 2016	Retrospective	Taiwan Urban Level I trauma center 1/1/2009 to 12/31/2014 6 years *Study population may include patients in Lai, 2016	17,992 analyzed for reverse shock index 20,106 in study 2,114 with trauma team activation, reverse shock index value not provided	Trauma registry for a single trauma center.
Lai, 2016	Retrospective	Taiwan Urban vs. rural: NR Level I regional trauma center 1/1/2009 to 12/31/2013 5 years *Study population may overlap with Kuo, 2016	3,715 analyzed 16,548 in registry 3,909 /16,548 excluded for transfer from another hospital 8,924/16,548 excluded for arrival by private vehicle	Trauma registry from one Level I regional trauma center
Lalezarzadeh, 2009	Retrospective	USA, California Urban Level II trauma center 1/1/2003 to 12/31/2007 5 years	6,964 analyzed 9,179 identified 1,881 excluded for inadequate documentation 7,298 eligible 167 excluded for dead on arrival 77 excluded for transfer to another facility for higher level of care 90 excluded for insufficient ED data	Trauma registry for a single trauma center.

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Kondo, 2011	Included: Patients with ISS >3. Excluded: Patients <16 years old, those who died at trauma scene, had other trauma mechanism such as burn, or with incomplete important data (age, GCS, SBP, RR, or ISS). Severe trauma subgroup: ISS >16	Adults (≥16): 100%	Civilian
Kuo, 2016	Included: Patients for whom there was not a trauma team activation. Excluded: Patients who died before hospital arrival or were discharged against advice from the ED.	Pediatrics (≤19): 14% Adults (20-59): 53% Elderly (≥60): 33% Adults (18-65)*: 64% *Adult subgroup for analysis.	Civilian
Lai, 2016	Included: Patients in the trauma registry who were transferred by EMS and hospitalized. Excluded: Patients transferred from other hospitals, deceased on arrival to ED, who arrived by private vehicle, were discharged from the ED, or who had incomplete data.	NR	Civilian
Lalezarzadeh, 2009	Included: Patients with adequate out of hospital data available. Excluded: Patients who were dead on arrival, transferred to another facility for a higher level of care, or who had incomplete data in the ED.	NR	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Kondo, 2011	Blunt: 94.5% (12,939/13,691) Penetrating: 5.5% (752/13,691)	Ambulance: 87.2% (11,511/13,691) Helicopter: 6.4% (841/13,691) Doctor's car: 3.2% (422/13,691) Own car: 1.9% (250/13,691) On foot: 0.5% (62/13,691) Other: 0.8% (109/13,691)	Male: 69% (9.494/13,691) Race: NR Age (mean): 51 (SD 22)	GAP score (GCS, Age, SBP) MGAP score (Mechanism, GCS, Age, SBP) RTS SBP T-RTS
Kuo, 2016	Blunt vs. Penetrating: NR Mechanism of injury Motor vehicle: 2% Motorcycle: 41% Bicycle: 4% Pedestrian: 2% Fall: 31% Unspecified: 20%	NR	Male: 57% Race: NR Age (mean): 47 (SD 22)	Reverse shock index (SBP/HR)
Lai, 2016	NR	NR	Male: 59% (2,177/3,715) Race: NR Age (mean): 42 (SD 14)	Reverse shock index
Lalezarzadeh, 2009	Blunt: 84% (5,830/6,964) Penetrating: 16% (1,134/6,964)	NR	Male: 75% Race: NR Age (mean): 35 (SD NR)	SBP

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Kondo, 2011	ED: on arrival	NR	NR	NR
Kuo, 2016	ED: on arrival	NR	NR	NR
Lai, 2016	Out of Hospital: on EMS arrival ED: on arrival	NR	NR	NR
Lalezarzadeh, 2009	Out of Hospital: on EMS arrival ED: on arrival	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Kondo, 2011	SBP: <60, 60-120, >120 Age: <60 or ≥60 Thresholds equal to those in the MGAP scoring system, which were predetermined based on clinical knowledge.	Mortality - Short-term: death in the ED or OR - Long-term: death at discharge	NR	Moderate
Kuo, 2016	Reverse SI <1: SBP lower than the HR	Blood transfusion in ED ISS ≥16 Mortality: in-hospital	Supported by a grant from Chang Gung Memorial Hospital (CDRPG8C0032 and CDRPG8C0033).	Moderate
Lai, 2016	Reverse SI <1: shock	Mortality: in-hospital Blood transfusion ISS ≥16	Supported by a grant from Chang Gung Memorial Hospital (CDRPG8C0031)	Moderate
Lalezarzadeh, 2009	Predefined cutoffs, based on iterative review SBP, out of hospital ≤80: severe hypotension 81-100: moderate hypotension 101-120: mild hypotension >120: normotension SBP, ED ≤90: hypotension	Operative intervention: ED disposition to OR ICU admission: ED disposition to ICU Mortality: in-hospital	NR	High

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Lee, 2014	Retrospective	Singapore Urban Trauma level: NR 1/2011 to 12/2012 2 years	92 analyzed 51,001 trauma-related ED consultations 4,746 admissions	Trauma registry for a single hospital.
Lehmann, 2007	Retrospective	USA, Washington Setting: Military base Level II trauma center 1/2002 to 12/2005 4 years	1,495 analyzed 1,782 in registry	Trauma registry for a single trauma center.
Lerner, 2017	Prospective	USA, New York, Texas and Wisconsin Urban Trauma system level: NR (pediatric trauma centers) 6/2009 to 8/2012 3 years, 3 months	5,594 analyzed 8,307 ED patients 2,697 missed enrollment 16 excluded for incomplete outcome data	Primary data collection

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Lee, 2014	Included: Patients with ISS ≥9 who were admitted. Excluded: Patients with submersion injury and those transferred from other hospitals.	Pediatrics (≤16): 100% <5 years: 52% (48/92) 5-9 years: 23% (21/92) 10-14 years: 18% (17/92) ≥15 years: 2.2% (2/92)	Civilian
Lehmann, 2007	Included: Adult (>16 years) trauma patients. Excluded: Patients with burn as the primary mechanism of injury, and those transferred from ED to another facility.	Adults (>16): 100%	Military and Civilian
Lerner, 2017	Included: Patients ≤15 years old who were transported to the ED by EMS with traumatic mechanism of injury. Excluded: Patients transported by means other than ground or air ambulance, or if EMS provider had not seen the scene of injury (e.g., interfacility transfers or transport by multiple agencies in serial).	Pediatrics (≤15): 100%	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Lee, 2014	Falls: 68% (63/92) Road traffic accident: 19% (17/92) Burn: 13% (12/92)	NR	Male: 63% (58/92) Race: NR Age (median): 4.75 (range 2 months to 15 years)	PTS (Pediatric Trauma Score) RR
Lehmann, 2007	Blunt: 88% (1,315/1,495) Penetrating: 12% (179/1,495)	NR	Male: 70% (1,045/1,495) Race: NR Age (mean): 41 (SD 22)	HR SBP
Lerner, 2017	Mechanism of injury Assault, gun shot, and stabbing: 3.9% (216/5,594) Bicyclist struck: 2.3% (128/5,594) Burn: 1.9% (104/5,594) Fall: 34.2% (1,915/5,594) Motor vehicle crash: 21.6% (1,206/5,594) Motorcycle crash: 0.4% (21/5,594) Pedestrian struck: 6.6% (368/5,594) Sports injury: 7.7% (429/5,594) Other: 21.6% (1,207/5,594)	EMS ground or air ambulance	Male: 60% (3,365/5,594) Race: NR Age (mean): 8 (SD 5)	RR SBP Physiologic criteria of the Field Triage Guidelines (GCS, RR, SBP)

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Lee, 2014	ED: not specified	NR	NR	NR
Lehmann, 2007	Out of Hospital: NR ED: NR	NR	NR	NR
Lerner, 2017	Out of hospital: on arrival ED: on arrival	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Lee, 2014	PTS ≥8 RR above or below normal range Predetermined: NR	Major trauma: ISS ≥16, admission to the ICU, life- or limb-saving procedures, or mortality. Calculation of ISS retrospectively performed by an Association for the Advancement of Automotive Medicine accredited database coordinator. Receipt of resuscitation in ED: endotracheal intubation, tube thoracotomy, intravenous fluid infusion ≥20 mL/kg body weight within the first 30 minutes, or unmatched emergency blood transfusion.	NR	Low
Lehmann, 2007	HR <60 bpm: bradycardia >110 bpm: tachycardia SBP EMS SBP <100 mmHg: hypotension ED SBP <90 mmHg: hypotension	Emergent intervention: Urgent surgical procedure in the OR (laparotomy, thoracotomy, craniotomy, or neck exploration), or required any of these procedures in the ED: intubation or surgical airway, tube or needle thoracostomy, thoracotomy, pericardiocentesis, central venous catheter placement, blood transfusion, or cardiopulmonary resuscitation.	NR	Moderate
Lerner, 2017	SBP <90 RR <10 or >29	Trauma center need: ICU admission, death, or non-orthopedic surgery within 24 hours of hospital arrival.	Supported by grant R01CE001835 from the Centers for Disease Control and Prevention (CDC).	Low

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Lin, 2011	Prospective	USA, Florida Urban Level I trauma center 7/1/2007 to 9/30/2007 3 months	601 analyzed	Prospective entry of trauma patients at a single trauma center.
Lipsky, 2006	Prospective	USA, California Urban Level I trauma center 9/1/1995 - 8/31/1996 1 year	1,028 analyzed 1,227 identified 33 excluded for cardiopulmonary arrest in the field 127 excluded for inadequate documentation 39 excluded for ED hypotension	Primary data collection
Liu, 2014a *Includes the study population from Liu, 2014b/Liu, 2015b	Prospective	USA, Texas Urban Level I trauma center 6/27/2011 to 1/6/2012 6 months	305 analyzed - 104 wireless monitor group* - 201 standard monitor group *Wireless monitor group comprised of the study population for Liu, 2014b/Liu 2015b (WVSM database).	Primary data collection/WVSM database

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Lin, 2011	Included: Patients meeting the Miami-Dade county trauma center triage criteria. Excluded: Patients <15 years old, those with thermal, chemical, or electrical injury, who had a cardiac arrest prior to any surgical procedure, were transferred from another hospital, or those without adequate out of hospital data.	Adults (≥15): 100% Elderly (>55): 17% (103/601)	Civilian
Lipsky, 2006	Included: Patients transported by EMS who had normal SBP on ED presentation. Excluded: Patients who did not meet trauma criteria, were in cardiopulmonary arrest at any time in the field, those not transported by EMS or were transferred from another facility.	NR	Civilian
Liu, 2014a *Includes the study population from Liu, 2014b/Liu, 2015b	Included: Patients >18 years old classified as a Code 2 or 3 (nonemergency but highly important response or life-threatening response) who suffered blunt or penetrating trauma and were transported directly from the scene to the trauma center by helicopter. Patients who did not wear the WVSM due to technical issues, time shortage, arm injuries precluding device use, device unavailable, or provider's decision, were assigned to the control group.	Adults (≥18): 100%	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Lin, 2011	Blunt: 69.38% (417/601) - Motor vehicle crash: 31.9% (192/601) - Pedestrian hit by car: 8.7% (52/601) - Motorcycle crash: 9.7% (58/601) - Fall: 10.8% (65/601) - Water sports: 1.2% (7/601) - Industrial/crush: 2.3% (14/601) - Assault: 4.8% (29/601) Penetrating: 30.62% (185/601) - Gunshot wounds: 17.3% (104/601) - Stab wound: 13.3% (80/601)	NR	Male: 81% (490/601) Race: NR Age (mean): 38 (SD 18; range 15 to 100)	SBP
Lipsky, 2006	Blunt: 73% Penetrating: 27%	EMS, land vs. air not specified	Male: 76% Race: NR Age (median): 28 (IQR 18-39)	SBP
Liu, 2014a *Includes the study population from Liu, 2014b/Liu, 2015b	NR	Helicopter	Male: 66% Race - White: 63% - Black: 10% - Hispanic: 21% - Asian/Pacific 1% - Not Recorded: 5% Age (mean): 39 (SD 16)	Combined vital signs: HR, RR, and SBP HR RR SBP

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Lin, 2011	Out of Hospital: during resuscitation ED: on arrival	NR	NR	NR
Lipsky, 2006	Out of Hospital: not specified ED: on arrival	SBP - EMS: auscultation or palpation - ED: auscultation or automated	NR	NR
Liu, 2014a *Includes the study population from Liu, 2014b/Liu, 2015b	Out of Hospital: continuous	Vital signs: automated - standard vital signs monitor or wireless vital signs monitor	NR	Wireless vital signs monitor: WVSM (Athena GTX, Inc. Des Moines, Iowa) Standard vital signs monitor: LIFEPAK 12 (Physio- Control, Inc., Redmond, Washington)

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Lin, 2011	SBP ≤90 mmHg Predetermined: based on trauma team activation criteria	Major trauma: emergency surgery, ISS ≥16, or need for ICU care. Very severe trauma: ISS ≥25 Emergency surgery: life-saving operation needed within minutes	NR	High
Lipsky, 2006	Hypotension: - Adults: SBP< 90 for adults - Children <10 years old: SBP < (2 x [age in years] +70) - nonpalpable pulse in any anatomic location	Need for an emergent therapeutic operation: 2 out of 3 surgeons categorized surgery as therapeutic, considered as organ repair that could not have been managed nonoperatively, or intra-thoracic or intra-abdominal injuries grade III or higher on organ injury scale.	Partial support by grants from the State of California Emergency Medical Services Authority (Federal Block Grant Fund numbers 4016, 4062).	High
Liu, 2014a *Includes the study population from Liu, 2014b/Liu, 2015b	NR	LSI: separated into prehospital or ED - Prehospital: blood transfusion, CPR, chest tube, intubation, needle decompression, pericardiocentesis, surgical cricothyrotomy, thoracotomy, or tourniquet. - ED: endotracheal intubation, blood product transfusion, tube thoracostomy, CPR, needle decompression, angioembolization, surgical cricothyrotomy, thoracotomy, cardioversion, or tourniquet.	Supported by the National Trauma Institute, the Combat Casualty Care Research Program, and the State of Texas Emerging Technology Fund. Athena GTX thanked for use of Murphy Factor to support protocol development.	High

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Liu, 2014b Liu, 2015b *Study population included in Liu, 2014a	Prospective	USA, Texas Urban Level I trauma center 6/27/2011 to 1/6/2012 6 months	104 analyzed *This study population comprises the WVSM database.	Primary data collection (makes up WVSM database)
Liu, 2014c	Retrospective	USA, Texas Urban Level I trauma centers Training dataset Time period: NR Validation dataset 1/27/20111 to 1/6/2012 6 months	79 in training dataset 24 in validation dataset Validation dataset 104 in database* - 72 excluded for no LSI - 8 excluded for no corresponding LSI prediction *Validation database, WVSM, is the study population of Liu, 2014b/Liu, 2015b	Training dataset: Trauma Vitals database Validation dataset: Wireless Vital Signs Monitor trial
Liu, 2015a	Retrospective	USA, Texas Urban Level I trauma centers Study dates: NR	108 analyzed	Trauma Vitals (TV) database

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Liu, 2014b Liu, 2015b *Study population included in Liu, 2014a	Included: Patients >18 years old classified as a Code 2 or 3 trauma patient, who suffered blunt or penetrating trauma and were transported directly from the scene to the trauma center by helicopter. Excluded: Patients discharged home from the ED, pregnant women, age <18 years, and those transported from a nursing home.	Adults (≥18): 100%	Civilian
Liu, 2014c	Overall Included: Severe trauma patients with blunt or penetrating injury transported from the scene by helicopter to a study trauma center. Additional criteria for each dataset: Training: Data from these patients selected based on 3 criteria: 1) availability of vital signs and Murphy Factor score; 2) BP measured over ≥15 min with change from initial measurement; 3) HR measurements uncorrupted by electromechanical noise. Validation: Patients with injury requiring hospital admission. Excluded: no exclusion criteria specified.	Adults (≥18): 100%	Civilian
Liu, 2015a	Included: Patients with blunt or penetrating injury transported from the scene to either study trauma center by helicopter, and with the following available in the database: vital signs data; ECG waveforms; and manual verification of all R-to-R interval (RRI) sequences. Excluded: no exclusion criteria specified.	NR (presumably 100% adult)	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Liu, 2014b Liu, 2015b *Study population included in Liu, 2014a	Blunt: 90% Penetrating: 10%	Helicopter	Male: 79% Race - White/Caucasian: 60% - Black: 10% - Hispanic: 22% - Asian/Pacific: 1% - Not Recorded: 7% Age (mean): 40 (SD 16)	HR RR HR data quality indices (% valid; deviation ratio) Heart rate variability (HF power to LF power ratio) Heart rate complexity (sample entropy) Machine learning model using HR, GCS, and heart rate complexity Models from multivariate analyses (combinations of vital signs, HRC, and GCS)
Liu, 2014c	Blunt or penetrating	Helicopter	Male: 65% Race - White/Caucasian: 60% - Black: 10% - Hispanic: 22% - Asian/Pacific: 1% - Not recorded: 7% Age (mean): 39 (SD 16)	HR RR SBP Multiparameter machine learning algorithms using vital signs and Murphy Factor using 16 features or 24 features - Multilayer perceptron - Single logit
Liu, 2015a	Blunt: 86% Penetrating: 12% Not recorded: 2%	Helicopter	Male: 76% (82/108) Race - White: 41% - Black: 6% - Hispanic: 22% - Asian/Pacific: 3% - Not recorded: 28% Age (mean): 37 (SD 14)	HR HRC: sample entropy HRV: Poincaré ratio, SD1/SD2

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Liu, 2014b Liu, 2015b *Study population included in Liu, 2014a	Out of Hospital: continuous ED: continuous	Vital signs: automated monitor with single-lead ECG waveform and thumb-mounted pulse oximeter	NR	Wireless Vital Signs Monitor (Athena GTX, Inc. Des Moines, Iowa)
Liu, 2014c	Out of hospital: during resuscitation	Machine learning algorithms: Vital signs measured automatically by monitors using ECG waveforms, photoplethysmogram, pulse oximeter and respiratory waveform; and calculated measurements of SI, pulse pressure, and Murphy Factor.	NR	Vital signs monitors Training dataset: Propaq 206 or PIC 50 (Welch Allyn; Skaneateles Falls, NY) Validation dataset: Wireless Vital Signs Monitor (WVSM, Athena GTX; Des Moines, IA) Machine learning modeler (WEKA; University of Waikato, New Zealand)
Liu, 2015a	Out of Hospital: during resuscitation	Automated vital signs monitor	Emergency Medical Services Medics	Vital signs monitor: Welch Allyn PIC 50 (Welch Allyn, Skaneateles Falls, NY)

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Liu, 2014b Liu, 2015b *Study population included in Liu, 2014a	HR ≥110 RR 20-26 Cutoffs for highest quartile	LSI: blood transfusion, chest tube, endotracheal intubation, needle decompression, CPR, cricothyrotomy, thoracotomy, tourniquet, angioembolization, or cardioversion. - reported total and separated by out of hospital and ED	National Trauma Institute, the Combat Casualty Care Research Program and the State of Texas Emerging Technology Fund	High
Liu, 2014c	Hybrid system basic detection rules (applied in the following order to filter out patients who required immediate attention) - SBP <90 or >200 - DBP <40 or >140 - Pulse pressure <20 or >100 - MAP <60 or >180 - Oxygen saturation <85% - mean HR >130 - mean SI <0.2 or >1.6 - max SBP >120 and max DBP >80 and max MAP >100 and mean HR >115 and max oxygen saturation ≤95% - MAP >131 and max RR >40 - max SBP >160 and max DBP >120 and mean RR >40	LSI: endotracheal intubation, transfusion, tube thoracostomy, cardiopulmonary resuscitation, needle decompression, angioembolization, cricothyrotomy, thoracotomy, or cardioversion.	Supported by the National Trauma Institute, the US Army Combat Casualty Care Research Program, and the State of Texas Emergency Technology Fund. Athena GTX, Inc. thanked for use of the Murphy Factor to support algorithm development.	High
Liu, 2015a	NR	LSI: interventions performed prehospital or in ED; endotracheal intubation, blood transfusion, tube thoracostomy, CPR, needle decompression, angioembolization, cricothyrotomy, thoracotomy, or cardioversion. Mortality: not specified	The National Trauma Institute, the Combat Casualty Care Research Program and the State of Texas Emerging Technology Fund.	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Mackenzie, 2014 *Mackenzie, 2014 study population is included in Shackelford, 2015	Prospective	USA, Maryland Urban Level I trauma center 12/2011 to 6/2012 7 months	556 analyzed	Primary collection of data then stored in centralized data repository; in-hospital mortality and hospital LOS obtained from the trauma registry; blood use was cross-validated with blood bank records.
Mackenzie, 2015 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	Prospective	USA, Maryland Urban Trauma system level: NR Study period: NR	135 analyzed	Primary data collection and patient chart review
Matsushima, 2016	Retrospective	USA, California Urban Trauma system level: NR 1/2002 - 12/2012 11 years	3,998 analyzed 10,554 identified 6,556 excluded due to triage criteria in addition to motor vehicle intrusion	County trauma database
McManus, 2005	Retrospective	USA, Texas Urban Level I trauma system 3/2002 to 10/2004 2 years, 7 months	342 analyzed (n varied by outcome)	Trauma Vitals System

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Mackenzie, 2014 *Mackenzie, 2014 study population is included in Shackelford, 2015	Included: Patients >17 years old who were admitted directly from the scene of injury and any of: EMS SI >0.62; rated as EMS Priority 1 as critically ill or injured requiring immediate attention or unstable with life-threatening injury or illness without available pre-hospital vital signs. Excluded: Patients with cervical spine injury with neurologic deficit, those surviving <15 minutes	Adults (>17): 100%	Civilian
Mackenzie, 2015 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	Included: Trauma patients age ≥18 years who survived ≥15 minutes after ED admission, and who had an SI >0.61 or were categorized as EMS Priority 1. Excluded: None specified. No patients were excluded because of an inability to obtain good quality waveform signals.	Adults (≥18): 100%	Civilian
Matsushima, 2016	Included: Patients involved in a motor vehicle crash with motor vehicle intrusion as the only trauma triage criterion met. Excluded: Patients with missing out-of-hospital vital signs and those who met trauma center triage criteria in addition to motor vehicle intrusion.	Children (≤18): 12.3% Adults (19-64): 80.5% Elderly (≥ 65): 7.2%	Civilian
McManus, 2005	Included: Patients age 18-50 years with records that contained radial pulse character. Excluded: Patients with head injuries (AIS head > 2).	Adults (18-50): 100%	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Mackenzie, 2014 *Mackenzie, 2014 study population is included in Shackelford, 2015	Type of injury Blunt: 84.5% (470/556) Penetrating: 10.1% (56/556) Mechanism of injury Motor vehicle-related: 46.9% (261/556) Falls: 26% (145/556) Interpersonal violence: 16% (89/556)	NR	Male: 69% (381/556) Race: NR Age (mean): 40 (SD 17)	HR SBP SI Vital signs features PPG waveform: 12 features of amplitude HR and SpO2 signals features (14 each) included dose and percentage of abnormal for different thresholds; and mean value and quartiles
Mackenzie, 2015 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	Type of injury Blunt: 79.3% (107/135) Penetrating: 16.3% (22/135) Other: 4.4% Mechanism of injury Motor vehicle-associated: 48.9% (66/135) Falls: 16.3% (22/135) Interpersonal violence: 24.4% (33/135) Other: 10.4% (14/135)	NR	Male: 70% (95/135) Race: NR Age (mean): 39 (SD 17)	Pulse oximeter (PPG) algorithms to predict life-saving interventions - algorithms were specific to each life-saving intervention
Matsushima, 2016	Specific injuries (not exhaustive list) Brain injury: 4.5% Hemo/pneumothorax: 5.7% Lung contusions: 6.9% Cervical fractures: 6.1% Rib fractures: 12.3% Pelvic fractures: 7.4%	NR	Male: 57% Race: NR Age (mean): NR	HR SBP
McManus, 2005	Blunt: 89%	Helicopter	Male: 75% Race - African-American: 10% - Asian: 3% - Hispanic: 35% - White: 50% - Other: 2% Age (mean): 32 (range 18-50)	Radial pulse character

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Mackenzie, 2014 *Mackenzie, 2014 study population is included in Shackelford, 2015	Out of hospital: not specified - HR, SBP ED: 1 hour beginning at time of arrival - continuous vital signs signals: HR, PPG, and SpO2	HR and SBP (out of hospital): NR Vital signs signals in ED: continuous collection by automated patient monitors PPG signals were filtered after collection to reduce noise using a PPG-SQI	NR	Vital signs data collection: BedMaster software (Excel Medical Electronics, Jupiter, FL) and networked patient monitors (GE-Marquette-Solar-7000/8000, GE Healthcare, Little Chalfont, United Kingdom)
Mackenzie, 2015 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	ED: on arrival	Pulse oximeter: automated, continuous PPG waveform from pulse oximeter PPG signal features: automated analysis	NR	NR
Matsushima, 2016	Out of Hospital: not specified	NR	NR	NR
McManus, 2005	Out of hospital: on arrival Radial pulse character assessed prior to BP measurement	BP automated Radial pulse character: manual	Paramedic	Propaq 206 EL (Welch Allyn, Skaneateles Falls NY)

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Mackenzie, 2014 *Mackenzie, 2014 study population is included in Shackelford, 2015	Optimal thresholds determined by Youden index were used to calculate sensitivity and specificity.	All models Blood transfusion: any transfusion within 24 hours Blood transfusion within 3 hours Models with all vital signs features (group 3 and 4) Massive transfusion: >4 units pRBCs transfused in <4 hours Mortality: in-hospital Hospital LOS >3 days	Partially funded by US Air Force (USAF) FA8650-11-2-6D01 and USAF FA8650-11-2-6142 and Office of Naval Research (ONR) N00014-12-C-0120.	Moderate
Mackenzie, 2015 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	Pulse oximeter signal features included: amplitude of PPG waveform from peak to valley; total millivolts of the PPG waveform amplitude; IQR of PPG amplitude; 25th percentile and 75th percentile of PPG amplitude; oxygen saturation features; and HR signal features.	Blood transfusion within 6 hours Surgical intervention within 6 hours Endotracheal intubation within 1 hour	Partially funded by the US Air Force (USAF) FA8650-11-2-6D01 and USAF FA8650-11-2-6142 and Office Naval Research (ONR) N00014-12-C-0120.	Moderate
Matsushima, 2016	SBP <110 HR >100 predetermined	Need for trauma center resources: ED intubation, non-orthopedic surgical procedure, ICU admission or in-hospital mortality.	No internal and external financial support was used for this study.	Moderate
McManus, 2005	Radial pulse character: normal, weak, or absent	ICU admission Intubation Mortality	Medical equipment supplied by Welch Allyn Protocol, Inc.	High

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
McNab, 2013	Retrospective	USA, Florida Urban and rural Level I trauma center 1/1/2006 to 12/31/2010 5 years	15,394 analyzed 16,269 identified 875 excluded for early mortality	Trauma Registry of American College of Surgeons from one trauma center.
Miller, 2017	Retrospective	USA Urban vs. rural: National registry 758 trauma centers, Level I-IV 1/1/2012 to 12/31/2012 1 year	429,711 analyzed 833,311 in database 300,720 excluded for transferred patient, <16 years old, or not having blunt or penetrating trauma 102,880 excluded for missing values for HR, RR, SBP, GCS or oxygen saturation	U.S. NTDB
Mizushima, 2011	Retrospective	Japan, Osaka Urban Level I trauma center equivalent 1/1/2002 to 12/31/2008 7 years	1,742 analyzed	Local trauma registry
Montoya, 2015	Retrospective	Colombia, Neiva Urban and rural Level I trauma center 1/2013 to 12/2013 1 year	666 analyzed	Medical record review using standardized form.

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
McNab, 2013	Included: Trauma patients presenting during study period. Excluded: Patients <16 years old, those with incomplete data and those not transported directly from the scene by EMS. Patients who died in the trauma center immediately on arrival or soon after hospital admission were excluded from analysis.	Adults (>16): 100% Elderly (≥60): 12% Distribution Age 16-20: 12% Age 20.1-30: 29% Age 30.1-40: 18% Age 40.1-50: 19% Age 50.1-60: 13% Age ≥60.1 12%	Civilian
Miller, 2017	Included: Patients ≥16 years old with blunt and/or penetrating injuries. Excluded: Patients transferred from another facility, burn and/or drowning victims, and those with missing data necessary to a modified Rapid Emergency Medicine Score (mREMS).	Adults (≥16): 100% Elderly (≥65): 30% Distribution <45: 44% 45-54: 14% 55-64: 12% 65-74: 9% >74: 21%	Civilian
Mizushima, 2011	Included: Patients ≥16 years old with trauma. Excluded: Patients who were dead on arrival.	Adults (≥16): 100%	Civilian
Montoya, 2015	Included: Trauma patients age 18-50 years with shock index taken at admission. Excluded: Patients with a history of hypertension or metabolic syndrome.	Adults (18-50): 100%	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
McNab, 2013	Overall Mechanism: NR Identified (includes early mortality patients): Motor vehicle crash: 44.9% Falls: 11.2% Gunshot wounds: 9.6% Motorcycle crashes: 8.7% Pedestrians struck by vehicles: 6.3% Stab wounds: 5.8%	NR	Male: NR Race: NR Age (mean): 39 (range 16 to 100)	SI increase from prehospital to trauma center
Miller, 2017	Type of injury: Blunt trauma: 89.3% (383,709/429.711) Penetrating trauma: 10.7% (46,002/429,711)	NR	Male: 61% (263,957/429,711) Race - White: 72% (298,213/429,711) - Black: 16% (64,311/429,711) - Other: 12% (49,856/429,711) Age (mean): 50 (SD 23)	MGAP mREMS RTS SI
Mizushima, 2011	Blunt: 94.5% Penetrating: 5.5%	NR	Male: 72% Race: NR Age (mean): 44 (SD 20)	Base Deficit Lactate
Montoya, 2015	Blunt: 78% (522/666) Penetrating: 22% (144/666)	NR	Male: 75% (501/666) Race: NR Age (mean): 33 (SD 15)	SI

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
McNab, 2013	Out of hospital: on EMS arrival ED: on arrival	NR	NR	NR
Miller, 2017	ED: not specified	NR	NR Scores calculated in data analysis phase	NR
Mizushima, 2011	ED: not specified	NR	NR	NR
Montoya, 2015	ED: on arrival	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
McNab, 2013	NR	Mortality: NR	NR	Moderate
Miller, 2017	NR	Mortality: in-hospital	No funding sources for this study.	Moderate
Mizushima, 2011	Base deficit: < -5 and < -10 Lactate: >2.5 and >5.0	Mortality: NR	NR	Moderate
Montoya, 2015	SI > 0.9	Mortality: 24-hour	Funding NR Conflict of interest declared: None.	High

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Moore, 2006	Retrospective	Canada, Quebec Urban Level I trauma centers 4/1995 to 3/2003 8 years	22,388 analyzed	Trauma registries of 3 trauma centers.
Moront, 1996	Retrospective	USA, Texas Urban Level I pediatric trauma center Study dates: NR 4 years	3,861 analyzed	Trauma registry for a single trauma center.
Mutschler, 2013	Retrospective	Germany Setting: NR (multicenter database) Trauma system level: NR (approximately 600 hospitals) 2002 to 2011 10 years	21,853 analyzed	TraumaRegister DGU of the German Trauma Society

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Moore, 2006	Included: Patients ≥16 years old with trauma who had a hospital length of stay ≥3 days, were admitted to the ICU, had been transferred from another hospital, or died. Excluded: Patients who died on arrival, had isolated hip fractures, or were <16 years old.	Adults (≥16): 100% Elderly (≥65): 30% Age ranges: 17-54: 59.4% (13,289/22,388) 55-64: 10.7% (2,393/22,388) 65-74: 11.5% (2,566/22,388) 75-84: 12.1% (2,715/22,388) 85-106: 6.4% (1,425/22,388)	Civilian
Moront, 1996	Included: Children <15 years old transported by EMS personnel with blunt or penetrating trauma. Excluded: No exclusion criteria specified.	Children (<15): 100%	Civilian
Mutschler, 2013	Included: Patients ≥16 years old, with primary admission, and for whom there were complete datasets for SBP, HR, GCS, and BD on ED admission. Excluded: Not specified.	Adults (≥16): 100%	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Moore, 2006	Mechanism of injury Motor vehicle collision: 32.9% (7,329/22,388) Fall: 46.4% (10.363/22,388) Firearm: 2.0% (435/22,388) Stab wound: 2.5% (565/22,388) Blunt object: 8.4% (1,878/22,388) Other: 7.8% (1,795/22,388)	NR	Male: NR Race: NR Age (mean*): 51 (NR) *mean calculated using midpoint of age intervals	RR RTS SBP
Moront, 1996	Mechanism of injury *(approximations from graph)* Children transported by air Motor vehicle crash: 35% Pedestrian: 15-20% Falls: 20-25% Bike: 10-15% Gunshot or stab wound: <5% Abuse: <5% Children transported by ground Motor vehicle crash: 20% Pedestrian: 20-25% Falls: 30-35% Bike: 5-10% Gunshot or stab wound: 5-10% Abuse: <5%	Mixed	Male: NR Race: NR Age (mean): 7 (SD 4)	Combined triage criteria: GCS <12 and HR >160
Mutschler, 2013	Blunt: 93% (20,215/21,853)	NR	Male: 73% (16,005/21,853) Race: NR Age (mean): 45 (SD 20)	SI

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Moore, 2006	NR	NR	NR	NR
Moront, 1996	Unclear; measures taken out of hospital and in hospital.	NA	NR	NR
Mutschler, 2013	ED: on arrival	SI: calculated for each individual by the ratio of HR to SBP.	NR	NR

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Moore, 2006	Coded values for SBP, RR, GCS are those used in the RTS	Mortality: in-hospital	Supported by the Canadian Institutes of Health Research through a doctoral research award, and Fonds de la recherche en santé du Québec (grant number 015102).	Low
Moront, 1996	GCS <12 HR >120	Need for immediate transport to trauma center: TRISS probability of survival <0.95	NR	Moderate
Mutschler, 2013	SI > 1.0	Mortality: in-hospital Blood transfusion: ≥1 blood product transfused	This is an unfunded study.	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Nabaweesi, 2014	Retrospective	USA Urban and suburban Level I pediatric trauma center 1/1/2008 to 12/31/2011 4 years	1,991 analyzed 3,213 identified 21 excluded for age ≥15 436 excluded for non-EMS transport to ED 459 excluded for transfer from another facility 62 excluded for burn injury 100 excluded for no trauma team activation 144 not in analysis, reason not specified	Pediatric Trauma Collector Registry
Newgard, 2009	Retrospective	USA and Canada Urban and rural Level I to Level IV trauma centers and non-trauma centers 12/1/2005 to 2/28/2007 1 year, 3 months	955 analyzed 382 (40%) used as validation set 1,096 met inclusion criteria 141 excluded for missing outcome information	Resuscitation Outcomes Consortium Epistry Trauma Registry

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Nabaweesi, 2014	Included: Patients age ≤14 years who were transported by EMS from scene of injury to the trauma center and for whom a trauma team activation was initiated. Excluded: Patients transferred from other acute care facilities, arrived at the ED as a walk in or by private vehicle, those older than 14 years, or who presented with simultaneous burn and traumatic injuries or with penetrating mechanism of injury.	Children (≤14): 100%	Civilian
Newgard, 2009	Included: Children age ≤14 years with injury (any blunt, penetrating, or burn mechanism suspected by EMS to be due to trauma), and who had EMS provider evaluation and documented physiologic abnormality (SBP ≤90 mmHg, respiratory rate <10 or >29 breaths/min, GCS score ≤12, or attempted field intubation) at any point during out-of-hospital resuscitation. Excluded: Children judged to be dead on EMS arrival with no attempted resuscitation.	Children (≤14): 100%	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Nabaweesi, 2014	Blunt: 93.1% Penetrating: 3.6%	Mixed	Male: NR Race: NR Age (median) - full TTA group: 6 - without full TTA group: 8 *Stated: The analysis of gender, race and age categories did not show any significant differences between patients with full TTA vs. partial TTA.	HR RR SBP
Newgard, 2009	Penetrating: 5.0% (48/955) Burns: 5.7% (54/955) Mechanism of injury Motor vehicle: 14.7% (140/955) Cyclist or pedestrian: 12.3% (117/955) Stabbing or firearm: 3.8% (36/955) Fall: 44.8% (428/955) Other: 23.1% (221/955)	NR	Male: 61% (582/955) Race: NR Age (mean): 5 (SD 5)	Out of hospital Pediatric Clinical Decision Tree physiologic measures RR SBP

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Nabaweesi, 2014	NR	NR	NR	NR
Newgard, 2009	Out of Hospital: on EMS arrival	NR	EMS on arrival	NR

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Nabaweesi, 2014	Low SBP: <80 mmHg if < 5 years <90 mmHg if ≥ 5 years Abnormal HR: <60 or >160 if < 5 years <50 or >140 if ≥ 5 years Respiratory distress: RR <20 or >60 if < 1 year RR <10 or >40 if ≥ 1 year	Intense resource use: ED disposition to ICU, OR or Morgue	NR	Moderate
Newgard, 2009	RR <10 or >29 SBP ≤90 Out of hospital Pediatric Clinical Decision Tree physiologic measures: GCS <11 SaO2 <95% SBP >96 mm Hg assisted ventilation	Mortality: field or in-hospital Hospital length of stay >2 days	The Resuscitation Outcomes Consortium was supported by cooperative agreements (5U01 HL077863, HL077871, HL077872, HL077866, HL077908, HL077867, HL077885, HL077873) from the National Heart, Lung and Blood Institute, National Institute of Neurological Disorders and Stroke, U.S. Army Medical Research& Materiel Command, The Canadian Institutes of Health Research (CIHR)-Institute of Circulatory and Respiratory Health, Defence Research and Development Canada, the Heart and Stroke Foundation of Canada, and the American Heart Association.	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Newgard, 2014 *Newgard, 2016 study population is included in Newgard, 2014	Retrospective	USA, multiple states Urban and rural Level I to Level V trauma centers and nontrauma centers (122 sites) 1/1/2006 to 12/31/2008 3 years	44,890 analyzed	Internal hospital data

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Newgard, 2014 *Newgard, 2016 study population is included in Newgard, 2014	Included: Injured patients ≥ 55 years old for whom the 9-1-1 EMS system was activated and were transported by EMS to an acute care hospital. Excluded: Patients who were interhospital transfers without an initial EMS presentation, non-transported patients, and those who died in the field.	Elderly (≥55): 100%	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Newgard, 2014 *Newgard, 2016 study population is included in Newgard, 2014	Mechanism of injury - Gunshot: 0.2% Stabbing: 0.4% Assault: 1.3% Fall: 71.4% Motor vehicle accident: 16.5% Pedestrian v auto: 1.9% Bicycle: 0.7% Other: 7.6%	NR	Male: 37% Race: NR Age (median): 77 (IQR 64-85)	Assisted ventilation RR SBP Physiologic triage criteria - current protocol Revised physiologic triage criteria and decision tree models

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Newgard, 2014 *Newgard, 2016 study population is included in Newgard, 2014	Out of hospital: on arrival	NR	NR	Statistical analysis: CART analysis v. 8.0 (Salford Systems, San Diego, California)

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Newgard, 2014 *Newgard, 2016 study population is included in Newgard, 2014	Revised physiologic triage criteria: - GCS ≤14 - RR <10 or >24 or assisted ventilation - SBP <110 or >200	Serious injury: ISS ≥16	Robert Wood Johnson Foundation Physician Faculty Scholars Program; the Oregon Clinical and Translational Research Institute (grant #UL1 RR024140); UC Davis Clinical and Translational Science Center (grant #UL1 RR024146); Stanford Center for Clinical and Translational Education and Research (grant #1UL1 RR025744); University of Utah Center for Clinical and Translational Science (grant #UL1-RR025764 and C06-RR11234); and UCSF Clinical and Translational Science Institute (grant #UL1 RR024131). All Clinical and Translational Science Awards are from the National Center for Research Resources, a component of the National Institutes of Health (NIH), and NIH Roadmap for Medical Research.	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Newgard, 2016 *Newgard, 2016 study population is included in Newgard, 2014	Retrospective	USA, multiple states Urban and rural Levels I through V trauma centers and nontrauma hospitals (122 sites) 1/1/2006 to 12/31/2008 3 years	13,401 analyzed (validation sample) 33,298 in overall study - 19,897 in derivation sample - 13,401 in validation sample	Trauma registries, ED databases, EMS charts, and matched EMS phone records.
Ocak, 2009	Retrospective case-control	The Netherlands Setting: NR 3 Level I trauma centers 7/2004 to 6/2005 1 year	302 analyzed 151 in major trauma group 151 in minor trauma group 2,548 identified 1,152 excluded for age <18 years, missing AIS scores, or not directly transported Major trauma group 177 identified with ISS >15 26 excluded for no prehospital data Minor trauma group 1,219 identified with ISS 1-15 151 randomly selected for control group	Primary data collection from ambulance forms. Patients identified using the regional trauma registry of the Trauma Center West-Netherlands.

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Newgard, 2016 *Newgard, 2016 study population is included in Newgard, 2014	Included: Patients ≥65 years old transported by EMS to an acute care hospital and with an available matched hospital record Excluded: Patients transferred from another hospital without an initial EMS presentation, non-transported patients, and those who died in the field.	Elderly (≥65): 100% - 65 to 74 years: 25.4% - 75 to 84 years: 37.8% - ≥85 years: 36.8%	Civilian
Ocak, 2009	Major trauma group (case) Included: Patients ≥18 years old, with major trauma (ISS >15), who were transported by ambulance from the scene and admitted to one of 3 trauma centers. Excluded: Not specified. Minor trauma group (control) Included: Patients who had minor or moderate injuries (ISS 1-15), and treated at the same trauma centers as major trauma group. Excluded: Not specified.	Adults (≥18): 100%	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Newgard, 2016 *Newgard, 2016 study population is included in Newgard, 2014	Mechanism of injury Gunshot wound: 0.1% Stabbing: 0.2% Assault: 0.6% Fall: 79.6% Motor vehicle crash: 9.9% Pedestrian vs. auto: 1.3% Bicycle: 0.3% Other: 8.0%	NR	Male: 32% Race: NR Age (mean): NR	National field triage guidelines Alternative elderly-specific triage protocol: uses current triage criteria, GCS, SBP, RR, and HR
Ocak, 2009	Type of injury Blunt: 95% Mechanism of injury Traffic: 44% Home-leisure: 41% Sport: 2% Violence: 5% Self-inflicted: 2% Work: 5% Unknown: 1%	Ambulance (air vs. ground not specified)	Male: 60% Race: NR Age (mean): 54 (SD 24)	Physiologic component of the ACS-COT field triage protocol: GCS, SBP, RR RR SBP

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Newgard, 2016 *Newgard, 2016 study population is included in Newgard, 2014	Out of Hospital: not specified	NR	NR	NR
Ocak, 2009	Out of hospital: on arrival	NR	Paramedics	NR

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Newgard, 2016 *Newgard, 2016 study population is included in Newgard, 2014	Alternative elderly-specific triage criteria any of the following: - A positive triage criterion from the current guidelines - GCS ≤14 - SBP ≤110 or ≥200 - Respiratory rate <10 or >29 - Heart rate ≤60 or ≥110	Serious injury: ISS ≥16	Supported by the Robert Wood Johnson Foundation Physician Faculty Scholars Program; Clinical and Translational Science Awards from the National Institutes of Health National Center for Advancing Translational Sciences: Oregon Clinical and Translational Research Institute (grant # UL1 RR024140); UC Davis Clinical and Translational Science Center (grant # UL1 RR024146); Stanford Center for Clinical and Translational Education and Research (grant # 1UL1 RR025744); University of Utah Center for Clinical and Translational Science (grant # UL1- RR025764 and C06-RR11234); and UCSF Clinical and Translational Science Institute (grant # UL1 RR024131).	Moderate
Ocak, 2009	RR <10 or >29 SBP <90	Major trauma: ISS >15	NR	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Pal, 2006	Prospective	USA, California Urban Trauma center level: NR 10/1997 to 9/2003 6 years	5,995 analyzed	Prospective collection of internal hospital data
Paladino, 2008 Paladino, 2011	Retrospective	USA, New York Urban Level I trauma center 1/2003 to 9/2005 2 years, 9 months	1,435 analyzed	Prospective collection of internal trauma registry data for a single hospital
Paladino, 2010a	Retrospective	USA, New York Urban Level I trauma center 1/2005 to 12/2008 4 years	805 analyzed	Prospective collection of internal trauma registry data for a single hospital.
Paladino, 2010b	Retrospective	USA, New York Urban Level I trauma center 8/2005 to 8/2008 3 years	1,649 analyzed	Prospective collection of patient information for a single trauma center.

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Pal, 2006	Included: Trauma patients evaluated at a single trauma center. Excluded: No exclusion criteria were specified.	NR (presumably 100% adult)	Civilian
Paladino, 2008 Paladino, 2011	Included: Patients age ≥13 with blunt or penetrating trauma suspected of having significant injury by mechanism. Excluded: Patients with obvious injuries requiring immediate surgery, isolated head trauma, those who were transferred from other institutions or were dead on arrival.	Adults and adolescents (≥13): 100% - range: 13-95	Civilian
Paladino, 2010a	Included: Patients age ≥13 years with significant mechanisms defined by trauma team activation protocol of blunt or penetrating trauma who had blood tests performed as part of their diagnostic evaluation. Excluded: Patients with obvious injuries requiring immediate surgery, those transferred from other institutions or who were dead on arrival, and patients with history of isolated head trauma.	Adults and adolescents (≥13): 100%	Civilian
Paladino, 2010b	Included: Patient ≥13 years old with blunt or penetrating trauma suspected of having significant injury by mechanism. Excluded: Patients with obvious injuries requiring immediate surgery, isolated head trauma, were transferred from other institutions or dead on arrival, and those with history of diabetes mellitus in the EHR.	Adults and adolescents (≥13): 100%	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Pal, 2006	Blunt: 80% Penetrating: 20%	NR	Male: 81% Race: NR Age (mean): 37 (SD 0.2)	Lactate
Paladino, 2008 Paladino, 2011	Blunt: 35% Penetrating: 42% Fall: 12% Other: 11%	NR	Male: 81% Race: NR Age (mean): 35 (SD 17)	BD HR Lactate SBP Combinations of abnormal measures: - HR or SBP - HR, SBP, lactate, or BD
Paladino, 2010a	Blunt: 45.6% Penetrating: 34.4% Fall: 17.3% Other: 2.7%	NR	Male: 75% Race: NR Age (mean): 39 (range 13-95)	BD DBP HR Lactate SBP
Paladino, 2010b	Blunt: 38.3% Penetrating: 43.06% Fall: 12.55% Other: 6.06%	NR	Male: 80% Race: NR Age (mean): 36 (range 13-95)	BD Lactate RTS

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Pal, 2006	ED: initial value	NR	NR	NR
Paladino, 2008 Paladino, 2011	ED: on arrival	Base deficit and lactate: arterial	Patients enrolled by emergency medicine staff and academic associates.	BD and Lactate: Radiometer ABL 725 (Copenhagen, Denmark)
Paladino, 2010a	ED: on arrival	Lactate: arterial	NR	BD and Lactate: arterial blood gas using Radiometer ABL 725 (Copenhagen, Denmark)
Paladino, 2010b	ED: on arrival	Lactate: arterial	NR	BD and Lactate: arterial blood gas using Radiometer ABL 725 (Copenhagen, Denmark)

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Pal, 2006	Lactate: >2.0 mmol/L	Mortality within 48 hours of admission	NR	Moderate
Paladino, 2008 Paladino, 2011	Abnormal laboratory values, predetermined based on hospital normal values BD < -2.0: normal Lactate <2.2: normal Abnormal vital signs, predetermined: not specified HR >100 bpm SBP <90 mmHg SI >0.9	Major injury: blood transfusion in the first 24 hours, decrease in hematocrit >10 points in the first 24 hours, or ISS ≥16.	No funding was received for this study.	Moderate
Paladino, 2010a	Predetermined based on hospital normal values BD >-2.0: normal Lactate <2.2: normal Predetermined: NR HR ≤100 bpm: normal SBP ≥90 mmHg: normal SI >0.9: abnormal	Major injury: blood transfusion in the first 24 hours, decrease in hematocrit >10 points in the first 24 hours, or ISS ≥16.	NR	Moderate
Paladino, 2010b	Predetermined based on hospital normal values BD >-2.0: normal Lactate <2.2: normal	Major injury: blood transfusion, decrease in hematocrit >10 points in the first 24 hours, or ISS ≥16.	NR	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Pandit, 2014	Retrospective	USA Urban vs. rural: NR Trauma system level: NR 2004 to 2007 4 years	217,190 analyzed 485,595 identified	National Trauma Data Bank
Parimi, 2016	Retrospective	USA, Maryland Urban Level I trauma center 1/2009 to 12/2012 4 years	10,636 analyzed 18,285 trauma admissions 7,649 excluded - 551 excluded for age <18 years - 35 excluded for death within 15 minutes of arrival or deceased on arrival - 5,163 excluded for missing EMS and ED SBP or HR - 1,900 excluded for missing data for 5, 10, and 15 minute SBP or HR	Trauma registry for a single trauma center, EHR, and blood bank records
Parsikia, 2014	Retrospective	USA, Pennsylvania Urban Level I trauma center 1/2007 to 6/2012 5 years, 6 months	1,941 analyzed 3,775 identified 571 excluded for no lactate measurement 72 excluded for age <18 years 110 excluded for ED presentation >24 hours after injury 1,065 excluded for lactate measured >35 minutes after admission 16 excluded for incompletely documented injuries	Internal hospital database of prospectively collected data for acutely injured patients

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Pandit, 2014	Included: Patients ≥65 years old. Excluded: Patients transferred from another institution, dead on presentation, or with burn injuries, isolated TBI, or recorded comorbidity of hypertension, or who had missing HR or SBP data.	Elderly (≥65): 100% - 65-74 years: 39.3% (85,454/217,190) - 75-84 years: 45.3% (98,479/217,190) - >85 years: 15.3% (33,257/217,190)	Civilian
Parimi, 2016	Included: Trauma patients transported directly to the trauma center by helicopter or ambulance. Excluded: Patients <18 years old, those in active cardiac arrest on admission, with missing HR or SBP data, or who died within 15 minutes of ED arrival.	Adults (≥18): 100%	Civilian
Parsikia, 2014	Included: Trauma patients ≥18 years old. Excluded: Patients presenting to ED >24 hours after initial injury, or who had incompletely documented injuries, and those with no lactate measurement, lactate measured >35 minutes after admission, or with unknown timing of lactate.	Adults (≥18): 100%	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Pandit, 2014	Blunt: 59.9% (130,025/217,190) Penetrating: 33.1% (71,852/217,190)	NR	Male: 61% (133,223/217,190) Race* - White: 88% (174,785/199,827) - Black: 7% (13,828/199,827) - Hispanic: 6% (11,214/199,817) Age (mean): 78 (SD 7) *Race not reported by the study for 17,363 patients. Percentages are of the 199,827 patients with reported race. May not total 100% due to rounding.	HR SBP SI
Parimi, 2016	Type of injury Blunt: 87.9% Penetrating: 10.0% Other: 2.1% Mechanism of injury Motor vehicle associated: 49.9% Falls: 26.0% Interpersonal violence: 10.9% Other: 13.1% Undocumented: 0.04%	Helicopter and Land	Male: 68% Race: NR Age (mean): 43 (SD 19)	Prediction models using vital signs (HR, SBP, SI) at 5 time frames: single measurement prehospital or at admission; and continuous over 5 minutes, 10 minutes, or 15 minutes.
Parsikia, 2014	Type of injury Blunt: 77.1% Penetrating: 22.8% Unknown: 0.1% Mechanism of injury Fall: 39.3% Gunshot: 16.4% Motor vehicle accident: 14.8% Motorcycle accident: 3.5% Pedestrian accident: 8.5% Stabbing: 5.9% Other: 11.6%	NR	Male: 33% (637/1,941) Race: NR Age (median): 47 (IQR 28-67)	Lactate

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Pandit, 2014	ED: on arrival	NR	NR	NR
Parimi, 2016	Out of Hospital: not specified ED: on arrival and for following 15 minutes	Prehospital and admission vital signs: manual Continuous vital signs: automated patient monitors - SBP: noninvasive or arterial	NR	Vital signs measurements: networked patient monitors (GE-Morquette-Soar-7000/8000, GE Healthcare, Little Chalfont, UK) Vital signs data collection: Bed Master software (Excel Medical Electronics, Jupiter, FL)
Parsikia, 2014	ED: on admission Lactate within 35 minutes of ED admission	Lactate: venous	NR	NR

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Pandit, 2014	SI ≥1: hemodynamic instability	Mortality: in-hospital Blood transfusion requirement: transfusion of PRBC, whole blood, blood plasma, or human fibrinogen. Exploratory laparotomy	NR	Moderate
Parimi, 2016	Extreme values removed during data preprocessing: - HR <250 bpm - SBP >300 mmHg Critical thresholds for abnormal vital signs: - HR ≥120 bpm - SBP ≤90 mmHg - SI ≥1.0	Massive transfusion, category 1 (MT1): Blood transfusion >4 units in 4 hours Massive transfusion, category 2 (MT2): Blood transfusion >10 units in 24 hours	NR	Moderate
Parsikia, 2014	NR	Mortality: in hospital	NR	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Perel, 2012 Perel, 2013	Retrospective	International Urban vs. rural: NR (large data sets) Trauma system level: NR (large number of hospitals) Validation data set (TARN): 2000-2008 9 years	34,347 analyzed Development dataset: 20,127 Validation dataset: 14, 220	Development: CRASH-2 trial Validation: TARN
Potoka, 2001	Retrospective	USA, Pennsylvania Urban vs. rural: NR (state-wide registry) Trauma system level: NR (trauma centers) 1993 to 1997 5 years Study data set: 1993 to 1996 Test data set: 1997	11,978 analyzed - 9730 in study data set - 2248 in test data set 14,284 identified 431 excluded for burn injury 1,875 excluded for incomplete data required for analysis	Pennsylvania Trauma Outcome Study registry

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Perel, 2012 Perel, 2013	<u>Development dataset</u> Included: Trauma patients with or at risk of significant bleeding within 8 hours of injury. Excluded: No exclusion criteria were specified. <u>Validation dataset</u> Included: Trauma patients age >15 years with estimated blood loss of ≥20%, and who had a hospital length of stay >3 days, died from injury at any point during admission, or needed intensive care or inter-hospital transfer for specialist care. Excluded: Patients who were dead on hospital arrival, had isolated closed limb injuries, or were >65 years old with isolated fractured neck of femur or pubic ramus.	Adults (>15): 100%	Civilian
Potoka, 2001	Included: Children ages 0 to 16 years who were treated at an accredited trauma center in the state. Excluded: Patients without complete data required for analysis, and burn patients.	Children (≤16): 100%	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Perel, 2012 Perel, 2013	Penetrating: 24.8% (8,515/34,347)	NR	Male: NR Race: NR Age (median) - Development dataset: 30 (IQR 24-43) - Validation dataset: 39 (IQR 25-57)	Simple prognostic model: uses age, SBP, GCS score (stratified by low-, middle-, and high-income countries)
Potoka, 2001	Blunt: 89.1% (10,670/11,978)	NR	Male: 68% (8,128/11,978) Race: NR Age (mean): 9 (SD 5)	T-ASPTS: SBP, RR, HR and GCS at age-specific cut-offs RTS: GCS, RR and SBP

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Perel, 2012 Perel, 2013	ED: on arrival	NR	NR	NR
Potoka, 2001	NR	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Perel, 2012 Perel, 2013	NR	In-hospital mortality within 4 weeks of injury	Funded by the UK Health Technology Assessment programme (09/22/165).	Moderate
Potoka, 2001	T-ASPTS <10 RTS <12	ISS >20 Mortality: time period not specified	Supported in part by the Children's Hospital Pittsburgh	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Pottecher, 2016	Retrospective	France Urban vs. rural: NR (regional multicenter registry) Levels I-III trauma centers 1/1/2009 to 12/31/2011 3 years	2,557 analyzed 3,689 major traumas in registry 594 excluded for non-EMS transport 538 excluded for missing data on HR, BP, or blood transfusion	TRENAU registry

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Pottecher, 2016	Included: Major trauma patients in registry. Excluded: Patients with intractable cardiac arrest prior to EMS arrival, those who had non-EMS or unknown prehospital transport, and those with missing data for HR, BP, or blood transfusion.	NR (presumed adult)	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Pottecher, 2016	Type of injury Blunt: 92% Penetrating: 8% Mechanism of blunt injury Traffic accident: 47% Falls: 19% Skiing accidents: 13% Other mountain accidents: 10% Other: 3% NR: 8%	NR	Male: 76% (1,941/2,557) Race: NR Age (mean): 37 (SD 19)	PP/HR ratio SBP SI

Author, Year (See Appendix B for complete	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Pottecher, 2016	Out of hospital: on arrival	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Pottecher, 2016	Cutoffs maximizing the Youden index: PP/HR ratio <0.433 for massive transfusion in 1- and 24-hours SI >0.967 for massive transfusion in 24 hours SI >0.933 for massive transfusion within 1 hour TRENAU triage grading system: A (highest clinical severity), B, or C (lowest clinical severity) - adapted from the French Vittel triage criteria Gray zone: approach used to determine a range of values for PP/HR and SI for which no conclusion can be made concerning forthcoming massive transfusion. The boundaries were defined as the values that did not allow sensitivity and specificity ≥90%.	Massive transfusion, classic definition: transfusion of ≥10 PRBC units in 24 hours. Massive transfusion, critical definition: transfusion of ≥3 PRBC units during the first hour after admission.	Supported only by institutional funds.	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Rahmani, 2017	Prospective	Iran Urban Trauma system level: NR 3/2014 to 10/2014 8 months	374 analyzed	Primary data collection
Rainer, 2011	Retrospective	Hong Kong Urban Trauma system level: NR (designated trauma center) 1/1/2001 to 6/30/2009 8 years, 6 months	1,891 analyzed 4,336 identified 140 excluded as dead on arrival 293 excluded for age <12 years 1,829 excluded for ISS <9 145 excluded for burn injury or drowning 10 excluded for anemia or chronic renal failure 28 excluded for transfusion <10 units and death within 24 hours	Trauma registry for a single trauma center

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Rahmani, 2017	Included: Patients ≥18 years old with multiple trauma (≥2 severe injuries in ≥2 areas of the body), transported to the ED by EMS or family members. Excluded: Patients with isolated trauma, those who had been transferred from other centers, refused to participate in the study, or were suffering cardiac arrest on ED arrival.	Adults (≥18): 100%	Civilian
Rainer, 2011	Included: Trauma patients ≥12 years old with an ISS ≥9. Excluded: Patients <12 years old, those with ISS <9, chronic renal failure or known anemia, any who were transfused <10 units of blood and died within 24 hours, and those who were dead on arrival.	Adults and adolescents (≥12): 100%	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Rahmani, 2017	Mechanism of injury: Blunt: 96% (359/374) Penetrating: 4% (15/374)	NR	Male: 82% (307/374) Race: NR Age (mean): 40 (SD 18)	GAP MGAP
Rainer, 2011	Type of injury Penetrating: 4% Mechanism of injury Motor vehicle crash: 21% Pedestrian: 14% Motorcycle crash: 7% Bicycle related: 8% Penetrating causes: 4% Fall: 35% Other: 11%	NR	Male: 75% Race: NR Age (mean): 44 (SD 19)	BD HR SBP pH Predictive model for massive transfusion (uses SBP, GCS, HR, BD, hemoglobin, pelvic fracture and abdominal free fluid)

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Rahmani, 2017	ED: not specified	NR	NR	NR
Rainer, 2011	ED: on arrival	BD and pH: point of care test Abdominal free fluid: CT scan or Focused assessment with sonography for trauma (FAST)	NR	NR

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Rahmani, 2017	Cutoff points; determination method not described. GAP - Need for surgery: 21 - Mortality, ED: 18 - Mortality, in-hospital: 14 MGAP - Need for surgery: 25 - Mortality, ED: 22 - Mortality, in-hospital: 18 GAP and MGAP scoring systems Age <60 = 5 points GCS = 3-15 points (direct value) SBP >120 = 5 points SBP 60-120 = 3 points for MGAP, mechanism Blunt trauma = 4 points	Need for surgery: laparotomy, chest tube insertion, craniotomy, spinal column and orthopedic procedures Mortality: ED Mortality: in-hospital	Not supported by any funding organization and there is no sponsor of the work.	Moderate
Rainer, 2011	BD: < -5 mmol/L HR: ≥120 bpm pH: ≤7.33 SBP: <90 mm Hg Predictive model for massive transfusion: score ≥6 scoring system: 1 point each: GCS ≤8, HR ≥120, displaced pelvic fracture, BD < -5, hemoglobin 7.1-10 2 points: positive CT scan or FAST 3 points: SBP ≤90 10 points: hemoglobin ≤7	Massive transfusion: transfusion of ≥10 PRBC units within 24 hours	No funding sources for this study.	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Ramanathan, 2015	Prospective	USA, Virginia Urban Level I trauma center 6/2011 to 7/2013 2 years	236 analyzed 288 identified 10 excluded for no lactate measurement 42 excluded as transfer patients	Prospective collection of internal hospital data
Raux, 2006 *Raux 2006 (study population) and Raux 2011/Sartorius 2010 (derivation cohort) draw from the same population, but number analyzed differs due to missing data exclusion based on different variables	Retrospective	France Urban vs. Rural: NR Trauma system level: NR 2002 1 year	1,481 analyzed - 675 with both RR and SpO2 measurements - 806 without RR or SpO2 measurements 1,501 identified 20 excluded for missing data	Vittel Trauma Group epidemiologic study, prospectively collected
Raux, 2011 Sartorius, 2010 *Raux 2006 (study population) and Raux 2011/Sartorius 2010 (derivation cohort) draw from the same population, but number analyzed differs due to missing data exclusion based on different variables	Prospective	France Urban vs. rural: NR Trauma system level: NR (multicenter) <u>Derivation (National) cohort</u> 22 centers 1/1/2002 to 12/31/2002 1 year <u>Validation (Lyon) cohort</u> 2003 to 2005 3 years	2,363 analyzed - 1,360 in National cohort - 1,003 in Lyon cohort <u>Derivation/National cohort:</u> 1,501 identified 141 excluded for missing data <u>Validation/Lyon cohort:</u> 1,050 identified 47 excluded for missing data	Prospectively collected; includes data from the Vittel Trauma Group epidemiologic study and 2nd separate cohort.

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Ramanathan, 2015	Included: Pediatric patients <15 years old who met trauma alert criteria. Excluded: Patients transferred from other hospitals and those without lactate measurements.	Children (<15): 100% - Infants (0 to18 months): 7.6% - Toddlers (19 months to 5 years): 17.8% - School age (6 to 12 years): 41.5% - Adolescents (13-14 years): 33.1%	Civilian
Raux, 2006 *Raux 2006 (study population) and Raux 2011/Sartorius 2010 (derivation cohort) draw from the same population, but number analyzed differs due to missing data exclusion based on different variables	Included: Trauma patients cared for by a mobile ICU. Excluded: Patients with important data missing.	NR	Civilian
Raux, 2011 Sartorius, 2010 *Raux 2006 (study population) and Raux 2011/Sartorius 2010 (derivation cohort) draw from the same population, but number analyzed differs due to missing data exclusion based on different variables	Included: Patients cared for by a mobile ICU for trauma severity warranting medical prehospital care. Excluded: Patients pronounced dead on the scene and those with important data missing.	NR	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Ramanathan, 2015	Mechanism of injury Motor vehicle crash: 47% Fall: 12.7% Pedestrian injury: 17.4% ATV: 5.5% Assault: 2.5% Bicycle: 2.5% Burn: 3% Gunshot: 3% Other: 6.4%	NR	Male: NR Race: NR Age (mean): 9 (SD 5)	Base deficit Lactate Lactate and pH pH
Raux, 2006 *Raux 2006 (study population) and Raux 2011/Sartorius 2010 (derivation cohort) draw from the same population, but number analyzed differs due to missing data exclusion based on different variables	Blunt: 91% (1,346/1,481) Penetrating: 9% (135/1,481) Sites of trauma (multiple sites reported when applicable) Head: 60% (896/1,481) Spinal: 23% (334/1,481) Thoracic: 49% (724/1,481) Abdominal: 25% (365/1,481) Pelvic: 20% (301/1,481) Limb: 55% (812/1,421)	Mobile ICU	Male: 75% (1,112/1,481) Race: NR Age (mean): 37 (SD 18)	RR RTS SpO2
Raux, 2011 Sartorius, 2010 *Raux 2006 (study population) and Raux 2011/Sartorius 2010 (derivation cohort) draw from the same population, but number analyzed differs due to missing data exclusion based on different variables	Blunt: 89% (2,096/2,363) Penetrating: 11% (267/2,363)	Mobile ICU	Male: 76% (1,790/2,363) Race: NR Age (mean): 38 (SD 17)	HR MGAP RTS SBP T-RTS

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Ramanathan, 2015	ED: on admission	NR	NR	NR
Raux, 2006 *Raux 2006 (study population) and Raux 2011/Sartorius 2010 (derivation cohort) draw from the same population, but number analyzed differs due to missing data exclusion based on different variables	Out of Hospital: during resuscitation ED: on arrival	NR	NR	NR
Raux, 2011 Sartorius, 2010 *Raux 2006 (study population) and Raux 2011/Sartorius 2010 (derivation cohort) draw from the same population, but number analyzed differs due to missing data exclusion based on different variables	Out of Hospital: during resuscitation	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Ramanathan, 2015	Lactate >2.0 and >4.7 mmol/L Base deficit < -5.0 mmol/L acidosis: pH <7.30	ICU admission ISS >15 Major procedure: performed in the OR	NR	Low
Raux, 2006 *Raux 2006 (study population) and Raux 2011/Sartorius 2010 (derivation cohort) draw from the same population, but number analyzed differs due to missing data exclusion based on different variables	RTS neutralized for RR: effect of RR neutralized by giving a RR of 20 min^{-1} in all patients.	Mortality: 30-day	NR	Moderate
Raux, 2011 Sartorius, 2010 *Raux 2006 (study population) and Raux 2011/Sartorius 2010 (derivation cohort) draw from the same population, but number analyzed differs due to missing data exclusion based on different variables	MGAP <23 T-RTS <12 RTS <7.5 Thresholds corresponding to sensitivity at or near 95% SBP >120, 60-120, and <60 Categories supported by clinical observation, no clear statistical cutoffs	Severe trauma: ISS >15 ICU LOS >2 days or death Massive hemorrhage: blood transfusion of >6 PRBCs or death from hemorrhagic shock. Emergency procedure: need for emergency thoracic drainage, emergency laparotomy, emergency embolization, or emergency surgery (other than laparotomy) within the first 3 hours after admission. Mortality: death from any cause within 30 days	Conflict of interest: authors declare no conflict of interest.	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Raux, 2017	Retrospective	France Urban vs. rural: NR Level I trauma centers 1/1/2013 to 4/15/2014 1 year, 4 months	1,075 analyzed 1,680 trauma admissions 605 excluded for no lactate and base deficit measurements	Prospectively collected data entered into a registry for 3 study centers.
Regnier, 2012	Prospective	France, Paris Urban Level I trauma center equivalent 1/2010 to 10/2011 1 year, 11 months	586 analyzed - 586 with initial blood lactate - 373 with lactate at 2 hours - 289 with lactate at 4 hours 730 identified 144 excluded for no initial lactate measurement	Prospective collection of internal data

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Raux, 2017	Included: Trauma patients ≥18 years old. Excluded: Patients without arterial blood lactate and base deficit measured at admission.	Adults (≥18): 100%	Civilian
Regnier, 2012	Included: Trauma patients requiring prehospital care by mobile ICU. Excluded: Patients without lactate measurement on ED arrival.	NR (presumably 100% adult)	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Raux, 2017	Type of injury Blunt: 90% (965/1,075) Penetrating: 9% (100/1,075) NR: 1% (10/1,075) Mechanism of injury* Fall: 29% (314/1,075) Road crash: 57% (615/1,075) Gunshot: 3% (30/1,075) Stab wound: 7% (80/1,075) Other: 3% (36/1,075) *Percentages may not total 100 due to rounding.	Medical mobile ICU	Male: 78% (843/1,075) Race: NR Age (mean): 39 (SD 18)	BD Lactate MGAP RTS
Regnier, 2012	Type of injury Blunt: 67% Penetrating: 16% Not reported: 17% Mechanism of injury* Fall: 25% Road crash: 54% Gunshot: 4% Stab wound: 11% Other: 5% *May not total 100% due to rounding	Land	Male: 75% Race: NR Age (mean): 38 (SD 15)	Lactate Lactate Clearance MGAP RTS Combination models: - Model 1: RTS, lactate and lactate clearance - Model 2: MGAP, lactate and lactate clearance

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Raux, 2017	Out of hospital: on arrival - RTS - MGAP ED: on arrival - Lactate - BD	Lactate: arterial BD: arterial blood gas	NR	NR
Regnier, 2012	ED: on arrival, 2 hours, 4 hours	NR	NR	Lactate concentration: Cobas Integra 400+ (Roche Diagnostics, Meylan, France)

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Raux, 2017	Lactate: - normal: ≤2.2 mmol/L - stratification in analyses, based on associations with mortality rates: ≤2.2, 2.3-4.9, 5.0-9.9, ≥10 Base deficit: - normal: ≤2.0 mmol/L - stratification in analyses, based on previous reporting: ≤2.0, 2.1-5.9, 6.0-9.9, ≥10	Mortality, in-hospital: death occurring within 30 days after admission or prior to discharge when discharge occurred within 30 days; deaths following hospital discharge were not considered (patients recorded as alive). Early death (mortality): death within 48 hours Severe trauma: ISS >15 ICU or mortality: ICU length of stay <2 days and/or death within 30 days Massive hemorrhage: blood transfusion of >6 PRBCs within 24 hours and/or death from hemorrhagic shock Emergency procedure: need for emergency thoracic drainage, emergency surgery, emergency embolization; or emergency transfusion within the first hour after admission.	Partial support by TRAUMABASE group (Clichy, France) and Agence Régionale de Santé Ile de France (Paris, France). Other support was provided solely from institutional and/or departmental sources.	Moderate
Regnier, 2012	NR	Mortality: 30-day Mortality, early within 48 hours Severe trauma: ISS >15 ICU stay ≥2 days and/or 30-day mortality Massive hemorrhage: blood transfusion >6 units within 24 hours and/or death from hemorrhagic shock Need for emergency procedure: thoracic drainage, surgery, embolization, or emergency transfusion within 1 hour of admission.	No external funding	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Reisner, 2016	Prospective	USA Urban vs. rural: NR Level I trauma center 6/2012 to 10/2014 2 years, 5 months	487 analyzed 942 screened 274 excluded for no IRB-approved NIRS site 95 excluded for no major trauma mechanism 25 excluded for lack of documented HR and/or BP data within initial evaluation interval 17 excluded for receiving blood transfusion without explicit hemorrhagic injuries 44 excluded for data archiving failure	Primary data collection of convenience sample for one hospital; combination of documentation by study staff, ED nurses, electronic records, and trauma registry.
Rickards, 2010	Retrospective	USA, Texas Urban Level I trauma centers Study dates: NR	159 analyzed 700 identified 455 excluded for abnormal vital signs or incomplete records or death within 24 hours 84 excluded for interference or ectopic beats or ECG <800 R-to-R intervals 2 excluded as outliers for heart period variability	Trauma Vitals database from the U.S. Army Institute of Surgical Research.
Ryan, 2011	Prospective	USA, Florida Urban Level I trauma center 10/2008 to 5/2010 1 year, 8 months	216 analyzed	Primary data collection, checked against patient chart and trauma registry data.

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Reisner, 2016	Included: Patients ≥18 years old. Excluded: Patients transferred from another hospital if prior workup already ruled out hemorrhagic injury, who had no suitable near-infrared spectrometry (NIRS) sensor placement site overlying the deltoid or thigh (due to tattoos, visible skin injury, gross blood, visible rash, clothing, request of treating clinician, or evident hirsutism), those with an estimated body mass index <19 or >40 kg/m^2, with minor trauma, who received blood transfusion but lacked documented hemorrhagic injury, and patients in which there was a failure to record SmO_2, HR, and BP within a matching 10-minute interval during initial evaluation.	Adults (≥18): 100%	Civilian
Rickards, 2010	Included: Patients with electronic vital sign data collected on a PIC-50 vital signs monitor, who had normal standard vital signs (SBP ≥90, motor GCS of 6, normal radial pulse, and normal capillary refill), and had a continuous ECG recorded. Excluded: Patients with <800 continuous R-to-R intervals on ECG without noise or interference, those with ECG waveform with >0.5% ectopic beats, and outliers on heart rate variability (>6 standard deviations away from the multivariate normal distribution).	Adults	Civilian
Ryan, 2011	Included: Patients who had a trauma team activation and received a head CT scan. Excluded: Patients who did not receive a head CT scan.	Adults (≥18): 100% range: 18-91 years	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Reisner, 2016	Blunt: 90%	NR	Male: 68% Race: NR Age (median): 47 (IQR 31-64)	HR Muscle oxygen saturation (SmO_2) PP SBP SI
Rickards, 2010	Blunt: 84.3% (134/159) Penetrating: 11.3% (18/159) Unknown: 4.4% (7/159)	Helicopter or ground	Male: 63% (100/159) Race: NR Age (mean): 38 (SD 1)	Heart rate variability: fractal dimensions by curve length (FD-L)
Ryan, 2011	Spinal cord injury: 3.7% (8/216)	NR	Male: 75% (162/216) Race: NR Age (mean): 50 (SD 1)	HRV features - spectral frequency at high frequency - spectral power at very low frequency (VLF) - low to high frequency index ratio (LF/HF) Mechanical ventilation Mortality score: algorithm using HRV features and age

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Reisner, 2016	ED: on arrival	SmO2: NIRS HR: vital signs monitor BP: vital signs monitor	SmO2: sensor placed on ED arrival by study staff; measurements recorded by study staff	SmO2: CareGuide 1100 tissue oximeter (Reflectance Medical, Inc., Westborough, Massachusetts) Vital signs monitors: Solar patient monitors (General Electric, Milwaukee, Wisconsin) Data archive - Vital signs from monitors: BedMasterEx software (Excel Medical, Jupiter, Florida) - Study data: REDCap
Rickards, 2010	Out of hospital: during resuscitation	ECG: Continuously collected at 375 Hz on vital signs monitor	NR	Vital signs monitor: PIC-50 (WelchAllyn, Buffalo Grove, IL).
Ryan, 2011	ED: on admission	HRV: ECG by digital recorder; ectopic beats manually verified	Research staff	ECG: two-channel SEER Light recorder (GE Healthcare, Milwaukee, WI) HRV analysis: Mars Holter monitor system (GE Healthcare) and proprietary software; MARS software suite to identify ectopic beats

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Reisner, 2016	NR	Hemorrhagic injury requiring blood transfusion - Hemorrhagic injury: any of the following: laceration or fracture of a solid organ; documented hematoma within the thorax, peritoneum, retroperitoneum, or pelvis; vascular injury that required operative repair or angioembolization; or limb amputation. - Blood transfusion ≥3 units PRBCs Hemorrhagic injury with receipt of ≥9 units PRBCs	Supported by the Combat Casualty Care Research Area Directorate of the U.S. Army Medical Research and Materiel Command, Fort Detrick, Maryland.	Moderate
Rickards, 2010	NR	Life-saving intervention: intubation, chest tube, pRBC transfusion, pericardiocentesis, cricothyrotomy, thoracotomy, angiography with or without embolization, needle decompression, cardioversion, cardiopulmonary resuscitation or surgical intervention.	Partially supported by the U.S. Army Combat Casualty Care Research Program.	Moderate
Ryan, 2011	Mortality Score cutoff 51.3 threshold determined using cumulative distribution frequency of all patients	Mortality: overall	Partial support by Grant N140610670 from the Office of Naval Research.	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Sammour, 2009	Retrospective	New Zealand, Auckland Urban Trauma system level: NR (tertiary hospital) 5/2000 to 9/2006 6 years, 5 months	1,197 analyzed 1,297 identified with trauma team activation 70 excluded for burns 30 excluded with diabetes	Prospective collection of internal data in trauma database
Schenarts, 2008	Retrospective	USA, North Carolina Rural Level I trauma center 1/1/2000 to 12/31/2005 6 years	2,130 analyzed - 44/2,130 EMS SBP <90 and ED SBP ≥90 (hypotensive group) - 2,086/2,130 with both EMS and ED SBP ≥90 (normotensive group) 7,199 identified 1,286 excluded for SBP not documented 3,706 excluded for transfer from other hospitals 77 excluded for hypotension on ED arrival	National Trauma Registry of the American College of Surgeons for a single trauma center.
Shackelford, 2015 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated. *Mackenzie, 2014 study population included in Shackelford, 2015	Prospective	USA, Maryland Urban Trauma system level: NR Study period: NR	852 analyzed - 557 subjects = Mackenzie 2014 study population - 295 additional subjects 1,191 enrolled 293 excluded for incomplete pulse oximetry signal data 46 excluded for incomplete laboratory availability	Primary data collection with blood use cross-validated against blood bank records.

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Sammour, 2009	Included: Trauma patients ≥15 years old with trauma team activation. Excluded: Patients with burn injury and diabetics. Note: patients on steroid treatment were *not* excluded.	Adults (≥15): 100%	Civilian
Schenarts, 2008	Included: Patients age ≥16 years, transported directly from the scene, and who were normotensive (SBP ≥90 mmHg) on arrival to the ED. Excluded: Patients transferred from other hospitals or with incomplete data.	Adults (≥16): 100%	Civilian
Shackelford, 2015 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated. *Mackenzie, 2014 study population included in Shackelford, 2015	Included: Patients ≥18 years old admitted directly from the scene of injury with ≥5 minutes of the first 15 minutes of pulse oximetry signal meeting quality index criteria, and who also had any of: EMS SI ≥0.62; "Priority 1" designation by EMS (critically ill or injured person requiring immediate attention); or, unstable patient with a life-threatening injury without EMS vital signs. Excluded: Patients who died within 15 minutes of ED admission or had cervical spine injury with neurological impairment.	Adults (≥18): 100%	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Sammour, 2009	Mechanism of injury* Road traffic accident: 62% Assault: 13% Fall: 9% Self inflicted; 5% Work related: 3% Sport: 2% Animal related: 1% Unknown: 6% *Total may not equal 100% due to rounding	NR	Male: 75% Race: NR Age (median): 31 (range 15-90)	Lactate
Schenarts, 2008	Blunt: 93%	NR	Male: 56% Race: NR Age (mean): 50 (SD 24)	SBP
Shackelford, 2015 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated. *Mackenzie, 2014 study population included in Shackelford, 2015	Type of injury Blunt: 81.8% (796/852) Penetrating: 31.3% (113/852) Other: 4.9% (42/852) Mechanism of injury Motor vehicle associated: 47.2% (402/852) Falls: 22.5% (192/852) Interpersonal violence: 17.8% (152/852) Other: 12.4% (106/852)	NR	Male: 70% (593/852) Race: NR Age (mean): 40 (SD 18)	Lactate Decision-assist algorithms: use HR, SBP, pulse oximetry features, laboratory tests

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Sammour, 2009	ED: on arrival	Lactate: arterial	ED clinician	NR
Schenarts, 2008	Out of Hospital: during resuscitation ED: on arrival	SBP: either manual or automated	NR	SBP: auscultatory method, automated oscillometric device, or palpation method
Shackelford, 2015 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated. *Mackenzie, 2014 study population included in Shackelford, 2015	Out of hospital: on arrival - HR - SBP ED: on arrival - Pulse oximetry features - Laboratory tests	Laboratory tests: venous blood sample Pulse oximetry features: waveforms recorded at 240 Hz, filtered to reduce noise using a pulse oximetry signal quality index.	NR	Laboratory tests: standard hospital-based chemistry and hematology analyzers - lab data sets correspond to iSTAT point-of-care analyzer cartridges (Abbott Laboratories Inc., Chicago, IL) Pulse oximeter: NR

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Sammour, 2009	Lactate >2.0 mmol/L	Mortality: All-cause death directly related to the trauma event.	No external funding	High
Schenarts, 2008	SBP <90 mmHg = hypotension Predetermined: NR	ICU, OR or death in ED ISS >16 Mortality: in-hospital	NR	High
Shackelford, 2015 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated. *Mackenzie, 2014 study population included in Shackelford, 2015	NR	Blood transfusion: any transfusion within the first 3 hours. Rapid blood transfusion: transfusion of ≥5 units of RBCs in the first 4 hours after admission. Massive transfusion: ≥10 units of pRBCs transfused within the first 24 hours after admission.	Supported by grant FA8650-11-2-6D01, US Air Force Medical Support Agency/Medical Modernization Directorate. No funding was received from NIH, Welcome Trust, or HHMI.	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Shah, 2013	Prospective	USA, 4-state region Urban vs. Rural: NR Level I pediatric trauma center 4/2008 to 3/2010 2 years	217 analyzed 493 identified 269 excluded for no EMS lactate 7 excluded for missing data	Prospective collection to out of hospital database, and cross-linked to hospital EHR.
Shoemaker, 2005	Prospective	USA, California Urban Level I trauma center Study time period: NR	185 analyzed No patients were excluded	Primary data collection
St John, 2016	Retrospective case-control	USA, Washington Urban Level I trauma center 1/1/2011 to 12/31/2012 2 years	3,224 analyzed - 721 elderly - 2,503 non-elderly Elderly 1,151 elderly identified 361 excluded for isolated TBI 47 excluded for isolated burn injury 19 excluded for isolated extremity injury 2 excluded for isolated suffocation 2 excluded for isolated drowning	Harborview Medical Center trauma registry, trauma registry for a single hospital.

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Shah, 2013	Included pediatric patients (<18 years) with an out of hospital lactate measured and who were admitted to the hospital*. Excluded: Patients whose lactate sample was taken from an extremity with a crush injury, amputation, or fracture, and patients with missing data. * Note: All trauma patients transported by air during this period were admitted to the hospital.	Pediatrics (<18): 100% - range: 0-17 years	Civilian
Shoemaker, 2005	Included: Patients with major blunt or penetrating injuries and significant risk of mortality or morbidity. Excluded: not specified	Mixed; percentages not provided	Civilian
St John, 2016	Included: Patients age ≥18 years found to have severe multisystem injury (death in the first 24 hours, blood transfusion in the first 24 hours, ED disposition to the OR in the first 4 hours, or ED disposition to the ICU. Excluded: Patients with TTA or hospital admission data that were incomplete or conflicting across multiple variables, and those with isolated burn injury, isolated drowning, isolated asphyxiation, or isolated TBI.	Adults (≥18): 100% Elderly (≥65): 22% (721/3,224)	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Shah, 2013	Injury Type Head and neck: 65% (142/217) Extremity: 32% (70/217) Face: 18% (40/217) Chest: 10% (22/217) Abdomen: 18% (39/217)	Helicopter Transported directly from field: 46% (100/217) Interfacility transport: 54% (117/217)	Male: 69% (149/217) Race: NR Age (median): 11 (IQR 6-14)	Lactate
Shoemaker, 2005	<u>Survivors</u> Blunt trauma: 35%/57% Fall: 7%/0% Gunshot: 41%/39% Stab wound: 17%/4% <u>Nonsurvivors</u> Blunt trauma: 57% Fall: 10% Gunshot wound: 39% Stab wound: 4%	NR	<u>Overall</u> Male: 81% (149/185) Race: NR Age (mean): NR <u>Survivors</u> Age (mean): 32 (SD 15) <u>Nonsurvivors</u> Age (mean): 39 (SD 21)	Cardiac Index HR MAP Oxygen delivery (DO_2) Survival Probability prediction model (using noninvasive hemodynamic monitoring) Transcutaneous oxygen tension indexed to fraction of inspired oxygen (PtcO2/FIO2)
St John, 2016	Type of injury Blunt: 82.1% (2,648/3,224) Penetrating: 16.9% (545/3,224) Unspecified: 1.0% (26/3,224) Mechanism of injury Fall: 27.5% (886/3,224) Motor vehicle collision: 23.5% (757/3,224) Motorcycle collision: 1.0% (321/3,224) Assault: 6.2% (200/3,224) Pedestrian struck: 6.1% (197/3,224) Bicycle collision: 4.0% (128/3,224) Other blunt injury: 4.9% (159/3,224) Stab wound: 7.9% (254/3,224) Gunshot wound: 6.5% (211/3,224) Other penetrating injury: 2.5% (80/3,224)	NR	Male: 72% (2,325/3,224) Race: NR Age (mean): NR	BD HR SBP

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Shah, 2013	Out of hospital: on EMS arrival	Lactate: POC, peripheral venous or capillary Vital signs: automated, using vital signs monitor	EMS: on arrival	POC serum lactate meter (Lactate Pro; FaCT Canada, Quesnel, British Columbia, Canada) Vital signs monitor: LIFEPAK 12 monitor (PhysioControl, Redmond, Washington)
Shoemaker, 2005	ED: within 1 hour of admission	Noninvasive monitoring - Cardiac output and cardiac index: thoracic bioelectric impedance - SaO2: routine pulse oximetry - Transcutaneous carbon dioxide tension (PtcCO2) and transcutaneous oxygen tension (PtcO2): continuous transcutaneous using electrodes	NR	Cardiac output and cardiac index: thoracic bio electric impedance device (IQ 101, Noninvasive Medical Technologies LLC, Auburn Hills, MI) SaO2: pulse oximeter (Nellcor, Pleasanton, CA) PtcO2: Clark polarographic oxygen electrode PtcCO2: Severinghaus electrode Clark polarographic oxygen electrode Severinghaus Electrode
St John, 2016	ED: on arrival - SBP used lowest value recorded	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Shah, 2013	Lactate: cut point of 2 mmol/L Vital signs: normal vs. abnormal, per age-specific Pediatric Advanced Life Support guidelines	Need for critical care: within 24 hours receiving vasopressor support, endotracheal intubation, or transfusion; emergent surgery; admission to the pediatric ICU.	NR	Moderate
Shoemaker, 2005	Survival probability prediction model: stochastic analysis to determine survival probability using "nearest neighbors" approach with primary diagnosis, covariates, and hemodynamic variables. Noninvasive hemodynamic values included cardiac output, cardiac index, MAP, HR, arterial oxygen saturation (SaO2), oxygen delivery (DO2) and transcutaneous oxygen tension indexed to fraction of inspired oxygen (PtcO2/FIO2).	Mortality: in-hospital	Supported in part by grants RR-11526, GM-65619, and DOD BAA99-1 from the National Institutes of Health (Bethesda, MD); and by DAMD 17-01-2-0070 from the U.S. Army Medical Research Acquisition Activity (Fort Detrick, MD).	Low
St John, 2016	NR	Severe multisystem injury: death in the first 24 hours, blood transfusion in the first 24 hours, ED disposition to the OR in the first 4 hours or ED disposition to the ICU.	NR	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Stanworth, 2010	Retrospective	International: UK, Norway, USA, The Netherlands and Germany Setting: NR Trauma system level: NR (major trauma centers) Datasets from London, San Francisco, Amsterdam, and Germany 2007 1 year Dataset from Oslo 2 years	5,693 analyzed Internal validation datasets London (n = 788) Oslo (n = 2,167) San Francisco (n = 384) Amsterdam (n = 649) External validation dataset Germany (n = 1,705)	Trauma registries of 4 trauma centers in a research network, and The Trauma Registry of the Deutsche Gesellschaft für Unfallchirurgie in Germany.
Tamim, 2002	Retrospective	Canada, Montreal Urban Level I trauma centers 4/1993 to 12/1996 3 years, 9 months	1,291 analyzed 2,847 identified 1,556 excluded for incomplete Prehospital Index data	Emergency medical service (Urgences-santé) data files and trauma registry data files.
Van Haren, 2014	Prospective	USA, Florida Urban Level I trauma center 12/2011 to 6/2013 1 year, 7 months	96 analyzed 113 identified 17 excluded as non-trauma	Primary Data Collection

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Stanworth, 2010	Included: All patients in the datasets were included.	Adults: 100% range: 20-58	Civilian
Tamim, 2002	Included: Patients >15 years old transported by Urgences-santé (EMS) to either of 2 study trauma centers from the scene of injury, were alive on ED arrival, and either died in the ED or were admitted to the hospital. Excluded: Patients for whom complete data was not available for the Prehospital Index (PHI) values evaluated at the scene of injury.	Adults (>15): 100%	Civilian
Van Haren, 2014	Included: Trauma patients transported by EMS participating in study. Excluded: Patients <18 years old and those who were pregnant or incarcerated.	Adults (≥18): 100%	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Stanworth, 2010	Penetrating: 10% (580/5,693)	NR	Male: 73% (4,161/5,693) Race: NR Age (mean): 36 (range: 20 to 58)	BD SBP
Tamim, 2002	Type of injury Penetrating: 7.5% (97/1,291) Mechanism of injury* Driver: 11% (142/1,291) Passenger: 4% (54/1,291) Motorcycle: 3% (41/1,291) Cyclist: 2% (22/1,291) Pedestrian: 9% (116/1,291) Fall: 43% (550/1,291) Firearm, stab, knife: 14% (178/1,291) Blunt object: 14% (119/1,291) Other: 6% (72/1,291) *Percentages may not total 100 due to rounding.	NR	Male: 62% (797/1,291) Race: NR Age (mean): 51 (SD 23)	Prehospital Index (PHI) score
Van Haren, 2014	Blunt: 83%	Land and Helicopter	Male: 82% Race: NR Age (mean): 48 (SD 19)	HR SaO2 SBP Murphy Factor (injury acuity algorithm using vital signs) Vital signs (combined HR, SBP and SaO2)

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Stanworth, 2010	ED: on arrival	NR	NR	NR
Tamim, 2002	Out of hospital: at scene	NR	NR	NR
Van Haren, 2014	Out of Hospital: during resuscitation ED: on arrival	Automated vital signs monitors	NR	Miniature wireless vital signs monitor: MiniMedic (Athena GTX) Standard vital signs monitor: Physio-Control LIFPAK (Medtronic) or Propaq MD (Welch Allyn)

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Stanworth, 2010	NR	Massive transfusion: ≥10 units PRBCs transfused within the first 24 hours	There was no external funding for the study.	Moderate
Tamim, 2002	NR	Major injury requiring treatment at a Level I trauma center: any of 3 criteria: 1) death in ED or within 7 days after hospital admission; 2) surgical intervention within 4 days after admission (nonorthopedic except hip-fracture surgery, and nonplastic); 3) ICU admission within 7 days after admission.	Supported by the National Health Research and Development Program (NHRDP) and the Fonds pour la formation de chercheurs et l'aide à la recherche (FCAR).	Moderate
Van Haren, 2014	HR>100 beats/min SaO2 <95% SBP <90 mm Hg Murphy Factor >3 Clinically relevant cutoffs	LSI, pre-hospital or in hospital: intubation, cricothyroidotomy, needle decompression, tube thoracostomy, central line insertion, blood product transfusion, or operative intervention.	Supported in part by grant #N140610670 from the Office of Naval Research and W81XWH1120098 from the US Army Medical Research and Material Command. Mark Darrah, PhD (CEO of Athena GTX, Des Moines, IA) provided the MiniMedics.	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Vandromme, 2010	Retrospective	USA, Alabama Urban Level I trauma center 1/2000 to 1/2009 9 years	2,519 analyzed - 787/2,519 with EMS SBP 90-110 - 2,413/2,519 with blood lactate measurement 31,032 evaluated at trauma center	Trauma registry for a single trauma center. Out of hospital SBP collected from patient care reports provided by EMS.
Vandromme, 2011	Retrospective	USA, Alabama Urban Level I trauma center 1/1/2000 to 10/12/2008 9 years	8,111 analyzed 20,095 identified 3,382 excluded as patient transfers 774 excluded for out of hospital SBP ≤90 7,828 excluded for no recorded out of hospital vital signs	University of Alabama at Birmingham University Hospital trauma registry.
Vandromme, 2011b	Retrospective	USA, Alabama Urban and rural Level I trauma center <u>Overall study period</u> 1/2005 to 12/2008 4 years <u>Developmental cohort</u> 1/2005 to 1/22/2007 2 years <u>Validation cohort</u> 1/23/2007 to 12/2008 2 years	514 analyzed 306 in developmental cohort 208 in validation cohort >12,000 identified for feasibility, a subset of these were selected for analysis - patients categorized by # of PRBC units transfused (0, 1-3, 4-6, 7-9, or massive transfusion of ≥10 units) - equal proportion of patients taken from all but the massive transfusion category - all patients were included from the massive transfusion category	Medical records and blood bank data.
Vassallo, 2015	Prospective	Afghanistan, Camp Bastion UK military base Trauma system level: not applicable (military base) 3/2011 to 9/2011 6 months	345 analyzed 482 identified 33 excluded for indeterminate Priority One designation 104 excluded for no SI recorded	Prospective collection using standardized data sheet.

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Vandromme, 2010	Included: Patients with SBP 90-110 mmHg on arrival to ED.	NR	Civilian
Vandromme, 2011	Included: Patients with blunt mechanism of injury and out of hospital SBP >90 mm Hg. Excluded: Patients who were transferred from another facility, had penetrating injury, an out of hospital SBP ≤90 mm Hg, or had no out of hospital vital signs in the UAB trauma registry.	NR	Civilian
Vandromme, 2011b	Included: Patients admitted to the trauma service. Excluded: No exclusion criteria detailed.	NR	Civilian
Vassallo, 2015	Included: Trauma patients >18 years who met trauma team activation criteria. Excluded: Patients with missing data on prehospital or in-hospital interventions performed, and those for whom the triage sort and SI couldn't be calculated.	Adults (>18): 100%	Military

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Vandromme, 2010	Blunt: 75.0% Penetrating: 17.9%	NR	Male: 63.9% Race - White 67.2% - African-American 28.0% Age (mean): 38.5	Lactate SBP
Vandromme, 2011	Blunt: 100%	NR	Male: 66.8% Race: NR Age (mean): 38.4	SI
Vandromme, 2011b	NR	NR	NR	HR Lactate Predictive model for massive transfusion (uses hemoglobin, SBP, international normalized ratio, lactate, and HR) SBP
Vassallo, 2015	NR	NR	NR	SI Triage Sort

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Vandromme, 2010	Out of Hospital: NR ED: on arrival	Lactate: POC test	NR	NR
Vandromme, 2011	Out of hospital: on EMS arrival ED: NR	NR	NR	NR
Vandromme, 2011b	ED: on arrival	NR	NR	NR
Vassallo, 2015	ED: on arrival	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Vandromme, 2010	SBP 90-100 Predetermined: patients most likely to be undertriaged.	Mortality: in-hospital Significant blood transfusion: ≥6 PRBC units within the first 24 hours of hospital admission	NR	Moderate
Vandromme, 2011	SI >0.9	Massive transfusion: ≥10 PRBC units within 24 hours of hospital arrival. Mortality	NR	High
Vandromme, 2011b	HR > 105 bpm SBP < 110 mmHg Lactate > 5 mmol/L Hemoglobin (Hb) ≤11 g/dL INR > 1.5	Massive transfusion: ≥10 units PRBCs transfused within the first 24 hours of admission	NR	Moderate
Vassallo, 2015	SI cutpoints: ≥0.90, ≥ 1.0, ≥0.75 Triage sort score ≤10: priority one designation	Priority One designation: Patients who received a life-saving intervention (predefined list), or who died in the ED.	Study not commissioned. Conflict of interest declared: authors JV, SH and JES are serving members of the HM Armed Forces.	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Vassallo, 2017	Retrospective	Afghanistan, Camp Bastion UK military base Trauma system level: not applicable (military base) 2006 to 2013 8 years	3,654 analyzed 6,095 in database 3,701 identified with complete physiologic data 47 excluded as outliers	Data for ED admissions at a single military base; obtained from the UK Joint Theatre Trauma Registry
Vettorello, 2013	Prospective	Italy, Milan Urban Trauma system level: NR 9/2010 to 3/2011 7 months	84 analyzed 104 enrolled 6 excluded for cardiac arrest 7 excluded for logistical reasons 3 excluded for arrhythmia 4 excluded for medical therapy	Primary data collection.

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Vassallo, 2017	Included: Trauma patients ≥18 years old presenting to the ED at the study site (Camp Bastion military base), and who had complete recordings of physiologic parameters on ED arrival (SBP, HR, GCS, and RR). - The UK Joint Theatre Trauma Registry includes: All seriously injured patients (including UK military, coalition forces, detainees, and local civilians) who had trauma team activation in a deployed field hospital or Primary Casualty Receiving Facility afloat and those returned to Royal Centre for Defence Medicine for definitive treatment. Excluded: Patients with outlying physiologic parameter (SBP >206, HR >170, or RR >45).	Adults (≥18): 100%	Military - includes local civilians and detainees
Vettorello, 2013	Included: Patients with major trauma criteria and response by helicopter EMS. Excluded: Patients <18 years old, those with need for immediate resuscitation before iHAT recording, cardiac arrest, chronic illnesses involving the autonomic nervous system (such as diabetes or hypertension, any neurologic disease), absent sinus rhythm, supraventricular ectopic beats >5% of recorded beats, intraventricular or bundle branch blocks, artificial pacemaker, burns or amputations prohibiting monitoring, spinal cord trauma, or medical therapy.	Adults (≥18): 100%	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Vassallo, 2017	Mechanism of injury - Assault: 0.2% (8/3,654) - Burns: 1.0% (32/3,654) - Crush: 1.3% (47/3,654) - Explosive: 55.1% (2,012/3,654) - Fall <5 meters: 1.3% (47/3,654) - Fall >5 meters: 0.5% (20/3,654) - Gunshot wound: 34.3% (1,252/3,654) - Motor vehicle collision: 4.3% (158/3,654) - Stabbing: 0.4% (16/3,654) - Other: 1.6% (58/3,654) - Unknown: 0.1% (4/3,654))	NR	Male: 98.3% (3,593/3,654) Race: NR Age (median): 24 (IQR: 21-29)	Careflight MPTT Military Sieve Modified Military Sieve START Triage Sieve
Vettorello, 2013	Mechanism of trauma Road accident: 79% Fall from height: 18% Sports injury: 2% Penetrating injury: 1%	Helicopter	Male: 79% Race: NR Age (median) No hemorrhage group: 41 (range: 18-83) Hemorrhage group: 29 (range: 18-74)	HR HRV: iHAT (index heart-to-arm time) SBP

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Vassallo, 2017	ED: on arrival	NR	NR	NR
Vettorello, 2013	Out of Hospital: during resuscitation	iHAT: calculated as the average beat-to-beat mPTT/RR interval ratio over 30 heartbeats - mPTT (modified pulse transit time, uses ECG and PPG) - RR interval (R-to-R interval from ECG) SBP and HR: non-invasive monitor	Study physician	ECG, photoplethysmographic pulse oximetry (PPG), and SBP: FM Datex-Ohmeda Monitor (GE Healthcare, Finland) Data recording: NEC Shield PRO FC-N21S laptop (NEC Europe, London, UK) with Datex-Ohmeda S/5 collect software (Datex-Ohmeda) Signal analysis: software developed by Porta (publication cited)

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Vassallo, 2017	All patients were assumed to be non-ambulant due to limitations of data in registry and inclusion criteria. Careflight and START: SBP of 90 was used as surrogate for presence of a radial pulse and absence of hypotension since the JTTR doesn't record radial pulse as a variable. MPTT: variables derived as optimum values for performance in isolation at predicting need for LSI through logistical regression models.	Life-saving intervention: endotracheal intubation and rapid sequence induction, surgical airway, or mechanical ventilation; thoracostomy; application of a chest seal, thoracotomy or pericardial window; application of a tourniquet or use of hemostatic agents or interventional radiology for hemorrhage control; arterial ligation, shunt, or cross clamping; transfusion of uncross-matched blood, ≥4 units of blood, or administration of tranexamic acid; insertion of an intra-osseous device for resuscitation; laparotomy; limb traction and coded pelvic injury; CPR or administration of epinephrine, atropine, amiodarone, or other "Resus Drugs"; neurosurgery for intracranial hemorrhage, or craniotomy/burr hole insertion; C1-C3 spinal fracture; administration of a seizure-terminating medication; rewarming for initial core temp <32 degrees Celsius; correction of low blood sugar; or administration of chemical antidote	NR	High
Vettorello, 2013	Optimal cutpoints calculated by Euclidean method. iHAT >58.78% HR >99 SBP <125	Blood transfusion or bleeding control: Transfusion of ≥4 PRBC units within 6 hours of admission and/or urgent laparotomy or radiological intervention for bleeding control within 3 hours.	No financial support from any company.	High

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Williams, 2016	Prospective	USA, Florida Urban Level I trauma center 10/1/2012 to 6/30/2014 1 year, 9 months	170 analyzed 171 enrolled 1 withdrew consent	Data collected at enrollment and by chart review.
Woodford, 2012	Retrospective	USA, Maryland Urban Level I trauma center 5/2007 to 2/2008 10 months	120 analyzed 177 identified 57 excluded for missing data	Maryland trauma registry and primary collection of EMS vital signs. Patients transported to Shock Trauma Center.
Yang, 2016 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	Prospective	USA, Maryland Urban Level I trauma center 12/2011 to 5/2013 18 months	677 analyzed 1,191 admitted to trauma resuscitation unit and met age and EMS SI criteria 480 excluded for no continuous oximetry monitoring 34 excluded for incomplete laboratory blood tests	Prospective, consecutive enrollment of trauma patients at a single trauma center. Primary data collection by research assistant.

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Williams, 2016	Included: Patients triaged to the trauma center by dispatch or upon arrival with written consent. Excluded: Patients <18 years old, those intubated before ED arrival, or who were pregnant, incarcerated, transferred from another ED, or did not tolerate the measurement device.	Adults (≥18): 100%	Civilian
Woodford, 2012	Included: Patients transported by three Maryland State Trooper helicopters from the fields to the University of Maryland Shock Trauma Center. Excluded: Patients with missing vital signs data in trauma registry or the VSDR.	NR	Civilian
Yang, 2016 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	Included: Adults (≥18 years) with out of hospital SI ≥0.62. Excluded: Patients without continuous SpHb monitoring and those with incomplete laboratory point of admission data.	Adults (≥18): 100%	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Williams, 2016	Blunt: 89% Penetrating: 9% Burn: 2%	NR	Male: 67% Race - Black: 27% - White: 71% - All other: 2% Age (mean): 43 (range: 18-82)	ETCO2
Woodford, 2012	NR	Helicopter	Male: 63% (75/120) Race: NR Age (mean): 42 (range 18-86)	GCS + SpO2 HR SpO_2 RTS SBP SI
Yang, 2016 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	Type of injury: Blunt: 87.0% (589/677) Penetrating: 11.7% (79/677) Other: 1.3% (9/677) Mechanism of injury Motor vehicle associated: 52.3% (354/677) Falls: 20.8% (141/677) Interpersonal violence: 19.5% (132/677) Other: 7.4% (50/677)	NR	Male: 70.8% (479/677) Race: NR Age (mean): 38.7 (SD 16.6)	Decision support models using combinations of 4 features of HR, SI, non-invasive Hb (SpHb), and laboratory Hb; and other laboratory tests (partial thromboplastin time, INR, fibrinogen, lactate, and glucose). Models are adjusted for age and sex. - HR model: EMS HR with and without combinations of features; adjusted for age and sex. - SI model: EMS SI with and without combinations of features; adjusted for age and sex

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Williams, 2016	ED: within 30 minutes of arrival	ET CO2: average of 3 readings, measured by sidestream sampling nasal cannula	Research assistant	Nihon Kohden TG-920P capnography cable attached to standard ED monitor (Nihon Kohden Corp., Tokyo, Japan)
Woodford, 2012	Out of hospital: - VSDR: continuous during resuscitation Trauma registry data: on arrival	VSDR: automated patient vital signs monitor - HR: pulse oximeter-derived - SpO_2: automated - SBP: non-invasive, automated Trauma registry vital signs: manually collected	NR	Vital signs monitor: Propaq 206E Vital signs data and event recorder: interface with vital signs monitor via miniature personal computer Waveform analysis: software application created in Matlab V7.7.0.471 (MathWorks, Natick, Massachusetts) and MedCalc V11.0 (MedCalc Software, Mariakerke, Belgium)
Yang, 2016 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	Out of hospital: NR ED: - blood draw on arrival for lab tests (Hb and other tests) - SpHb continuous monitoring and vital sign collection for 15 minutes after admission; SpHb also recorded at time of blood draw	Hemoglobin - Noninvasive (SpHb): automated sensor - Laboratory Hb concentration: venous Vital signs: automated	Research assistant recorded SpHb reading at time of laboratory blood draw.	Noninvasive hemoglobin (SpHb): Masimo Rainbow Pulse CO-Oximetry (Masimo Corporation, Irvine, California), using Masimo Rad-87 (ver. 1405) software and Rev F sensor. Vital signs: BedMaster (GE Marquette, Milwaukee, Wisconsin) Laboratory Hb concentration: Sysmex XN-2000 Automated Hematology Analyzer; Sysmex Corp., Kobe, Japan) Laboratory glucose: Analyzer NSN 6630015205212; Abbott Laboratories Inc., Chicago, Illinois.

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Williams, 2016	ETCO2 ≤30 mm Hg based on prior studies	Severe injury: ICU admission, operative intervention, acute clinically significant finding on CT, invasive procedure, blood product transfusion or acute blood loss anemia.	Supported by a University of Florida Faculty Dean's Fund Grant.	Moderate
Woodford, 2012	Abnormal vital signs: SpO_2 <90% HR >110 bpm SBP <90 mmHg Predetermined: NR; cut-off points determined to by the research group and others be clinically relevant	Mortality: NR	Supported by DoD-TATRC grants W81XWH-05-0374, W81XWH-06-C-0034, W81XWH-07-2-0118, AND FA8650-11-2-6DO1.	Moderate
Yang, 2016 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	Inclusion criterion of SI ≥0.62 How value was determined was not reported.	Blood transfusion: use of pRBC 1-3 hours after admission, validated via blood bank records Mortality: NR	Funded by U.S. Air Force (FA8650-11-2-6D01) Continuing Noninvasive Monitoring and the Development of Predictive Triage Indices for Outcomes Following Trauma. Masimo (Masimo Corporation, Irvine, California) provided the SpHb monitors but had no role in the design, execution, or analysis of this research.	Moderate

Author, Year (See Appendix B for complete reference)	Study Design	Setting and Dates Performed	Number of Study Subjects	Data Source
Yuen, 2016	Retrospective	Hong Kong Urban Trauma system level: NR 1/1/2010 to 12/31/2011 (validation dataset) 2 years	850 analyzed (validation cases) 1.998 identified - 1,057 used for development - 850 used for validation	Hong Kong East Cluster Trauma Registry
Zarzaur, 2008	Retrospective	USA, Tennessee Urban Level I trauma center 1996 to 2005 10 years	16,077 analyzed 36,599 identified 4,350 excluded for no palpable pulse 6,513 excluded for significant brain or spinal cord injury 4,300 excluded for presentation >24 hours after injury 5,359 excluded for no blunt injury	Trauma registry for a single trauma center.

Author, Year (See Appendix B for complete reference)	Eligibility Criteria	Age Groups Included (Age Range Used*): % of Study Population	Type of Population
Yuen, 2016	Two hospitals in registry: Pamela Youde Nethersole Eastern Hospital (PYNEH), and Ruttonjee Hospital (RH) Included: Patients with trauma team activation for both hospitals; Hong Kong Hospital Authority triage category 1 or 2 trauma cases in PYNEH; neurological trauma patients transferred from RH to PYNEH; trauma patients who died and had received medical intervention in the ED of PYNEH. Excluded: Non-trauma patients; Hong Kong Hospital Authority triage categories 3, 4, or 5 trauma cases in PYNEH that did not require trauma team activation; trauma patients who died and did not receive medical intervention in the ED of PYNEH; patients with unknown age.	Mixed; percentages not provided Range: 2 months - 102 years	Civilian
Zarzaur, 2008	Included: Patients 18-81 years old, with blunt trauma, and a palpable pulse (defined as HR >10 bpm or SBP >30 mmHg) on admission. Excluded: Patients with spinal cord injuries, significant brain injuries (head AIS score ≥3), who had missing values for admission HR or SBP, or who presented >24 hours after the time of injury.	Adults (≥18): 100% - Young (<55 years): 85% - Elderly (≥55 years): 15%	Civilian

Author, Year (See Appendix B for complete reference)	Mechanism or Type Injury	Mode of Transport	Other Population Characteristics (Sex, Race)	Name of Measure Being Evaluated
Yuen, 2016	All identified (development and validation) Blunt: 98%	NR	All identified (development and validation) Male: 66% Race: NR Age (mean): 48 (SD 25)	RTS Simplified emergency trauma score - uses GCS, RR, mechanism of injury, and age
Zarzaur, 2008	Blunt: 100%	NR	Male: 67% Race: NR Age (mean): 39 (SD 16)	Age x SI HR SBP SI

Author, Year (See Appendix B for complete reference)	Location and Timing of Measurement	Method of Measurement	Personnel Administering Test or Using Measure	Equipment Used/Needed
Yuen, 2016	ED: not specified	NR	NR	NR
Zarzaur, 2008	ED: on arrival	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Threshold Value(s) for Physiologic Measures	Indicator of Serious Injury Used (including definition and time period)	Funding Source	Risk of Bias
Yuen, 2016	Simplified emergency trauma score = 60: cut-off point	Mortality: NR	NR	Moderate
Zarzaur, 2008	Cutpoints based on Youden's index to maximize sensitivity and specificity for predicting 48-hour mortality: Overall SI ≥0.83 Age x SI ≥32.3 Elderly Age x SI ≥52.1	Mortality: 48-hour Blood transfusion: receipt of ≥4 units of blood within 48 hours of admission	NR	Moderate

See Appendix B. Included Studies for full study references.

ABG = arterial blood gas: ACS-COT = American College of Surgeons Committee on Trauma; AIS = Abbreviated Injury Scale; AOR = adjusted odds ratio; APACHE II = Acute Physiology and Chronic Health Evaluation II; AUROC = area under the receiver operating characteristic curve; BD = base deficit; BP = blood pressure; CHAID = chi-square automatic interaction detection; CI = confidence interval; CNS = central nervous system; CPR = cardiopulmonary resuscitation; CRAMS = Circulation, Respiration, Abdomen, Motor, and Speech; CT = computed tomography; DBP = diastolic blood pressure; ECG = electrocardiogram; ED = emergency department; EHR = electronic health record; EMS = emergency medical services; EMT = emergency medical technician; EMTRAS = Emergency Trauma Score; ETCO2 = end-tidal carbon dioxide; FTS = Field Triage Score; GAP = Glasgow Coma Scale, Age, and Arterial Pressure; GCS = Glasgow Coma Scale; Hb = hemoglobin; HF = high frequency; HR = heart rate; HRC = heart rate complexity; HRV = heart rate variability; ICD-9 = International Classification of Diseases 9th Revision; ICU = intensive care unit; INR = international normalized ratio; IQR = interquartile range; ISS = Injury Severity Score; IV = intravenous; LF = low frequency; LOS = length of stay; LSI = life-saving intervention; MAP = mean arterial pressure; MGAP = Mechanism, Glasgow Coma Scale, Age, and Arterial Pressure; MOD = multiple organ dysfunction; MPTT = Modified Physiological Triage Tool; NA = not applicable; NIRS = near-infrared spectrometry; NLR = negative likelihood ratio; NPV = negative predictive value; NR = not reported; NTDB = National Trauma Data Bank; NTTP = National Trauma Triage Protocol: OH = out-of-hospital; OR = operating room; pCO_2 = partial pressure of carbon dioxide; PHI = Prehospital Index; PLR = positive likelihood ratio; POC = point of care; PP = pulse pressure; PPG = photoplethysmography, photoplethysmogram; PPV = positive predictive value; PRBC = packed red blood cell; PTS = Pediatric Trauma Score; RBC = red blood cell; REMS = Rapid Emergency Medicine Score; ROC = receiver operating characteristic; RR = respiratory rate; RTS = Revised Trauma Score; SaO2 = oxygen saturation; SBP = systolic blood pressure; SD = standard deviation; Sen = sensitivity; SETS = Simplified Emergency Trauma Score; SI = shock index; SLCO2 = sublingual partial pressure of carbon dioxide; SmO2 = muscle oxygen saturation; Sp = specificity; SpHb = noninvasive continuous hemoglobin concentration; SpO2 = peripheral oxygen saturation; START = Simple Triage and Rapid Treatment; StO2 = tissue oxygen saturation; TARN = Trauma Audit and Research Network; T-ASPTS = Triage Age-Specific Pediatric Trauma Score; TBI = traumatic brain injury; TRISS = Trauma and Injury Severity Score; T-RTS = Revised Trauma Score for Triage; ViEWS-L = VitalPAC Early Warning Score-Lactate; vs. = versus; VSDR = vital signs data and event recorder; WVSM = wireless vital signs monitor

Table D2. Univariate results

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Ahun, 2014	GAP < 19	24-hour mortality	83.33% (36.1 to 97.2)	87.50% (78.7 to 93.6)	NR
Ahun, 2014	MGAP < 23	24-hour mortality	100.00% (54.1 to 100.0)	89.77% (81.5 to 95.2)	NR
Ahun, 2014	RTS < 5.68	24-hour mortality	50.00% (12.4 to 87.6)	100.00% (95.9 to 100.0)	NR
Ahun, 2014	GAP < 21	4-week mortality	91.67% (61.5 to 99.8)	78.41% (68.4 to 86.5)	NR
Ahun, 2014	MGAP) < 25	4-week mortality	100.00% (73.5 to 100.0)	80.68% (70.9 to 88.3)	NR
Ahun, 2014	RTS < 5.97	4-week mortality	41.67% (15.2 to 72.3)	95.45% (88.8 to 98.7)	NR
Al-Salamah, 2004	T-RTS <12	Mortality, in-hospital	84% (CI NR)	64% (CI NR)	NR
Al-Salamah, 2004	RR (using RTS scoring 0-4)	Mortality, in-hospital	NR	NR	NR
Al-Salamah, 2004	T-RTS	Mortality, in-hospital	NR	NR	NR
Al-Salamah, 2004	SBP (using RTS scoring 0-4)	Mortality, in-hospital	NR	NR	NR
Allen, 2014	BD < -7	Blood transfusion	29% (NR)	95% (NR)	NR
Allen, 2014	BD < -5	Blood transfusion	54% (NR)	88% (NR)	NR
Allen, 2014	BD < 0	Blood transfusion	94% (NR)	30% (NR)	NR
Arbabi, 2004	SBP <90, ED	Mortality	41.72% (39.00 to 44.48) calculated	97.78% (97.50 to 98.04) calculated	67.17% (64.10 to 70.10) calculated
Arbabi, 2004	SBP <120, ED	Mortality	60.94% (58.20 to 63.62) calculated	80.60% (79.87 to 81.31) calculated	25.49% (24.42 to 26.59) calculated
Arbabi, 2004	SBP <90, EMS	Mortality	50.86% (47.49 to 54.21) calculated	86.64% (85.76 to 87.50) calculated	35.74% (33.66 to 37.87) calculated
Arbabi, 2004	SBP <120, EMS	Mortality	67.54% (64.33 to 70.63) calculated	59.81% (58.56 to 61.05) calculated	19.73% (18.87 to 20.62) calculated
Aslar, 2004	APACHE II score ≥15	Mortality, 30-day in-hospital	80.00% (59.30 to 93.17) calculated	94.87% (82.68 to 99.37) calculated	90.91% (71.88 to 97.51) calculated
Aslar, 2004	BD ≤ -6	Mortality, 30-day in-hospital	76.00% (54.87 to 90.64) calculated	62.16% (44.76 to 77.54) calculated	57.58% (45.94 to 68.43) calculated
Aslar, 2004	Lactate ≥4	Mortality, 30-day in-hospital	84.00% (63.92 to 95.46) calculated	86.49% (71.23 to 95.46) calculated	80.77% (64.62 to 90.62) calculated
Aslar, 2004	pH ≤7.3	Mortality, 30-day in-hospital	72.00% (50.61 to 87.93) calculated	84.62% (69.47 to 94.14) calculated	75.00% (58.01 to 86.69) calculated

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Ahun, 2014	NR	NR	NR	0.910 (CI NR), p<0.001	NR
Ahun, 2014	NR	NR	NR	0.970 (CI NR), p<0.001	NR
Ahun, 2014	NR	NR	NR	0.727 (CI NR), p=0.012	NR
Ahun, 2014	NR	NR	NR	0.904 (CI NR), p<0.001	NR
Ahun, 2014	NR	NR	NR	0.938 (CI NR), p<0.001	NR
Ahun, 2014	NR	NR	NR	0.680 (CI NR), p=0.026	NR
Al-Salamah, 2004	NR	NR	NR	NR	NR
Al-Salamah, 2004	NR	NR	NR	0.68 (CI NR), tau c = 0.21	NR
Al-Salamah, 2004	NR	NR	NR	0.83 (CI NR), tau c = 0.39	NR
Al-Salamah, 2004	NR	NR	NR	0.63 (CI NR), tau c = 0.15	NR
Allen, 2014	NR	NR	NR	NR	NR
Allen, 2014	NR	NR	NR	NR	NR
Allen, 2014	NR	NR	NR	NR	NR
Arbabi, 2004	93.90% (93.63 to 94.16) calculated	18.78 (16.39 to 21.53) calculated	0.60 (0.57 to 0.62) calculated	NR	NR
Arbabi, 2004	94.99% (94.65 to 95.30) calculated	3.14 (2.97 to 3.33) calculated	0.48 (0.45 to 0.52) calculated	NR	NR
Arbabi, 2004	92.35% (91.86 to 92.82) calculated	3.81 (3.47 to 4.17) calculated	0.57 (0.53 to 0.61) calculated	NR	NR
Arbabi, 2004	92.65% (91.95 to 93.29) calculated	1.68 (1.59 to 1.78) calculated	0.54 (0.49 to 0.60) calculated	NR	NR
Aslar, 2004	88.10% (77.10 to 94.21) calculated	15.60 (3.99 to 61.03) calculated	0.21 (0.10 to 0.46) calculated	NR	NR
Aslar, 2004	79.31% (64.62 to 88.95) calculated	2.01 (1.26 to 3.21) calculated	0.39 (0.18 to 0.81) calculated	NR	NR
Aslar, 2004	88.89% (76.36 to 95.20) calculated	6.22 (2.70 to 14.30) calculated	0.19 (0.07 to 0.46) calculated	NR	NR
Aslar, 2004	82.50% (71.26 to 89.96) calculated	4.68 (2.15 to 10.16) calculated	0.33 (0.17 to 0.63) calculated	NR	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Aslar, 2004	RTS ≤8	Mortality, 30-day in-hospital	68.00% (46.50 to 85.05) calculated	94.87% (82.68 to 99.37) calculated	89.47% (68.21 to 97.12) calculated
Aslar, 2004	SI >0.9	Mortality, 30-day in-hospital	84.00% (63.92 to 95.46) calculated	23.08% (11.13 to 39.33) calculated	41.18% (35.45 to 47.15) calculated
Baron, 2004	Base deficit	Blood loss (none vs. minimal-moderate or severe)	NR	NR	NR
Baron, 2004	Lactate	Blood loss (none vs. minimal-moderate or severe)	NR	NR	NR
Baron, 2004	SLCO2	Blood loss (none vs. minimal-moderate or severe)	NR	NR	NR
Baron, 2004	SLCO2 >45 mmHg	Blood loss (none vs. minimal-moderate or severe)	90% (79 to 96)	45% (31 to 60)	65% (53 to 75)
Baron, 2007	Base deficit	Mortality	NR	NR	NR
Baron, 2007	Lactate	Mortality	NR	NR	NR
Baron, 2007	SLCO2	Mortality	NR	NR	NR
Baron, 2007	SLCO2 >62 mmHg	Mortality	75% (NR)	86% (NR)	NR
Baron, 2007	SLCO2	Blood transfusion	NR	NR	NR
Baron, 2007	SLCO2	ICU stay	NR	NR	NR
Beekley, 2010	StO2 ≤ 75	Blood Transfusion	64%(48-78)	59% (49-69)	39%(27-51)
Beekley, 2010	StO2 ≤ 80	Blood transfusion	76% (61-88)	41% (31-51)	34% (25-45)
Beekley, 2010	BD < -4	Blood transfusion	40% (24-57)	90% (82-95)	63% (41-81)
Beekley, 2010	BD < -5	Blood transfusion	32% (18-49)	92% (85-97)	63% (38-84)
Beekley, 2010	BD < -6	Blood transfusion	29% (15-46)	95% (88-98)	69% (41-89)
Beekley, 2010	BD < -7	Blood transfusion	21% (10-37)	96% (89-99)	67% (35-90)
Beekley, 2010	SBP	Blood transfusion	NR	NR	NR
Beekley, 2010	HR	Blood transfusion	NR	NR	NR
Beekley, 2010	DBP	Blood transfusion	NR	NR	NR
Beekley, 2010	Radial pulse character	Blood transfusion	NR	NR	NR
Beekley, 2010	Base deficit	Blood transfusion	NR	NR	NR
Beekley, 2010	pH	Blood transfusion	NR	NR	NR
Beekley, 2010	StO2 average	Blood transfusion	NR	NR	NR
Beekley, 2010	StO2 minimum	Blood transfusion	NR	NR	NR
Beekley, 2010	StO2 ≤ 75	LSI	61% (49-72)	65% (53-76)	63% (50-74)
Beekley, 2010	StO2 ≤ 80	LSI	75% (63-84)	47% (35-59)	57% (47-68)
Beekley, 2010	BD < -4	LSI	28% (17-40)	91% (81-96)	75% (53-90)
Beekley, 2010	BD < -5	LSI	23% (14-35)	94% (85-98)	79% (54-94)
Beekley, 2010	BD < -6	LSI	20% (11-32)	95% (87-99)	81% (54-95)
Beekley, 2010	BD < -7	LSI	15% (8-26)	97% (89-100)	83% (52-98)

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Aslar, 2004	82.22% (72.22 to 89.16) calculated	13.26 (3.35 to 52.52) calculated	0.34 (0.19 to 0.60) calculated	NR	NR
Aslar, 2004	69.23% (43.67 to 86.72) calculated	1.09 (0.86 to 1.39) calculated	0.69 (0.24 to 2.01) calculated	NR	NR
Baron, 2004	NR	NR	NR	0.76 (0.68–0.85), p <0.001	NR
Baron, 2004	NR	NR	NR	0.69 (0.59–0.80), p <0.001	NR
Baron, 2004	NR	NR	NR	0.74 (0.65–0.84), p<0.001	NR
Baron, 2004	79% (60 to 92)	1.63 (1.25 to 2.12)	0.23 (0.10 to 0.53)	NR	NR
Baron, 2007	NR	NR	NR	0.87 (0.77 to 0.98), p<0.001	NR
Baron, 2007	NR	NR	NR	0.80 (0.69 to 0.91), p<0.001	NR
Baron, 2007	NR	NR	NR	0.82 (0.70 to 0.96), p <0.001	NR
Baron, 2007	NR	5.4 (NR)	0.29 (NR)	NR	NR
Baron, 2007	NR	NR	NR	0.64 (0.49 to 0.79), p<0.05	NR
Baron, 2007	NR	NR	NR	0.71 (0.58 to 0.84), p<0.01	NR
Beekley, 2010	81% (70-89)	NR	NR	NR	NR
Beekley, 2010	81% (68-91)	NR	NR	NR	NR
Beekley, 2010	78% (69-86)	NR	NR	NR	NR
Beekley, 2010	76% (67-84)	NR	NR	NR	NR
Beekley, 2010	76% (67-84)	NR	NR	NR	NR
Beekley, 2010	74% (65-82)	NR	NR	NR	NR
Beekley, 2010	NR	NR	NR	0.77 (0.69 to 0.85)	NR
Beekley, 2010	NR	NR	NR	0.68 (0.59 to 0.77)	NR
Beekley, 2010	NR	NR	NR	0.64 (0.55 to 0.73)	NR
Beekley, 2010	NR	NR	NR	0.61 (0.52 to 0.70)	NR
Beekley, 2010	NR	NR	NR	0.70 (0.61 to 0.79)	NR
Beekley, 2010	NR	NR	NR	0.70 (0.61 to 0.79)	NR
Beekley, 2010	NR	NR	NR	0.64 (0.55 to 0.73)	NR
Beekley, 2010	NR	NR	NR	0.69 (0.61 to 0.77)	NR
Beekley, 2010	64% (52-74)	NR	NR	NR	NR
Beekley, 2010	66% (52-78)	NR	NR	NR	NR
Beekley, 2010	55% (45-65)	NR	NR	NR	NR
Beekley, 2010	55% 45-64)	NR	NR	NR	NR
Beekley, 2010	54% (44-63)	NR	NR	NR	NR
Beekley, 2010	53% (44-62)	NR	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Beekley, 2010	SBP	LSI	NR	NR	NR
Beekley, 2010	HR	LSI	NR	NR	NR
Beekley, 2010	DBP	LSI	NR	NR	NR
Beekley, 2010	Radial pulse character	LSI	NR	NR	NR
Beekley, 2010	Base deficit	LSI	NR	NR	NR
Beekley, 2010	pH	LSI	NR	NR	NR
Beekley, 2010	StO2 average	LSI	NR	NR	NR
Beekley, 2010	StO2 minimum	LSI	NR	NR	NR
Beekley, 2010	StO2 ≤ 78	LSI or blood transfusion	71% (NR)	NR	NR
Beekley, 2010	StO2 ≤ 75	Massive transfusion	90% (56-100)	55% (47-64)	13% (6-23)
Beekley, 2010	StO2 ≤ 78	Massive transfusion	100% (NR)	NR	NR
Beekley, 2010	StO2 ≤ 80	Massive transfusion	100% (69-100)	39% (30-47)	11% (5-19)
Beekley, 2010	BD < -4	Massive transfusion	38% (9-76)	83% (75-89)	13% (3-32)
Beekley, 2010	BD < -5	Massive transfusion	25% (3-65)	86% (78-92)	11% (1-33)
Beekley, 2010	BD < -6	Massive transfusion	25% (3-65)	88% (81-94)	13% (2-38)
Beekley, 2010	BD < -7	Massive transfusion	25% (3-65)	92% (85-96)	17% (2-48)
Beekley, 2010	SBP	Massive transfusion	NR	NR	NR
Beekley, 2010	HR	Massive transfusion	NR	NR	NR
Beekley, 2010	DBP	Massive transfusion	NR	NR	NR
Beekley, 2010	Radial pulse character	Massive transfusion	NR	NR	NR
Beekley, 2010	Base deficit	Massive transfusion	NR	NR	NR
Beekley, 2010	pH	Massive transfusion	NR	NR	NR
Bond, 1997	Prehospital Index (PHI) ≥4	ISS ≥16	41% (NR)	98% (NR)	40% (NR)
Bond, 1997	Prehospital Index ≥4 or mechanism of injury	ISS ≥16	78% (NR)	89% (NR)	17% (NR)

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Beekley, 2010	NR	NR	NR	0.65 (0.58 to 0.72)	NR
Beekley, 2010	NR	NR	NR	0.74 (0.67 to 0.81)	NR
Beekley, 2010	NR	NR	NR	0.59 (0.51 to 0.67)	NR
Beekley, 2010	NR	NR	NR	0.58 (0.50 to 0.66)	NR
Beekley, 2010	NR	NR	NR	0.71 (0.64 to 0.78)	NR
Beekley, 2010	NR	NR	NR	0.68 (0.60 to 0.76)	NR
Beekley, 2010	NR	NR	NR	0.61 (0.53 to 0.69)	NR
Beekley, 2010	NR	NR	NR	0.67 (0.60 to 0.74)	NR
Beekley, 2010	NR	NR	NR	NR	NR
Beekley, 2010	NR	NR	NR	NR	NR
Beekley, 2010	NR	NR	NR	NR	NR
Beekley, 2010	NR	NR	NR	NR	NR
Beekley, 2010	NR	NR	NR	NR	NR
Beekley, 2010	NR	NR	NR	NR	NR
Beekley, 2010	NR	NR	NR	NR	NR
Beekley, 2010	NR	NR	NR	NR	NR
Beekley, 2010	NR	NR	NR	0.70 (0.54 to 0.86)	NR
Beekley, 2010	NR	NR	NR	0.78 (0.63 to 0.93)	NR
Beekley, 2010	NR	NR	NR	0.70 (0.54 to 0.86)	NR
Beekley, 2010	NR	NR	NR	0.72 (0.57 to 0.87)	NR
Beekley, 2010	NR	NR	NR	0.69 (0.51 to 0.87)	NR
Beekley, 2010	NR	NR	NR	0.75 (0.59 to 0.91)	NR
Bond, 1997	98% (NR)	NR	NR	NR	Accuracy: 97% Undertriage: 59% Overtriage: 2.0% Undertriage = false negative rate Overtriage = false positive rate
Bond, 1997	99% (NR)	NR	NR	NR	Accuracy: 89% Undertriage: 22% Overtriage: 11.0% Undertriage = false negative rate Overtriage = false positive rate

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Bouzat, 2016	Lactate ≥3.5, capillary	Blood transfusion ≥4 units	100% (74 to 100) reported 100.00% (73.54 to 100.00) calculated	53% (43 to 62) reported 53.70% (43.85 to 63.35) calculated	19.35% (16.38 to 22.72) calculated
Bouzat, 2016	Lactate ≥3.5, capillary	Emergency treatment for hemostasis (surgery or embolization)	68.75% (49.99 to 83.88) calculated	54.55% (43.58 to 65.20) calculated	35.48% (28.40 to 43.27) calculated
Bouzat, 2016	Lactate, capillary	Blood transfusion ≥4 units	NR	NR	NR
Bouzat, 2016	Lactate, capillary	Blood transfusion, any	NR	NR	NR
Bouzat, 2016	Lactate, serum	Blood transfusion, any	NR	NR	NR
Bouzat, 2016	SI	Blood transfusion ≥4 units	NR	NR	NR
Brown, 2011	Physiologic criteria of NTTP (step 1): GCS ≤14, SBP <90 or RR <10 or >29	Trauma center need	32% (NR)	91% (NR)	72% (NR)
Brown, 2015a	SBP <118: elderly	Mortality	29% (CI NR)	86% (CI NR)	NR
Brown, 2015a	SBP <106: adults	Mortality	49% (CI NR)	88% (CI NR)	NR
Brown, 2015a	SBP <90: adults	Trauma center need	10% (CI NR)	98% (CI NR)	79% (CI NR)
Brown, 2015a	SBP <110: adults	Trauma center need	23% (CI NR)	90% (CI NR)	63% (CI NR)
Brown, 2015a	SBP <90: elderly	Trauma center need	5% (CI NR)	99% (CI NR)	66% (CI NR)
Brown, 2015a	SBP <110: elderly	Trauma center need	13% (CI NR)	93% (CI NR)	50% (CI NR)
Brown, 2015a	SBP <122: elderly	Trauma center need	22% (CI NR)	83% (CI NR)	NR
Brown, 2015a	SBP <118: adults	Trauma center need	32% (CI NR)	73% (CI NR)	NR
Brown, 2016b	Lactate >4.0	Trauma center need	23.21% (21.26 to 25.25) calculated	92.81% (92.02 to 93.54) calculated	55.54% (52.21 to 58.83) calculated
Brown, 2016b	Lactate ≥2.5	Trauma center need	52.46% (50.10 to 54.80) calculated	71.33% (69.99 to 72.64) calculated	41.45% (39.92 to 43.01) calculated
Bruijns, 2013	Blood pressure-age index ≤1.5	Mortality, 48-hour	33.2% (27.6-39.3)	95.0% (94.8-95.1)	NR
Bruijns, 2013	Blood pressure-age index ≤1.7	Mortality, 48-hour	46.4% (40.3 to 52.6)	90% (89.8 to 90.3)	NR
Bruijns, 2013	Blood pressure-age index: moderately injured	Mortality, 48-hour	NR	NR	NR
Bruijns, 2013	Blood pressure-age index: overall	Mortality, 48-hour	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Bouzat, 2016	100.00% calculated	2.16 (1.76 to 2.65) calculated	0.00 calculated	NR	NR
Bouzat, 2016	82.76% (73.51 to 89.25) calculated	1.51 (1.09 to 2.10) calculated	0.57 (0.33 to 0.99) calculated	NR	NR
Bouzat, 2016	NR	NR	NR	0.68 (0.58 to 0.78)	NR
Bouzat, 2016	NR	NR	NR	0.59 (0.46 to 0.72)	NR
Bouzat, 2016	NR	NR	NR	0.77 (0.62 to 0.91)	NR
Bouzat, 2016	NR	NR	NR	0.68 (0.51 to 0.85)	NR
Brown, 2011	65% (NR)	NR	NR	NR	Undertriage rate: 68% (NR) Overtriage rate: 9% (NR) Undertriage = false negative rate Overtriage = false positive rate
Brown, 2015a	NR	NR	NR	NR	NR
Brown, 2015a	NR	NR	NR	NR	NR
Brown, 2015a	59% (CI NR)	NR	NR	0.539 (0.538 to 0.541)	NR
Brown, 2015a	61% (CI NR)	NR	NR	0.564 (0.563 to 0.566)	NR
Brown, 2015a	67% (CI NR)	NR	NR	0.519 (0.517 to 0.522)	NR
Brown, 2015a	68% (CI NR)	NR	NR	0.532 (0.530 to 0.534)	NR
Brown, 2015a	NR	NR	NR	NR	NR
Brown, 2015a	NR	NR	NR	NR	NR
Brown, 2016b	75.74% (75.25 to 76.23) calculated	3.23 (2.82 to 3.69) calculated	0.83 (0.81 to 0.85) calculated	NR	NR
Brown, 2016b	79.49% (78.63 to 80.33) calculated	1.83 (1.72 to 1.95) calculated	0.67 (0.63 to 0.70) calculated	NR	NR
Bruijns, 2013	NR	6.6 (5.6-7.9)	NR	NR	NR
Bruijns, 2013	NR	4.7 (4.1 to 5.3)	NR	NR	NR
Bruijns, 2013	NR	NR	NR	0.83 (0.78 to 0.88)	NR
Bruijns, 2013	NR	NR	NR	0.74 (0.71 to 0.78)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Bruijns, 2013	Blood pressure-age index: severely injured	Mortality, 48-hour	NR	NR	NR
Bruijns, 2013	HR ≥104	Mortality, 48-hour	41.1% (35.2-47.3)	89.6% (89.4-89.9)	NR
Bruijns, 2013	HR ≥112	Mortality, 48-hour	27.2% (22.0-33.0)	95.0% (94.8-95.1)	NR
Bruijns, 2013	HR: moderately injured	Mortality, 48-hour	NR	NR	NR
Bruijns, 2013	HR: overall	Mortality, 48-hour	NR	NR	NR
Bruijns, 2013	HR: severely injured	Mortality, 48-hour	NR	NR	NR
Bruijns, 2013	HR metric, Minpulse ≤44	Mortality, 48-hour	30.9% (25.5-36.9)	94.9% (94.8-95.1)	NR
Bruijns, 2013	HR metric, Minpulse ≤54	Mortality, 48-hour	43.0% (37.0 to 49.2)	90.0% (89.8 to 90.2)	NR
Bruijns, 2013	HR metric, Minpulse: moderately injured	Mortality, 48-hour	NR	NR	NR
Bruijns, 2013	HR metric, Minpulse: overall	Mortality, 48-hour	NR	NR	NR
Bruijns, 2013	HR metric, Minpulse: severely injured	Mortality, 48-hour	NR	NR	NR
Bruijns, 2013	HR metric, Pulse max index ≥60	Mortality, 48-hour	46.0% (40.0 to 52.2)	90.0% (89.7 to 90.2)	NR
Bruijns, 2013	HR metric, Pulse max index ≥70	Mortality, 48-hour	34.0% (28.3-40.1)	95.0% (94.8-95.1)	NR
Bruijns, 2013	HR metric, Pulse max index: moderately injured	Mortality, 48-hour	NR	NR	NR
Bruijns, 2013	HR metric, Pulse max index: overall	Mortality, 48-hour	NR	NR	NR
Bruijns, 2013	HR metric, Pulse max index: severely injured	Mortality, 48-hour	NR	NR	NR
Bruijns, 2013	RR ≥24	Mortality, 48-hour	39.6% (33.7-45.8)	87.8% (87.6-88.1)	NR
Bruijns, 2013	RR ≥27	Mortality, 48-hour	25.7% (20.6-31.4)	95.3% (95.1-95.4)	NR
Bruijns, 2013	RR: moderately injured	Mortality, 48-hour	NR	NR	NR
Bruijns, 2013	RR: overall	Mortality, 48-hour	NR	NR	NR
Bruijns, 2013	RR: severely injured	Mortality, 48-hour	NR	NR	NR
Bruijns, 2013	SBP ≤101	Mortality, 48-hour	31.3% (25.9-37.3)	94.1% (93.9-94.2)	NR
Bruijns, 2013	SBP ≤110	Mortality, 48-hour	36.6% (30.9-42.7)	89.8% (89.6-90.0)	NR
Bruijns, 2013	SBP: moderately injured	Mortality, 48-hour	NR	NR	NR
Bruijns, 2013	SBP: overall	Mortality, 48-hour	NR	NR	NR
Bruijns, 2013	SBP: severely injured	Mortality, 48-hour	NR	NR	NR
Bruijns, 2013	SI ≥0.8	Mortality, 48-hour	45.3% (39.2 to 51.5)	90.0% (89.8 to 90.2)	NR
Bruijns, 2013	SI ≥0.9	Mortality, 48-hour	37.4% (31.6-43.5)	95.0% (94.9-95.2)	NR
Bruijns, 2013	SI: moderately injured	Mortality, 48-hour	NR	NR	NR
Bruijns, 2013	SI: overall	Mortality, 48-hour	NR	NR	NR
Bruijns, 2013	SI: severely injured	Mortality, 48-hour	NR	NR	NR
Bruijns, 2013	SIA (SI x Age) ≥48	Mortality, 48-hour	55.1% (48.9 to 61.2)	90.0% (89.7 to 90.2)	NR

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Bruijns, 2013	NR	NR	NR	0.71 (0.66 to 0.75)	NR
Bruijns, 2013	NR	4.0 (3.4-4.6)	NR	NR	NR
Bruijns, 2013	NR	5.4 (4.4-6.6)	NR	NR	NR
Bruijns, 2013	NR	NR	NR	0.61 (0.54 to 0.68)	NR
Bruijns, 2013	NR	NR	NR	0.69 (0.65 to 0.73)	NR
Bruijns, 2013	NR	NR	NR	0.64 (0.59 to 0.69)	NR
Bruijns, 2013	NR	6.1 (5.1-7.3)	NR	NR	NR
Bruijns, 2013	NR	4.3 (3.7 to 5.0)	NR	NR	NR
Bruijns, 2013	NR	NR	NR	0.82 (0.77 to 0.87)	NR
Bruijns, 2013	NR	NR	NR	0.77 (0.74 to 0.80)	NR
Bruijns, 2013	NR	NR	NR	0.73 (0.68 to 0.77)	NR
Bruijns, 2013	NR	4.6 (4.0 to 5.2)	NR	NR	NR
Bruijns, 2013	NR	6.7 (5.7-8.0)	NR	NR	NR
Bruijns, 2013	NR	NR	NR	0.77 (0.71 to 0.83)	NR
Bruijns, 2013	NR	NR	NR	0.77 (0.73 to 0.80)	NR
Bruijns, 2013	NR	NR	NR	0.71 (0.66 to 0.75)	NR
Bruijns, 2013	NR	3.3 (2.8-3.8)	NR	NR	NR
Bruijns, 2013	NR	5.4 (4.4-6.7)	NR	NR	NR
Bruijns, 2013	NR	NR	NR	0.59 (0.52 to 0.65)	NR
Bruijns, 2013	NR	NR	NR	0.66 (0.62 to 0.70)	NR
Bruijns, 2013	NR	NR	NR	0.57 (0.52 to 0.62)	NR
Bruijns, 2013	NR	5.3 (4.4-6.3)	NR	NR	NR
Bruijns, 2013	NR	3.6 (3.1-4.2)	NR	NR	NR
Bruijns, 2013	NR	NR	NR	0.59 (0.51 to 0.66)	NR
Bruijns, 2013	NR	NR	NR	0.66 (0.62 to 0.70)	NR
Bruijns, 2013	NR	NR	NR	0.65 (0.60 to 0.70)	NR
Bruijns, 2013	NR	4.5 (4.0 to 5.2)	NR	NR	NR
Bruijns, 2013	NR	7.5 (6.4-8.8)	NR	NR	NR
Bruijns, 2013	NR	NR	NR	0.65 (0.58 to 0.72)	NR
Bruijns, 2013	NR	NR	NR	0.73 (0.70 to 0.77)	NR
Bruijns, 2013	NR	NR	NR	0.69 (0.64 to 0.73)	NR
Bruijns, 2013	NR	5.5 (4.9 to 6.1)	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Bruijns, 2013	SIA (SI x Age) ≥55	Mortality, 48-hour	42.3% (36.3-48.5)	95.0% (94.8-95.1)	NR
Bruijns, 2013	SIA (SI x age): moderately injured	Mortality, 48-hour	NR	NR	NR
Bruijns, 2013	SIA (SI x age): overall	Mortality, 48-hour	NR	NR	NR
Bruijns, 2013	SIA (SI x age): severely injured	Mortality, 48-hour	NR	NR	NR
Bruijns, 2014	HR difference (ED-EMS)	Mortality: 48-hour	NR	NR	NR
Bruijns, 2014	HR difference ≥14 (ED-EMS)	Mortality: 48-hour	9% (4.5 to 16.8)	90% (89.9 to 90.6)	NR
Bruijns, 2014	HR difference ≥21 (ED-EMS)	Mortality: 48-hour	7% (3.1 to 14.4)	95% (94.6 to 95.1)	NR
Bruijns, 2014	RR difference (ED-EMS)	Mortality: 48-hour	NR	NR	NR
Bruijns, 2014	RR difference ≥6 (ED-EMS)	Mortality: 48-hour	26% (18.0 to 35.9)	89% (88.9 to 89.7)	NR
Bruijns, 2014	RR difference ≥8 (ED-EMS)	Mortality: 48-hour	13% (7.4 to 21.6)	96% (96.0 to 96.4)	NR
Bruijns, 2014	SBP difference (ED-EMS)	Mortality: 48-hour	NR	NR	NR
Bruijns, 2014	SBP difference ≤-26 (ED-EMS)	Mortality: 48-hour	14% (8.1 to 22.7)	90% (89.4 to 90.1)	NR
Bruijns, 2014	SBP difference ≤-37 (ED-EMS)	Mortality: 48-hour	8% (3.8 to 15.6)	95% (94.7 to 95.3)	NR
Bruijns, 2014	SI ≥0.2 difference (ED-EMS)	Mortality: 48-hour	12% (6.6 to 20.4)	95% (94.8 to 95.3)	NR
Bruijns, 2014	SI difference (ED-EMS)	Mortality: 48-hour	NR	NR	NR
Bruijns, 2014	SI difference ≥0.1 (ED-EMS)	Mortality: 48-hour	20% (12.9 to 29.4)	90% (89.7 to 90.4)	NR
Callaway, 2009	BD	Mortality	NR	NR	NR
Callaway, 2009	BD 0 to -6: ≥65 years	Mortality	36.94% (27.97-46.62) calculated	76.60% (72.50-80.35) calculated	27.15% (21.76-33.32) calculated
Callaway, 2009	BD < -6: ≥65 years	Mortality	15.32% (9.18-23.39) calculated	94.47% (92.00-96.35) calculated	39.53% (26.89-53.75) calculated
Callaway, 2009	Lactate	Mortality	NR	NR	NR
Callaway, 2009	Lactate ≥2.5: ≥65 years	Mortality	41.07% (31.86 to 50.76) calculated	76.05% (71.96 to 79.82) calculated	28.75% (23.48 to 34.66) calculated
Callaway, 2009	Lactate >4.0: ≥65 years	Mortality	18.75% (12.00-27.22) calculated	93.28% (90.64-95.36) calculated	39.62% (28.26-52.23) calculated
Cannon, 2009	SI >0.9, ED	Mortality	40.98% (34.17 to 48.04) calculated	80.18% (78.47 to 81.81) calculated	15.91% (13.60 to 18.53) calculated
Cannon, 2009	SI >0.9 and SBP ≥90, ED	Mortality	32.56% (25.62 to 40.11) calculated	82.47% (80.81 to 84.05) calculated	12.84% (10.45 to 15.69) calculated

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Bruijns, 2013	NR	8.4 (7.2-9.7)	NR	NR	NR
Bruijns, 2013	NR	NR	NR	0.85 (0.80 to 0.90)	NR
Bruijns, 2013	NR	NR	NR	0.79 (0.76 to 0.82)	NR
Bruijns, 2013	NR	NR	NR	0.74 (0.70 to 0.78)	NR
Bruijns, 2014	NR	NR	NR	0.51 (0.46 to 0.6), p=0.5	NR
Bruijns, 2014	NR	0.9 (0.5 to 1.7)	NR	NR	NR
Bruijns, 2014	NR	1.4 (0.7 to 2.8)	NR	NR	NR
Bruijns, 2014	NR	NR	NR	0.56 (0.50 to 0.63), p=0.02	NR
Bruijns, 2014	NR	2.4 (1.7 to 3.4)	NR	NR	NR
Bruijns, 2014	NR	3.4 (2.1 to 5.7)	NR	NR	NR
Bruijns, 2014	NR	NR	NR	0.57 (0.52 to 0.63), p<0.01	NR
Bruijns, 2014	NR	1.4 (0.8 to 2.2)	NR	NR	NR
Bruijns, 2014	NR	1.6 (0.8 to 3.1)	NR	NR	NR
Bruijns, 2014	NR	2.4 (1.4 to 4.1)	NR	NR	NR
Bruijns, 2014	NR	NR	NR	0.53 (0.47 to 0.59), p=0.22	NR
Bruijns, 2014	NR	2.0 (1.4 to 3.0)	NR	NR	NR
Callaway, 2009	NR	NR	NR	0.65 (NR)	NR
Callaway, 2009	83.72% (81.56-85.67) calculated	1.58 (1.18-2.12) calculated	0.82 (0.71-0.96) calculated	NR	NR
Callaway, 2009	82.53% (81.31-83.68) calculated	2.77 (1.56-4.92) calculated	0.90 (0.83-0.97) calculated	NR	NR
Callaway, 2009	NR	NR	NR	0.63 (NR)	NR
Callaway, 2009	84.58% (82.34 to 86.58) calculated	1.71 (1.30 to 2.25) calculated	0.77 (0.66 to 0.91) calculated	NR	NR
Callaway, 2009	82.99% (81.65-84.25) calculated	2.79 (1.67-4.65) calculated	0.87 (0.79-0.96) calculated	NR	NR
Cannon, 2009	93.69% (92.97 to 94.34) calculated	2.07 (1.72 to 2.49) calculated	0.74 (0.66 to 0.83) calculated	NR	NR
Cannon, 2009	93.91% (93.27 to 94.48) calculated	1.86 (1.47 to 2.35) calculated	0.82 (0.74 to 0.91) calculated	NR	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Cannon, 2009	SI >0.9, EMS	Mortality	43.75% (32.68 to 55.30) calculated	67.13% (64.24 to 69.92) calculated	8.93% (7.01 to 11.31) calculated
Cannon, 2009	SI increase ≥0.3 from EMS to ED	Mortality	20.00% (11.89 to 30.44) calculated	96.13% (94.81 to 97.20) calculated	27.59% (18.33 to 39.27) calculated
Cannon, 2009	SI increase (any) from EMS to ED	Mortality	45.00% (33.85 to 56.53) calculated	67.50% (64.62 to 70.28) calculated	9.25% (7.31 to 11.65) calculated
Caputo, 2012	ET CO2 <35 mmHg	Massive transfusion	97.22% (85.47 to 99.93) calculated	66.67% (54.29 to 77.56) calculated	60.34% (52.04 to 68.09) calculated
Caputo, 2012	Lactate >4 mmol/L	Massive transfusion	91.67% (77.53 to 98.25) calculated	85.51% (74.96 to 92.83) calculated	76.74% (64.85 to 85.51) calculated
Caputo, 2012	ET CO2 <35 mmHg	Operative intervention	81.97% (70.02 to 90.64) calculated	81.82% (67.29 to 91.81) calculated	86.21% (76.76 to 92.20) calculated
Caputo, 2012	Lactate >4 mmol/L	Operative intervention	54.10% (40.85 to 66.94) calculated	77.27% (62.16 to 88.53) calculated	76.74% (64.61 to 85.64) calculated
Caputo, 2012	SBP <100	Operative intervention	6.56% (1.82 to 15.95) calculated	97.73% (87.98 to 99.94) calculated	80.00% (41.04 to 44.98) calculated
Caputo, 2015	BD < -2	Massive transfusion	59% (45 to 72)	59% (45 to 71)	58% (44 to 72)
Caputo, 2015	Lactate >4	Massive transfusion	54% (39 to 68)	75% (62 to 84)	59% (44 to 75)
Caputo, 2015	BD < -2	Operative intervention	57% (42 to 76)	61% (52 to 77)	55% (43 to 70)
Caputo, 2015	Lactate >4	Operative intervention	55% (41 to 67)	76% (65 to 87)	60% (46 to 78)
Chan, 1997	SBP <90 (EMS) *all patients normotensive at ED arrival*	Blood transfusion	80.00% (44.39 to 97.48) calculated	53.19% (42.61 to 63.56) calculated	15.38% (11.08 to 20.96) calculated
Chan, 1997	SBP <90 (EMS) *all patients normotensive at ED arrival*	ICU admission	70.00% (53.47 to 83.44) calculated	62.50% (49.51 to 74.30) calculated	53.85% (44.48 to 62.95) calculated
Chan, 1997	SBP <90 (EMS) *all patients normotensive at ED arrival*	Mortality	90.91% (58.72 to 99.77) calculated	54.84% (44.17 to 65.91) calculated	19.23% (15.10 to 24.17) calculated
Chen, 2007	SBP linear classifier	Major hemorrhage	NR	NR	NR
Chen, 2007	SI linear classifier	Major hemorrhage	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Cannon, 2009	94.19% (93.00 to 95.18) calculated	1.33 (1.02 to 1.73) calculated	0.84 (0.69 to 1.02) calculated	NR	NR
Cannon, 2009	94.22% (93.59 to 94.80) calculated	4.78 (2.96 to 7.72) calculated	0.77 (0.66 to 0.90) calculated	NR	NR
Cannon, 2009	94.34% (93.15 to 95.33) calculated	1.38 (1.07 to 1.79) calculated	0.81 (0.67 to 1.00) calculated	NR	NR
Caputo, 2012	97.87% (86.86 to 99.69) calculated	2.92 (2.08 to 4.09) calculated	0.04 (0.01 to 0.29) calculated	NR	NR
Caputo, 2012	95.16% (86.89 to 98.32) calculated	6.33 (3.54 to 11.31) calculated	0.10 (0.03 to 0.29) calculated	NR	NR
Caputo, 2012	76.60% (65.31 to 85.05) calculated	4.51 (2.38 to 8.53) calculated	0.22 (0.13 to 0.38) calculated	NR	NR
Caputo, 2012	54.84% (46.96 to 62.49) calculated	2.38 (1.32 to 4.30) calculated	0.59 (0.43 to 0.81) calculated	NR	NR
Caputo, 2012	43.00% (41.04 to 44.98) calculated	2.89 (0.33 to 24.94) calculated	0.96 (0.88 to 1.04) calculated	NR	NR
Caputo, 2015	60% (46 to 74)	1.44 (0.96 to 2.15)	0.69 (0.46 to 1.04)	0.82 (0.75 to 0.89)	NR
Caputo, 2015	70% (59 to 81)	2.11 (1.25 to 3.56)	0.62 (0.43 to 0.89)	0.83 (0.7 to 0.95)	NR
Caputo, 2015	56% (36 to 66)	1.5 (0.99 to 2.3)	0.75 (0.5 to 1.0)	0.67 (0.58 to 0.76)	NR
Caputo, 2015	75% (64 to 88)	2.21 (1.25 to 3.7)	0.66 (0.47 to 0.96)	0.62 (0.5 to 0.73)	NR
Chan, 1997	96.15% (87.71 to 98.87) calculated	1.71 (1.17 to 2.49) calculated	0.38 (0.11 to 1.32) calculated	NR	NR
Chan, 1997	76.92% (66.68 to 84.74) calculated	1.87 (1.28 to 2.72) calculated	0.48 (0.29 to 0.80) calculated	NR	NR
Chan, 1997	98.08% (88.63 to 99.70) calculated	2.01 (1.50 to 2.69) calculated	0.17 (0.03 to 1.08) calculated	NR	NR
Chen, 2007	NR	NR	NR	0.71 (0.706 to 0.714)	NR
Chen, 2007	NR	NR	NR	0.77 (NR)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Chen, 2007	Pulse pressure (PP) linear classifier	Major hemorrhage	NR	NR	NR
Chen, 2008 *Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	Ensemble classifier (non-linear model of vital signs that allows missing data; uses HR, RR, DBP, SBP, and SaO2)	Hemorrhage	90% (NR) Set as clinically relevant level to determine specificity	40% (SD 0.10)	NR
Chen, 2008 *Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	Ensemble classifier (non-linear model of vital signs that allows missing data)	Hemorrhage	69% (SD 0.08)	68% (SD 0.09)	NR
Chen, 2008 *Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	Hemorrhage index (HR x RR)/(MAP x pulse pressure)	Hemorrhage	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Chen, 2007	NR	NR	NR	0.73 (NR)	NR
Chen, 2008 *Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	NR	NR	NR	NR
Chen, 2008 *Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	NR	NR	0.76 (SD 0.05)	NR
Chen, 2008 *Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	NR	NR	0.73 (SD 0.06)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Chen, 2008 *Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	HR/PP	Hemorrhage	NR	NR	NR
Chen, 2008 *Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	Pulse pressure	Hemorrhage	NR	NR	NR
Chen, 2008 *Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	RR/pulse pressure	Hemorrhage	NR	NR	NR
Chen, 2008 *Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	SI	Hemorrhage	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Chen, 2008 *Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	NR	NR	0.75 (SD 0.10)	NR
Chen, 2008 *Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	NR	NR	0.73 (SD 0.06)	NR
Chen, 2008 *Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	NR	NR	0.67 (SD 0.08)	NR
Chen, 2008 *Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	NR	NR	0.76 (SD 0.06)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Chen, 2009 *Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	RR, standard: overall	Major hemorrhage	NR	NR	NR
Chen, 2009 *Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	RR, standard: thoracic injury	Major hemorrhage	NR	NR	NR
Chen, 2009 *Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	SBP, reliable	Major hemorrhage	NR	NR	NR
Chen, 2009 *Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	SI, reliable	Major hemorrhage	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Chen, 2009 *Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	NR	NR	0.60 (0.49 to 0.70)	NR
Chen, 2009 *Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	NR	NR	0.56 (0.39 to 0.71)	NR
Chen, 2009 *Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	NR	NR	0.71 (0.61 to 0.80)	NR
Chen, 2009 *Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	NR	NR	0.78 (0.67 to 0.86)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Chen, 2009 *Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	RR, reliable: nonthoracic	Major in-hospital respiratory intervention	NR	NR	NR
Chen, 2009 *Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	RR, reliable: overall	Major in-hospital respiratory intervention	NR	NR	NR
Chen, 2009 *Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	RR, reliable: thoracic injury	Major in-hospital respiratory intervention	NR	NR	NR
Chen, 2009 *Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	RR, standard: nonthoracic	Major in-hospital respiratory intervention	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Chen, 2009 *Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	NR	NR	0.73 (0.49 to 0.89)	NR
Chen, 2009 *Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	NR	NR	0.67 (0.57 to 0.77)	NR
Chen, 2009 *Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	NR	NR	0.63 (0.51 to 0.75)	NR
Chen, 2009 *Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	NR	NR	0.56 (0.37 to 0.74)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Chen, 2009 *Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	RR, standard: overall	Major in-hospital respiratory intervention	NR	NR	NR
Chen, 2009 *Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	RR, standard: thoracic injury	Major in-hospital respiratory intervention	NR	NR	NR
Chen, 2009 Note: Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	Breath index (RR/pulse pressure), reliable	Major hemorrhage	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Chen, 2009 *Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	NR	NR	0.59 (0.48 to 0.69)	NR
Chen, 2009 *Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	NR	NR	0.52 (0.38 to 0.66)	NR
Chen, 2009 Note: Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	NR	NR	0.85 (0.77 to 0.91)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Chen, 2009 Note: Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	DBP, reliable	Major hemorrhage	NR	NR	NR
Chen, 2009 Note: Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	HR, reliable	Major hemorrhage	NR	NR	NR
Chen, 2009 Note: Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	MAP, reliable	Major hemorrhage	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Chen, 2009 Note: Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	NR	NR	0.55 (0.43 to 0.67)	NR
Chen, 2009 Note: Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	NR	NR	0.74 (0.63 to 0.83)	NR
Chen, 2009 Note: Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	NR	NR	0.60 (0.49 to 0.71)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Chen, 2009 Note: Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	PP, reliable	Major hemorrhage	NR	NR	NR
Chen, 2009 Note: Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	RR, reliable: nonthoracic	Major hemorrhage	NR	NR	NR
Chen, 2009 Note: Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	RR, reliable: overall	Major hemorrhage	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Chen, 2009 Note: Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	NR	NR	0.78 (0.69 to 0.86)	NR
Chen, 2009 Note: Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	NR	NR	0.79 (0.66 to 0.89)	NR
Chen, 2009 Note: Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	NR	NR	0.77 (0.67 to 0.85)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Chen, 2009 Note: Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	RR, reliable: thoracic injury	Major hemorrhage	NR	NR	NR
Chen, 2009 Note: Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	RR, standard: nonthoracic	Major hemorrhage	NR	NR	NR
Chen, 2010 *Chen 2010, Chen 2009, and Chen 2008 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	Amplitude IQR, photoplethysmogram (PPG) metric	Major hemorrhage	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Chen, 2009 Note: Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	NR	NR	0.76 (0.61 to 0.87)	NR
Chen, 2009 Note: Chen 2008, Chen 2009, and Chen 2010 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	NR	NR	0.60 (0.45 to 0.73)	NR
Chen, 2010 *Chen 2010, Chen 2009, and Chen 2008 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	NR	NR	0.64 (0.51 to 0.75)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Chen, 2010 *Chen 2010, Chen 2009, and Chen 2008 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	Amplitude max-min, photoplethysmogram (PPG) metric	Major hemorrhage	NR	NR	NR
Chen, 2010 *Chen 2010, Chen 2009, and Chen 2008 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	HR, reliable	Major hemorrhage	NR	NR	NR
Chen, 2010 *Chen 2010, Chen 2009, and Chen 2008 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	Metric and reliable vital signs model: peak height IQR metric, HR, RR, SpO2, SBP, and DBP	Major hemorrhage	73% (NR)	82% (NR)	NR
Chen, 2010 *Chen 2010, Chen 2009, and Chen 2008 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	Peak height IQR, photoplethysmogram (PPG) metric	Major hemorrhage	54% (NR)	73% (NR)	NR

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Chen, 2010 *Chen 2010, Chen 2009, and Chen 2008 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	NR	NR	0.57 (0.45 to 0.68)	NR
Chen, 2010 *Chen 2010, Chen 2009, and Chen 2008 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	NR	NR	0.62 (0.50 to 0.73)	NR
Chen, 2010 *Chen 2010, Chen 2009, and Chen 2008 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	NR	NR	NR	NR
Chen, 2010 *Chen 2010, Chen 2009, and Chen 2008 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	NR	NR	0.65 (0.54 to 0.76)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Chen, 2010 *Chen 2010, Chen 2009, and Chen 2008 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	Peak height max-min, photoplethysmogram (PPG) metric	Major hemorrhage	NR	NR	NR
Chen, 2010 *Chen 2010, Chen 2009, and Chen 2008 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	Reliable vital signs model: HR, RR, SpO2, SBP, and DBP	Major hemorrhage	77% (CI NR)	76% (CI NR)	NR
Chen, 2010 *Chen 2010, Chen 2009, and Chen 2008 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	SBP, reliable	Major hemorrhage	NR	NR	NR
Cooke, 2006a	Intubation status	Mortality	53.33% (26.59 to 78.73) calculated	100.00% (78.20 to 100.00) calculated	100.00% (CI not able to be calculated) calculated

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Chen, 2010 *Chen 2010, Chen 2009, and Chen 2008 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	NR	NR	0.60 (0.48 to 0.71)	NR
Chen, 2010 *Chen 2010, Chen 2009, and Chen 2008 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	NR	NR	NR	NR
Chen, 2010 *Chen 2010, Chen 2009, and Chen 2008 draw from the same 898 patients, but differ in eligibility criteria, number analyzed, and some measures evaluated.	NR	NR	NR	0.75 (0.65 to 0.84)	NR
Cooke, 2006a	68.18% (55.51 to 78.64) calculated	not able to be calculated	0.47 (0.27 to 0.80) calculated	NR	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Courville, 2009	Chi-square-assisted interaction detection model (CHAID) for mortality: testing data model uses: demographics; ED SBP, RR, temperature, GCS, airway status; EMS GCS; mechanism; days since injury	Mortality, in-hospital	59.9% (CI NR)	99.0% (CI NR)	58.2% (CI NR)
Courville, 2009	Airway: intubated, with or without chemical sedation	Mortality, in-hospital	55.26% (53.52 to 56.98) calculated	96.71% (96.62 to 96.80) calculated	26.68% (25.87 to 27.49) calculated
Davis, 1996	BD -3 to -5 (mild)	Blood transfusion	23.82% (21.01 to 26.80) calculated	73.38% (71.43 to 75.27) calculated	27.03% (24.38 to 29.86) calculated
Davis, 1996	BD -6 to -9 (moderate)	Blood transfusion	29.60% (26.57 to 32.76) calculated	92.48% (91.27 to 93.58) calculated	61.99% (57.61 to 66.18) calculated
Davis, 1996	BD ≤ -10 (severe)	Blood transfusion	27.75% (24.78 to 30.86) calculated	98.13% (97.46 to 98.67) calculated	86.02% (81.58 to 89.53) calculated
Davis, 1996	BD -3 to -5 (mild)	Mortality	19.86% (16.16 to 23.98) calculated	73.21% (71.44 to 74.93) calculated	11.02% (9.19 to 13.17) calculated
Davis, 1996	BD -6 to -9 (moderate)	Mortality	22.46% (18.57 to 26.74) calculated	87.44% (86.08 to 88.70) calculated	23.00% (19.58 to 26.83) calculated
Davis, 1996	BD ≤ -10 (severe)	Mortality	33.81% (29.31 to 38.53) calculated	94.63% (93.68 to 95.47) calculated	51.25% (45.99 to 56.49) calculated
DeMuro, 2013	SI ≥0.8, elderly ≥65 years	Bleeding	58.8% (NR)	91.9% (NR)	5.6% (NR)
DeMuro, 2013	SI ≥0.8, overall	Bleeding	76.1% (NR)	87.4% (NR)	11.3% (NR)
DeMuro, 2013	SI ≥0.8, adult <65 years	Bleeding	80.3% (NR)	83% (NR)	13.7% (NR)
DeMuro, 2013	SI ≥0.9, elderly ≥65 years	Bleeding	41.2% (NR)	95.7% (NR)	7.3% (NR)
DeMuro, 2013	SI ≥0.9, overall	Bleeding	54.5% (NR)	93.6% (NR)	15.2% (NR)

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Courville, 2009	99.1% (CI NR)	NR	NR	NR	NR
Courville, 2009	99.01% (98.97 to 99.05) calculated	16.80 (16.12 to 17.51) calculated	0.46 (0.45 to 0.48) calculated	NR	NR
Davis, 1996	69.94% (68.97 to 70.88) calculated	0.89 (0.78 to 1.03) calculated	1.04 (0.99 to 1.09) calculated	NR	NR
Davis, 1996	76.03% (75.21 to 76.84) calculated	3.94 (3.28 to 4.72) calculated	0.76 (0.73 to 0.80) calculated	NR	NR
Davis, 1996	76.64% (75.88 to 77.37) calculated	14.86 (10.70 to 20.65) calculated	0.74 (0.71 to 0.77) calculated	NR	NR
Davis, 1996	84.53% (83.83 to 85.21) calculated	0.74 (0.61 to 0.91) calculated	1.09 (1.04 to 1.15) calculated	NR	NR
Davis, 1996	87.09% (86.48 to 87.68) calculated	1.79 (1.46 to 2.19) calculated	0.89 (0.84 to 0.94) calculated	NR	NR
Davis, 1996	89.53% (88.87 to 90.16) calculated	6.29 (5.09 to 7.77) calculated	0.70 (0.65 to 0.75) calculated	NR	NR
DeMuro, 2013	99.6% (NR)	NR	NR	NR	NR
DeMuro, 2013	99.4% (NR)	NR	NR	NR	NR
DeMuro, 2013	99.2% (NR)	NR	NR	NR	NR
DeMuro, 2013	99.5% (NR)	NR	NR	NR	NR
DeMuro, 2013	99.0% (NR)	NR	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
DeMuro, 2013	SI ≥0.9, adult <65 years	Bleeding	57.7% (NR)	91% (NR)	18.7% (NR)
DeMuro, 2013	SI ≥1.0, overall	Bleeding	39.8% (NR)	97.2% (NR)	22.9% (NR)
DeMuro, 2013	SI ≥1.0, elderly >65 years	Bleeding	29.4% (NR)	98.1% (NR)	11.1% (NR)
DeMuro, 2013	SI ≥1.0, adult <65 years	Bleeding	42.3% (NR)	96% (NR)	27.8% (NR)
Dinh, 2014	SBP <90 or >180, EMS	Major trauma	14.66% (12.04 to 17.60) calculated	97.39% (96.66 to 97.99) calculated	60.76% (53.24 to 67.80) calculated
Dinh, 2014	HR <50 or >110, EMS	Major trauma	27.48% (24.09 to 31.07) calculated	93.93% (92.89 to 94.86) calculated	55.56% (50.55 to 60.46) calculated
Dinh, 2014	RR <10 or >24, EMS	Major trauma	19.85% (16.86 to 23.11) calculated	97.05% (96.29 to 97.69) calculated	65.00% (58.46 to 71.02) calculated
Dinh, 2014	Vital signs, EMS: abnormal HR, SBP, or RR	Major trauma	42.60% (38.77 to 46.48) calculated	89.25% (87.93 to 90.47) calculated	52.25% (48.60 to 55.87) calculated
Dunham, 2017	BD	Mortality: NR	NR	NR	NR
Dunham, 2017	HR	Mortality: NR	NR	NR	NR
Dunham, 2017	SBP	Mortality: NR	NR	NR	NR
Dunham, 2017	SI	Mortality: NR	NR	NR	NR
Dunne, 2005	Lactate >6	Mortality	55.3% (51.3 to 59.3) calculated	91.7% (91.2 to 92.1) calculated	NR
Eastridge, 2007	SBP <110, ED	Mortality	33.7% (CI NR)	87.5% (CI NR)	5.2% (CI NR)
Eastridge, 2007	SBP <90, ED	Mortality	18.7% (CI NR)	97.6% (CI NR)	13.7% (CI NR)
Eastridge, 2007	SBP 123 (optimal cutoff), ED	Mortality	47% (CI NR)	69.7% (CI NR)	NR
Eastridge, 2007	SBP, ED	Mortality	NR	NR	NR
Edla, 2015b	HR	Blood transfusion ≥1 pRBC unit in 24 hours	NR	NR	NR
Edla, 2015b	Pulse pressure (SBP - DBP)	Blood transfusion ≥1 pRBC unit in 24 hours	NR	NR	NR
Edla, 2015b	RR	Blood transfusion ≥1 pRBC unit in 24 hours	NR	NR	NR
Edla, 2015b	SBP	Blood transfusion ≥1 pRBC unit in 24 hours	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
DeMuro, 2013	98.5% (NR)	NR	NR	NR	NR
DeMuro, 2013	98.7% (NR)	NR	NR	NR	NR
DeMuro, 2013	99.4% (NR)	NR	NR	NR	NR
DeMuro, 2013	98.0% (NR)	NR	NR	NR	NR
Dinh, 2014	80.52% (80.00 to 81.02) calculated	5.61 (4.12 to 7.63) calculated	0.88 (0.85 to 0.91) calculated	NR	NR
Dinh, 2014	82.43% (81.72 to 83.11) calculated	4.53 (3.70 to 5.54) calculated	0.77 (0.74 to 0.81) calculated	NR	NR
Dinh, 2014	81.43% (80.84 to 82.01) calculated	6.73 (5.10 to 8.88) calculated	0.83 (0.79 to 0.86) calculated	NR	NR
Dinh, 2014	84.92% (84.03 to 85.76) calculated	3.96 (3.42 to 4.59) calculated	0.64 (0.60 to 0.69) calculated	NR	NR
Dunham, 2017	NR	NR	NR	0.900 (0.850 to 0.949)	NR
Dunham, 2017	NR	NR	NR	0.667 (0.562 to 0.771)	NR
Dunham, 2017	NR	NR	NR	0.753 (0.651 to 0.854)	NR
Dunham, 2017	NR	NR	NR	0.773 (0.685 to 0.861)	NR
Dunne, 2005	NR	NR	NR	NR	NR
Eastridge, 2007	NR	NR	NR	NR	NR
Eastridge, 2007	NR	NR	NR	NR	NR
Eastridge, 2007	NR	NR	NR	NR	NR
Eastridge, 2007	NR	NR	NR	0.582 (0.577 to 0.588), p<0.001	NR
Edla, 2015b	NR	NR	NR	0.68 (0.59 to 0.76)	NR
Edla, 2015b	NR	NR	NR	0.74 (0.65 to 0.81)	NR
Edla, 2015b	NR	NR	NR	0.65 (0.56 to 0.73)	NR
Edla, 2015b	NR	NR	NR	0.70 (0.61 to 0.78)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Edla, 2015b	HRV: Standard deviation of the R-to-R intervals (SDNN)	Blood transfusion ≥1 pRBC units in 24 hours	NR	NR	NR
Edla, 2015b	HRV: Sample entropy (SampEn)	Blood transfusion ≥1 pRBC units in 24 hours	NR	NR	NR
Edla, 2015b	HRV: Rate of sinus arrhythmia (RSA)	Blood transfusion ≥1 pRBC units in 24 hours	NR	NR	NR
Edla, 2015b	HR	Blood transfusion ≥5 pRBC units in 24 hours	NR	NR	NR
Edla, 2015b	Pulse pressure (SBP - DBP)	Blood transfusion ≥5 pRBC units in 24 hours	NR	NR	NR
Edla, 2015b	RR	Blood transfusion ≥5 pRBC units in 24 hours	NR	NR	NR
Edla, 2015b	SBP	Blood transfusion ≥5 pRBC units in 24 hours	NR	NR	NR
Edla, 2015b	HRV: Standard deviation of the R-to-R intervals (SDNN)	Blood transfusion ≥5 pRBC units in 24 hours	NR	NR	NR
Edla, 2015b	HRV: Sample entropy (SampEn)	Blood transfusion ≥5 pRBC units in 24 hours	NR	NR	NR
Edla, 2015b	HRV: Rate of sinus arrhythmia (RSA)	Blood transfusion ≥5 pRBC units in 24 hours	NR	NR	NR
Edla, 2015b	HR	Blood transfusion ≥9 pRBC units in 24 hours	NR	NR	NR
Edla, 2015b	Pulse pressure (SBP - DBP)	Blood transfusion ≥9 pRBC units in 24 hours	NR	NR	NR
Edla, 2015b	RR	Blood transfusion ≥9 pRBC units in 24 hours	NR	NR	NR
Edla, 2015b	SBP	Blood transfusion ≥9 pRBC units in 24 hours	NR	NR	NR
Edla, 2015b	HRV: Standard deviation of the R-to-R intervals (SDNN)	Blood transfusion ≥9 pRBC units in 24 hours	NR	NR	NR
Edla, 2015b	HRV: Sample entropy (SampEn)	Blood transfusion ≥9 pRBC units in 24 hours	NR	NR	NR
Edla, 2015b	HRV: Rate of sinus arrhythmia (RSA)	Blood transfusion ≥9 pRBC units in 24 hours	NR	NR	NR
Engum, 2000	RR <10 or >29	Major trauma	2.11% (0.92 to 4.12) calculated	99.67% (99.04 to 99.93) calculated	73% (NR) calculated: 72.73% (41.56 to 90.91)
Engum, 2000	SBP ≤90	Major trauma	14.78% (11.36 to 18.75) calculated	99.01% (98.12 to 99.54) calculated	86% (NR) calculated: 86.15% (75.67 to 92.57)

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Edla, 2015b	NR	NR	NR	0.67 (0.59 to 0.75)	NR
Edla, 2015b	NR	NR	NR	0.60 (0.53 to 0.68)	NR
Edla, 2015b	NR	NR	NR	0.72 (0.64 to 0.79)	NR
Edla, 2015b	NR	NR	NR	0.74 (0.59 to 0.84)	NR
Edla, 2015b	NR	NR	NR	0.79 (0.68 to 0.88)	NR
Edla, 2015b	NR	NR	NR	0.74 (0.63 to 0.83)	NR
Edla, 2015b	NR	NR	NR	0.72 (0.58 to 0.82)	NR
Edla, 2015b	NR	NR	NR	0.72 (0.61 to 0.82)	NR
Edla, 2015b	NR	NR	NR	0.63 (0.52 to 0.73)	NR
Edla, 2015b	NR	NR	NR	0.76 (0.62 to 0.85)	NR
Edla, 2015b	NR	NR	NR	0.72 (0.53 to 0.85)	NR
Edla, 2015b	NR	NR	NR	0.79 (0.61 to 0.90)	NR
Edla, 2015b	NR	NR	NR	0.73 (0.53 to 0.84)	NR
Edla, 2015b	NR	NR	NR	0.73 (0.55 to 0.86)	NR
Edla, 2015b	NR	NR	NR	0.71 (0.57 to 0.82)	NR
Edla, 2015b	NR	NR	NR	0.62 (0.46 to 0.75)	NR
Edla, 2015b	NR	NR	NR	0.79 (0.64 to 0.89)	NR
Engum, 2000	70.88% (70.56 to 71.19) calculated	6.37 (1.70 to 23.90) calculated	0.98 (0.97 to 1.00) calculated	NR	NR
Engum, 2000	73.52% (72.69 to 74.34) calculated	14.87 (7.43 to 29.76) calculated	0.86 (0.83 to 0.90) calculated	NR	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Folkert, 2015	Lactate >2.2	Blood transfusion	71.43% (41.90 to 91.61) calculated	33.05% (24.67 to 42.31) calculated	11.24% (8.15 to 15.29) calculated
Folkert, 2015	Lactate (continuous variable)	Clinically significant bleeding	NR	NR	NR
Folkert, 2015	Lactate >2.2	Clinically significant bleeding	68.63% (54.11 to 80.89) calculated	33.33% (23.24 to 44.68) calculated	39.33% (33.74 to 45.20) calculated
Folkert, 2015	Lactate >2.2	Operative intervention for bleeding control	63.89% (46.22 to 79.18) calculated	30.53% (21.49 to 40.82) calculated	25.84% (20.86 to 31.55) calculated
Franklin, 2000	SBP <90, EMS	ICU admission	15.61% (13.42 to 18.00) calculated	86.17% (84.92 to 87.35) calculated	26.25% (23.14 to 29.63) calculated
Franklin, 2000	SBP <90, EMS: subgroup with any SBP <90 (ED or EMS)	Urgent operation	34.45% (30.64 to 38.41) calculated	69.23% (60.54 to 77.02) calculated	83.74% (79.55 to 87.21) calculated
Franklin, 2000	SBP <90, EMS	ED disposition to OR	21.85% (19.60 to 24.24) calculated	89.01% (87.83 to 90.12) calculated	46.15% (42.54 to 49.81) calculated
Franklin, 2000	SBP <90, EMS	Mortality: in-hospital	44.06% (38.22 to 50.02) calculated	87.92% (86.86 to 88.93) calculated	21.07% (18.60 to 23.77) calculated
Franklin, 2000	SBP <90, EMS	Mortality: ED	50.00% (34.56 to 65.44) calculated	86.12% (85.03 to 87.16) calculated	3.68% (2.74 to 4.93) calculated
Garner, 2001	Capillary refill >2 seconds	Critical injury	36.3% (NR)	93.2% (NR)	NR
Garner, 2001	CareFlight Triage algorithm	Critical injury	82% (75 to 88)	96% (94 to 97)	NR
Garner, 2001	HR	Critical injury	NR	NR	NR
Garner, 2001	HR >120	Critical injury	33.3% (NR)	91.8% (NR)	NR
Garner, 2001	Modified Simple Triage and Rapid Treatment algorithm (modified START), using palpable radial pulse	Critical injury	84% (76 to 89)	91% (89 to 93)	NR
Garner, 2001	RR	Critical injury	NR	NR	NR
Garner, 2001	RR <10 or >29	Critical injury	25.2% (NR)	95.3% (NR)	NR
Garner, 2001	RR >29	Critical injury	14.8% (NR)	95.3% (NR)	NR
Garner, 2001	SBP	Critical injury	NR	NR	NR
Garner, 2001	SBP <80	Critical injury	30.4% (NR)	99.2% (NR)	NR

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Folkert, 2015	90.70% (80.38 to 95.87) calculated	1.07 (0.75 to 1.52) calculated	0.86 (0.36 to 2.06) calculated	NR	NR
Folkert, 2015	NR	NR	NR	0.57 (0.46 to 0.67)	NR
Folkert, 2015	62.79% (5.34 to 73.75) calculated	1.03 (0.81 to 1.31) calculated	0.94 (0.57 to 1.57) calculated	0.51 (0.42 to 0.59)	NR
Folkert, 2015	69.05% (56.77 to 79.12) calculated	0.92 (0.70 to 1.22) calculated	1.18 (0.70 to 2.01) calculated	NR	NR
Franklin, 2000	76.39% (75.85 to 76.93) calculated	1.13 (0.95 to 1.33) calculated	0.98 (0.95 to 1.01) calculated	NR	NR
Franklin, 2000	18.67% (16.80 to 20.70) calculated	1.12 (0.85 to 1.48) calculated	0.95 (0.83 to 1.08) calculated	NR	NR
Franklin, 2000	72.55% (71.91 to 73.18) calculated	1.99 (1.72 to 2.30) calculated	0.88 (0.85 to 0.91) calculated	NR	NR
Franklin, 2000	95.55% (95.09 to 95.97) calculated	3.65 (3.12 to 4.26) calculated	0.64 (0.57 to 0.71) calculated	NR	NR
Franklin, 2000	99.39% (99.18 to 99.54) calculated	3.60 (2.66 to 4.89) calculated	0.58 (0.43 to 0.78) calculated	NR	NR
Garner, 2001	NR	NR	NR	NR	NR
Garner, 2001	NR	NR	NR	NR	NR
Garner, 2001	NR	NR	NR	0.64 (0.58 to 0.70)	NR
Garner, 2001	NR	NR	NR	NR	NR
Garner, 2001	NR	NR	NR	NR	NR
Garner, 2001	NR	NR	NR	0.50 (0.43 to 0.56)	NR
Garner, 2001	NR	NR	NR	NR	NR
Garner, 2001	NR	NR	NR	NR	NR
Garner, 2001	NR	NR	NR	0.72 (0.67 to 0.77)	NR
Garner, 2001	NR	NR	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Garner, 2001	Simple Triage and Rapid Treatment algorithm (START), using capillary refill	Critical injury	85% (78 to 90)	86% (84 to 88)	NR
Garner, 2001	Triage Sieve algorithm, using capillary refill	Critical injury	45% (37 to 54)	89% (87 to 91)	NR
Garner, 2001	Triage Sieve algorithm, using HR	Critical injury	45% (37 to 54)	88% (86 to 90)	NR
Gebhart, 2007	START triage: tabulated score ≤1	Mortality: inpatient	57% (NR)	96% (NR)	40% (NR)
Gebhart, 2007	START triage: tabulated score ≥2	Mortality: inpatient	85% (NR)	63% (NR)	8% (NR)
Gray, 1997	T-RTS <12	Major injury composite	60% (49.3 to 69.6)	90% (84.1 to 95.2)	NR
Gray, 1997	T-RTS <8	Major injury composite	19% (11.4 to 27.7)	100% (96.9 to 100)	NR
Gray, 1997	CRAMS score <9	Major injury composite	69% (58.9 to 78.1)	75% (67.1 to 82.9)	NR
Grimme, 2005	HR	Organ failure	NR	NR	NR
Grimme, 2005	RR	Organ failure	NR	NR	NR
Grimme, 2005	RTS	Organ failure	NR	NR	NR
Grimme, 2005	SBP	Organ failure	NR	NR	NR
Grimme, 2005	SI	Organ Failure	NR	NR	NR
Guyette, 2012	Deoxygenation slope (DeO2)	Life-saving intervention	NR	NR	NR
Guyette, 2015	Lactate (POC), EMS	Need for resuscitative care	NR	NR	NR
Guyette, 2015	Lactate ≥2.5 (POC), EMS	Need for resuscitative care	93% (84 to 98)	49% (NR)	NR
Guyette, 2015	Lactate (POC), EMS: early lactate subgroup	Need for resuscitative care	100% (73 to 100)	NR	NR
Guyette, 2015	Lactate (POC), EMS: late lactate subgroup	Need for resuscitative care	89% (77 to 96)	NR	NR
Guyette, 2015	SBP, EMS	Need for resuscitative care	NR	NR	NR
Guyette, 2015	SBP ≤90, EMS	Need for resuscitative care	67% (55 to 78)	48% (NR)	NR
Guyette, 2015	SBP ≤90, EMS; early lactate subgroup	Need for resuscitative care	59% (33 to 82)	NR	NR
Guyette, 2015	SBP ≤90, EMS; late lactate subgroup	Need for resuscitative care	70% (56 to 82)	NR	NR
Guyette, 2015	SI	Need for resuscitative care	NR	NR	NR
Haider, 2016	SBP <90	Trauma center need	NR	NR	NR
Haider, 2016	SI >1.0	Trauma center need	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Garner, 2001	NR	NR	NR	NR	NR
Garner, 2001	NR	NR	NR	NR	NR
Garner, 2001	NR	NR	NR	NR	NR
Gebhart, 2007	98% (NR)	NR	NR	0.57 (NR)	NR
Gebhart, 2007	99% (NR)	NR	NR	0.86 (NR)	NR
Gray, 1997	NR	NR	NR	NR	NR
Gray, 1997	NR	NR	NR	NR	NR
Gray, 1997	NR	NR	NR	NR	NR
Grimme, 2005	NR	NR	NR	0.579 (NR)	NR
Grimme, 2005	NR	NR	NR	0.377 (NR)	NR
Grimme, 2005	NR	NR	NR	0.633 (NR)	NR
Grimme, 2005	NR	NR	NR	0.564 (NR)	NR
Grimme, 2005	NR	NR	NR	0.684 (NR)	NR
Guyette, 2012	NR	NR	NR	0.7119 (NR)	Abnormal DeO2 identified 56% of patients requiring LSI (29/52) and 88% of hypotensive patients requiring LSI (7/8).
Guyette, 2015	NR	NR	NR	0.78 (0.73 to 0.83)	NR
Guyette, 2015	97% (93 to 99)	NR	NR	NR	NR
Guyette, 2015	NR	NR	NR	NR	NR
Guyette, 2015	NR	NR	NR	NR	NR
Guyette, 2015	NR	NR	NR	0.59 (0.53 to 0.66)	NR
Guyette, 2015	87% (81 to 91)	NR	NR	NR	NR
Guyette, 2015	NR	NR	NR	NR	NR
Guyette, 2015	NR	NR	NR	NR	NR
Guyette, 2015	NR	NR	NR	0.66 (0.60 to 0.74)	NR
Haider, 2016	NR	NR	NR	0.526 (0.524-0.527)	NR
Haider, 2016	NR	NR	NR	0.534 (0.532-0.535)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Haider, 2016	National Trauma Triage Protocol, physiologic step 1 (current, using SBP <90)	Trauma center need	NR	NR	NR
Haider, 2016	National Trauma Triage Protocol, physiologic step 1 - investigational model using SI >1.0 (SI >1.0 instead of SBP <90)	Trauma center need	NR	NR	NR
Hamada, 2014	Oxygen saturation (SpO2) <90%, EMS	Major trauma	16% (NR)	94% (NR)	79% (NR)
Hamada, 2014	SBP <90, EMS	Major trauma	34% (NR)	86% (NR)	77% (NR)
Hamada, 2014	Airway support (assisted ventilation)	Major trauma	52% (NR)	88% (NR)	86% (NR)
Henry, 1996	SBP <90	LOS >2 days	46% (NR)	88% (NR)	25% (NR)
Henry, 1996	SBP <90	Major non-orthopedic interventions or death	55% (NR)	99% (NR)	46% (NR)
Holcomb, 2005	SBP <99	Life-saving intervention	50.67% (38.86 to 62.42) calculated	82.35% (77.61 to 86.46) calculated	41.30% (33.61 to 49.45) calculated
Holcomb, 2005b	Capillary refill >2 seconds	Life-saving intervention	22.08% (13.42 to 32.98) calculated	98.40% (94.34 to 99.81) calculated	89.47% (66.88 to 97.28) calculated
Holcomb, 2005b	RR ≥19	Life-saving intervention	79.37% (67.30 to 88.53) calculated	11.19% (6.40 to 17.79) calculated	29.59% (26.76 to 32.57) calculated
Holcomb, 2005b	RR ≥21	Life-saving intervention	66.67% (53.66 to 78.05) calculated	26.12% (18.92 to 34.41) calculated	29.79% (25.53 to 34.17) calculated
Holcomb, 2005b	RR ≥24	Life-saving intervention	38.10% (26.15 to 51.20) calculated	69.40% (60.86 to 77.07) calculated	36.92% (28.08 to 46.74) calculated
Holcomb, 2005b	SBP <90	Life-saving intervention	33.75% (23.55 to 45.19) calculated	97.06% (92.64 to 99.19) calculated	87.10% (71.02 to 94.90) calculated
Holcomb, 2005b	HR ≥100	Life-saving intervention	60.00% (48.44 to 70.80) calculated	51.47% (42.75 to 60.12) calculated	42.11% (36.18 to 48.26) calculated
Holcomb, 2005b	HR ≥116	Life-saving intervention	21.83% (15.34 to 29.53) calculated	66.22% (54.28 to 76.81) calculated	55.36% (44.26 to 65.94) calculated

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Haider, 2016	NR	NR	NR	0.599 (0.597–0.601)	NR
Haider, 2016	NR	NR	NR	0.604 (0.603–0.606)	NR
Hamada, 2014	44% (NR)	2.6 (NR)	0.9 (NR)	NR	NR
Hamada, 2014	48% (NR)	2.4 (NR)	0.8 (NR)	NR	NR
Hamada, 2014	56% (NR)	4.4 (NR)	0.6 (NR)	NR	NR
Henry, 1996	95% (NR)	NR	NR	NR	NR
Henry, 1996	99% (NR)	NR	NR	NR	NR
Holcomb, 2005	87.20% (84.33 to 89.60) calculated	2.87 (2.07 to 3.99) calculated	0.60 (0.47 to 0.76) calculated	NR	NR
Holcomb, 2005b	67.21% (64.49 to 69.82) calculated	13.80 (3.28 to 58.09) calculated	0.79 (0.70 to 0.89) calculated	NR	NR
Holcomb, 2005b	53.57% (36.90 to 69.48) calculated	0.89 (0.78 to 1.03) calculated	1.84 (0.93 to 3.64) calculated	NR	NR
Holcomb, 2005b	62.50% (51.51 to 72.34) calculated	0.90 (0.74 to 1.10) calculated	1.28 (0.81 to 2.00) calculated	NR	NR
Holcomb, 2005b	70.45% (65.59 to 74.89) calculated	1.25 (0.83 to 1.87) calculated	0.89 (0.71 to 1.12) calculated	NR	NR
Holcomb, 2005b	71.35% (67.99 to 74.49) calculated	11.47 (4.17 to 31.60) calculated	0.68 (0.58 to 0.80) calculated	NR	NR
Holcomb, 2005b	68.63% (61.51 to 74.97) calculated	1.24 (0.96 to 1.59) calculated	0.78 (0.57 to 1.06) calculated	NR	NR
Holcomb, 2005b	30.62% (26.85 to 34.68) calculated	0.65 (0.41 to 1.01) calculated	1.18 (0.98 to 1.42) calculated	NR	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Horne, 2013	Triage Sieve military: complete data subgroup RR <10 or >29, HR >120, or GCS <13	Priority 1 casualty (life-saving intervention)	58.5% (58.4-62.1)	89.2% (84.7-90.4)	NR
Horne, 2013	Triage Sieve military: overall dataset alternate thresholds: RR <12 or >24, HR <60 or >120, or GCS <13	Priority 1 casualty (life-saving intervention)	72.3% (NR)	77.1% (NR)	NR
Horne, 2013	Triage Sieve military: overall dataset RR <10 or >29, HR >120, or GCS <13	Priority 1 casualty (life-saving intervention)	65.2% (NR)	89.2% (NR)	NR
Horne, 2013	Triage Sieve civilian: overall dataset RR <10 or >29, or HR >120	Priority 1 casualty (life-saving intervention)	41.8% (NR)	91.7% (NR)	NR
Horne, 2013	Triage Sieve civilian: complete data subgroup RR <10 or >29, or HR >120	Priority 1 casualty (life-saving intervention)	53.2% (49.4-56.8)	87.8% (84.7-90.4)	NR
Ichwan, 2015	Geriatric triage criteria: elderly >70 years	OR visit within 48 hours	47% (46 to 49)	42% (41 to 42)	NR
Ichwan, 2015	Geriatric triage criteria: non-elderly ≤70 years	OR visit within 48 hours	73% (72 to 73)	27% (26 to 27)	NR
Ichwan, 2015	Geriatric triage criteria: elderly >70 years	ICU admission	81% (80 to 82)	48% (47 to 48)	NR
Ichwan, 2015	Geriatric triage criteria: non-elderly ≤70 years	ICU admission	91% (90 to 91)	34% (33 to 34)	NR
Ichwan, 2015	Geriatric triage criteria: elderly >70 years	Mortality	90% (89 to 91)	45% (45 to 46)	NR
Ichwan, 2015	Geriatric triage criteria: non-elderly ≤70 years	Mortality	99% (99 to 100)	30% (29 to 30)	NR
Ichwan, 2015	Geriatric triage criteria: elderly >70 years	ISS >15	93% (92 to 93)	49% (48 to 49)	NR
Ichwan, 2015	Geriatric triage criteria: non-elderly ≤70 years	ISS >15	94% (94 to 95)	35% (35 to 35)	NR
Ichwan, 2015	Adult triage criteria: elderly >70 years	OR visit within 48 hours	35% (34 to 37)	57% (56 to 58)	NR
Ichwan, 2015	Adult triage criteria: non-elderly ≤70 years	OR visit within 48 hours	65% (64 to 65)	36% (35 to 36)	NR

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Horne, 2013	NR	NR	NR	NR	NR
Horne, 2013	NR	NR	NR	NR	NR
Horne, 2013	NR	NR	NR	NR	NR
Horne, 2013	NR	NR	NR	NR	NR
Horne, 2013	NR	NR	NR	NR	NR
Ichwan, 2015	NR	NR	NR	0.44 (NR)	NR
Ichwan, 2015	NR	NR	NR	0.5 (NR)	NR
Ichwan, 2015	NR	NR	NR	0.64 (NR)	NR
Ichwan, 2015	NR	NR	NR	0.62 (NR)	NR
Ichwan, 2015	NR	NR	NR	0.68 (NR)	NR
Ichwan, 2015	NR	NR	NR	0.64 (NR)	NR
Ichwan, 2015	NR	NR	NR	0.71 (NR)	NR
Ichwan, 2015	NR	NR	NR	0.65 (NR)	NR
Ichwan, 2015	NR	NR	NR	0.46 (NR)	NR
Ichwan, 2015	NR	NR	NR	0.5 (NR)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Ichwan, 2015	Adult triage criteria: elderly >70 years	ICU admission	56% (55 to 57)	61% (60 to 62)	NR
Ichwan, 2015	Adult triage criteria: non-elderly ≤70 years	ICU admission	82% (82 to 83)	42% (42 to 43)	NR
Ichwan, 2015	Adult triage criteria: elderly >70 years	Mortality	74% (72 to 76)	60% (60 to 61)	NR
Ichwan, 2015	Adult triage criteria: non-elderly ≤70 years	Mortality	98% (97 to 98)	39% (39 to 39)	NR
Ichwan, 2015	Adult triage criteria: elderly >70 years	ISS >15	61% (60 to 62)	61% (61 to 62)	NR
Ichwan, 2015	Adult triage criteria: non-elderly ≤70 years	ISS >15	87% (86 to 87)	44% (44 to 45)	NR
Imhoff, 2014	REMS (Rapid Emergency Medicine Score)	Mortality, in-hospital	NR	NR	NR
Imhoff, 2014	RTS	Mortality, in-hospital	NR	NR	NR
Imhoff, 2014	SI	Mortality, in-hospital	NR	NR	NR
Jo, 2014	ViEWS-L (VitalPAC early warning score-lactate): uses BP, HR, RR, temperature, SpO2, need for supplemental O2, CNS grade not "alert", and lactate level	Mortality, in-hospital	NR	NR	NR
Jones, 2014	SBP <90	Mortality, 30-day	29.25% (24.96 to 33.83) calculated	97.41% (96.93 to 97.83) calculated	49.21% (43.59 to 54.85) calculated
Jones, 2014	RR <10 or >29	Mortality, 30-day	42.45% (37.70 to 47.31) calculated	93.70% (92.99 to 94.36) calculated	36.66% (33.15 to 40.31) calculated
Jones, 2014	T-RTS <12	Mortality, 30-day	84.20% (80.37 to 87.54) calculated	77.22% (76.03 to 78.39) calculated	24.09% (22.91 to 25.31) calculated
Jones, 2014	T-RTS ≤8	Mortality, 30-day	54.01% (49.13 to 58.83) calculated	96.11% (95.54 to 96.63) calculated	54.39% (50.30 to 58.43) calculated
Jones, 2014	Intubation status: derivation data set	Mortality, 30-day	56.60% (51.74 to 61.38) calculated	84.92% (83.89 to 85.90) calculated	24.37% (22.46 to 26.38) calculated

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Ichwan, 2015	NR	NR	NR	0.58 (NR)	NR
Ichwan, 2015	NR	NR	NR	0.62 (NR)	NR
Ichwan, 2015	NR	NR	NR	0.67 (NR)	NR
Ichwan, 2015	NR	NR	NR	0.68 (NR)	NR
Ichwan, 2015	NR	NR	NR	0.61 (NR)	NR
Ichwan, 2015	NR	NR	NR	0.65 (NR)	NR
Imhoff, 2014	NR	NR	NR	0.91 (0.909 to 0.911)	NR
Imhoff, 2014	NR	NR	NR	0.89 (0.889 to 0.891)	NR
Imhoff, 2014	NR	NR	NR	0.55 (0.54 to 0.56)	NR
Jo, 2014	NR	NR	NR	0.838 (0.771 to 0.906)	Net reclassification improvement: ViEWS-L vs. TRISS, 10% cutoff for risk of death: 22.4% (95% CI: 3.9 to 41), p=0.04
Jones, 2014	94.13% (93.78 to 94.46) calculated	11.28 (9.00 to 14.15) calculated	0.73 (0.68 to 0.77) calculated	NR	NR
Jones, 2014	94.99% (94.59 to 95.37) calculated	6.74 (5.78 to 7.87) calculated	0.61 (0.57 to 0.67) calculated	NR	NR
Jones, 2014	98.27% (97.86 to 98.61) calculated	3.70 (3.46 to 3.95) calculated	0.20 (0.16 to 0.26) calculated	NR	NR
Jones, 2014	96.05% (95.64 to 96.43) calculated	13.89 (11.79 to 16.37) calculated	0.48 (0.43 to 0.53) calculated	NR	NR
Jones, 2014	95.80% (95.33 to 96.22) calculated	3.75 (3.37 to 4.17) calculated	0.51 (0.46 to 0.57) calculated	NR	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Joosse, 2014	EMTRAS (age, GCS, base excess, prothrombin time): center A	Mortality, in-hospital	NR	NR	NR
Joosse, 2014	EMTRAS (age, GCS, base excess, prothrombin time): center B	Mortality, in-hospital	NR	NR	NR
Joosse, 2014	EMTRAS (age, GCS, base excess, prothrombin time): patients with ISS ≥16, center A	Mortality, in-hospital	NR	NR	NR
Joosse, 2014	EMTRAS (age, GCS, base excess, prothrombin time): patients with ISS ≥16, center B	Mortality, in-hospital	NR	NR	NR
Joosse, 2014	EMTRAS (age, GCS, base excess, prothrombin time): patients with ISS <16, center A	Mortality, in-hospital	NR	NR	NR
Joosse, 2014	EMTRAS (age, GCS, base excess, prothrombin time): patients with ISS <16, center B	Mortality, in-hospital	NR	NR	NR
Khasawneh, 2014	StO2 <65%	Massive transfusion	25% (9-49)	94% (90-96)	21% (8-44)
Kim, 2016	Age SI	Mortality: in-hospital	NR	NR	NR
Kim, 2016	Age SI	Mortality: ED	NR	NR	NR
Kim, 2016	Age SI ≥49	Mortality: in-hospital	73.0% (NR)	74.9% (NR)	NR
Kim, 2016	Age SI ≥50	Mortality: in-hospital	69.42% (65.31 to 73.31) calculated	78.66% (78.28 to 79.03) calculated	3.68% (3.48 to 3.90) calculated
Kim, 2016	Age SI ≥50	Mortality: ED	NR	NR	NR
Kim, 2016	Age SI ≥55	Mortality: in-hospital	62.1% (NR)	87.1% (NR)	NR
Kim, 2016	Age SI: age ≥85	Mortality: ED	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Joosse, 2014	NR	NR	NR	0.94 (0.93 to 0.96)	NR
Joosse, 2014	NR	NR	NR	0.92 (0.90 to 0.94)	NR
Joosse, 2014	NR	NR	NR	0.90 (NR)	NR
Joosse, 2014	NR	NR	NR	0.89 (NR)	NR
Joosse, 2014	NR	NR	NR	0.94 (NR)	NR
Joosse, 2014	NR	NR	NR	0.82 (NR)	NR
Khasawneh, 2014	95% (91-97)	NR	NR	NR	NR
Kim, 2016	NR	NR	NR	0.808 (0.785 to 0.831), continuous model	NR
Kim, 2016	NR	NR	NR	0.890 (0.860 to 0.920), continuous model	NR
Kim, 2016	NR	NR	NR	NR	NR
Kim, 2016	99.55% (99.48 to 99.60) calculated	3.25 (3.07 to 3.45) calculated	0.39 (0.34 to 0.44) calculated	0.740 (0.721 to 0.760), binary model	NR
Kim, 2016	NR	NR	NR	0.807 (0.780 to 0.834), binary model	NR
Kim, 2016	NR	NR	NR	NR	NR
Kim, 2016	NR	NR	NR	0.744 (0.707 to 0.782), binary model 0.909 (0.857 to 0.962), continuous model	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Kim, 2016	Age SI: ages 65-74	Mortality: ED	NR	NR	NR
Kim, 2016	Age SI: ages 75-84	Mortality: ED	NR	NR	NR
Kim, 2016	Modified SI (HR/mean BP)	Mortality: in-hospital	NR	NR	NR
Kim, 2016	Modified SI (HR/mean BP)	Mortality: ED	NR	NR	NR
Kim, 2016	Modified SI ≥0.9 (HR/mean BP)	Mortality: in-hospital	75.8% (NR)	65.4% (NR)	NR
Kim, 2016	Modified SI ≥1.1 (HR/mean BP)	Mortality: in-hospital	55.9% (NR)	90.9% (NR)	NR
Kim, 2016	Modified SI ≥1.3 (HR/mean BP)	Mortality: in-hospital	38.65% (34.49 to 42.93) calculated	97.77% (97.63 to 97.90) calculated	16.91% (15.25 to 18.71) calculated
Kim, 2016	Modified SI ≥1.3 (HR/mean BP)	Mortality: ED	NR	NR	NR
Kim, 2016	SI	Mortality: in-hospital	NR	NR	NR
Kim, 2016	SI	Mortality: ED	NR	NR	NR
Kim, 2016	SI ≥0.7	Mortality: in-hospital	70.0% (NR)	73.6% (NR)	NR
Kim, 2016	SI ≥0.8	Mortality: in-hospital	58.5% (NR)	89.4% (NR)	NR
Kim, 2016	SI ≥1	Mortality: in-hospital	36.59% (32.49 to 40.83) calculated	98.23% (98.11 to 98.35) calculated	19.58% (17.60 to 21.73) calculated
Kim, 2016	SI ≥1	Mortality: ED	NR	NR	NR
King, 1996	SI ≥0.83	Severe injury: mortality <24 hour, ISS ≥16, ICU admission or blood transfusion ≥2 units	37% (33 to 42)	83% (80 to 87)	73% (67 to 77)
King, 1996	SI ≥1.10	Mortality: 24-hour	57% (20 to 94)	94% (92 to 95)	5% (0 to 10)
King, 1996	SI ≥0.71	ISS ≥16	65% (59 to 71)	57% (54 to 61)	32% (28 to 36)
King, 1996	SI ≥0.77	ICU admission	44% (40 to 48)	73% (69 to 76)	57% (52 to 62)
King, 1996	SI ≥0.85	Blood transfusion ≥2 units	54% (46 to 63)	80% (77 to 83)	29% (23 to 35)
King, 1996	HR ≥112	Mortality: 24-hour	43% (6 to 80)	82% (80 to 84)	2% (0 to 3)

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Kim, 2016	NR	NR	NR	0.816 (0.773 to 0.860), binary model 0.876 (0.824 to 0.927), continuous model	NR
Kim, 2016	NR	NR	NR	0.779 (0.738 to 0.821), binary model 0.882 (0.828 to 0.926), continuous model	NR
Kim, 2016	NR	NR	NR	0.788 (0.765 to 0.812), continuous model	NR
Kim, 2016	NR	NR	NR	0.884 (0.853 to 0.915), continuous model	NR
Kim, 2016	NR	NR	NR	NR	NR
Kim, 2016	NR	NR	NR	NR	NR
Kim, 2016	99.27% (99.22 to 99.32) calculated	17.32 (15.31 to 19.59) calculated	0.63 (0.59 to 0.67) calculated	0.682 (0.661 to 0.703), binary model	NR
Kim, 2016	NR	NR	NR	0.779 (0.744 to 0.814), binary model	NR
Kim, 2016	NR	NR	NR	0.786 (0.762 to 0.810), continuous model	NR
Kim, 2016	NR	NR	NR	0.880 (0.848 to 0.911), continuous model	NR
Kim, 2016	NR	NR	NR	NR	NR
Kim, 2016	NR	NR	NR	NR	NR
Kim, 2016	99.25% (99.20 to 99.29) calculated	20.71 (18.17 to 23.61) calculated	0.65 (0.61 to 0.69) calculated	0.674 (0.654 to 0.695), binary model	NR
Kim, 2016	NR	NR	NR	0.771 (0.735 to 0.806), binary model	NR
King, 1996	53% (50 to 57)	NR	NR	0.61 (SD 0.02)	NR
King, 1996	99% (99 to 100)	NR	NR	0.75 (SD 0.10)	Accuracy: 93% (92 to 95)
King, 1996	84% (81 to 87)	NR	NR	0.62 (SD 0.02)	Accuracy: 60% (56 to 62)
King, 1996	61% (57 to 64)	NR	NR	0.58 (SD 0.02)	Accuracy: 60% (57 to 62)
King, 1996	92% (90 to 94)	NR	NR	0.70 (SD 0.03)	Accuracy: 77% (74 to 79)
King, 1996	99% (99 to 100)	NR	NR	NR	Accuracy: 82% (80 to 84)

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
King, 1996	HR ≥102	ISS ≥16	41% (35 to 47)	71% (68 to 75)	30% (26 to 35)
King, 1996	HR ≥109	ICU admission	27% (23 to 31)	83% (80 to 86)	58% (52 to 64)
King, 1996	HR ≥113	Blood transfusion ≥2 units	36% (28 to 44)	87% (85 to 89)	29% (22 to 36)
King, 1996	SBP ≤104	Mortality: 24-hour	100% (100 to 100)	91% (89 to 92)	6% (2 to 11)
King, 1996	SBP ≤127	ISS ≥16	56% (50 to 62)	64% (61 to 68)	33% (28 to 37)
King, 1996	SBP ≤119	ICU admission	33% (29 to 37)	80% (76 to 83)	57% (52 to 63)
King, 1996	SBP ≤120	Blood transfusion ≥2 units	51% (42 to 59)	77% (74 to 80)	25% (20 to 30)
King, 2009	Heart rate variability: SDNN	Life-saving intervention in OR	NR	NR	NR
King, 2009	Heart rate variability: SDNN <24 msec	Life-saving intervention in OR	80% (NR)	75% (NR)	33% (NR)
King, 2009	Heart rate variability: SDNN	Serious injury	NR	NR	NR
King, 2009	Heart rate variability: SDNN <39 msec	Serious injury	80% (NR)	NR	63% (NR)
King, 2009	Heart rate variability: SDNN <55 msec	Serious injury	94% (NR)	NR	59% (NR)
Kondo, 2011	GAP score (Glasgow coma scale, Age, Systolic blood pressure)	Mortality, in ED or OR	NR	NR	NR
Kondo, 2011	GAP score (Glasgow coma scale, Age, Systolic blood pressure); severe trauma subgroup (ISS >16)	Mortality, in ED or OR	NR	NR	NR
Kondo, 2011	MGAP score (Mechanism, Glasgow coma scale, Age, Systolic blood pressure)	Mortality, in ED or OR	NR	NR	NR
Kondo, 2011	RTS	Mortality, in ED or OR	NR	NR	NR
Kondo, 2011	T-RTS	Mortality, in ED or OR	NR	NR	NR
Kondo, 2011	GAP score	Mortality, in-hospital	NR	NR	NR
Kondo, 2011	GAP score); severe trauma subgroup (ISS >16)	Mortality, in-hospital	NR	NR	NR
Kondo, 2011	MGAP score	Mortality, in-hospital	NR	NR	NR
Kondo, 2011	RTS	Mortality, in-hospital	NR	NR	NR
Kondo, 2011	T-RTS	Mortality, in-hospital	NR	NR	NR
Kuo, 2016	Reverse SI <1: overall	Mortality, in-hospital	11.32% (5.99 to 18.94) calculated	96.80% (96.53 to 97.05) calculated	2.05% (1.21 to 3.47) calculated
Kuo, 2016	Reverse SI <1: overall	ISS ≥16	4.66% (3.70 to 5.77) calculated	96.89% (96.62 to 97.16) calculated	13.50% (11.02 to 16.45) calculated

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
King, 1996	80% (77 to 83)	NR	NR	NR	Accuracy: 64% (61 to 67)
King, 1996	58% (55 to 61)	NR	NR	NR	Accuracy: 58% (55 to 61)
King, 1996	90% (88 to 92)	NR	NR	NR	Accuracy: 80% (78 to 83)
King, 1996	100% (100 to 100)	NR	NR	NR	Accuracy: 91% (89 to 92)
King, 1996	83% (80 to 86)	NR	NR	NR	Accuracy: 62% (60 to 75)
King, 1996	59% (55 to 62)	NR	NR	NR	Accuracy: 58% (55 to 61)
King, 1996	91% (89 to 93)	NR	NR	NR	Accuracy: 73% (71 to 76)
King, 2009	NR	NR	NR	0.74 (NR)	NR
King, 2009	96% (NR)	NR	NR	NR	Overall accuracy: 76%
King, 2009	NR	NR	NR	0.80 (NR)	NR
King, 2009	NR	NR	NR	NR	Over-triage rate: 37%
King, 2009	NR	NR	NR	NR	Over-triage rate: 41%
Kondo, 2011	NR	NR	NR	0.965 (NR)	NR
Kondo, 2011	NR	NR	NR	0.943 (NR)	NR
Kondo, 2011	NR	NR	NR	0.954 (NR)	NR
Kondo, 2011	NR	NR	NR	0.966 (NR)	NR
Kondo, 2011	NR	NR	NR	0.968 (NR)	NR
Kondo, 2011	NR	NR	NR	0.933 (NR)	NR
Kondo, 2011	NR	NR	NR	0.905 (NR)	NR
Kondo, 2011	NR	NR	NR	0.924 (NR)	NR
Kondo, 2011	NR	NR	NR	0.919 (NR)	NR
Kondo, 2011	NR	NR	NR	0.917 (NR)	NR
Kuo, 2016	99.46% (99.42 to 99.50) calculated	3.53 (2.06 to 6.06) calculated	0.92 (0.86 to 0.98) calculated	NR	NR
Kuo, 2016	90.71% (90.62 to 90.80) calculated	1.50 (1.19 to 1.89) calculated	0.98 (0.97 to 0.99) calculated	NR	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Kuo, 2016	Reverse SI <1: adults 18-65	Mortality, in-hospital	7.89% (1.66 to 21.38) calculated	98.66% (98.43 to 98.86) calculated	1.90% (0.64 to 5.48) calculated
Kuo, 2016	Reverse SI <1: adults 18-65	ISS ≥16	4.11% (2.99 to 5.50) calculated	98.91% (98.69 to 99.10) calculated	27.22% (20.24 to 34.54) calculated
Kuo, 2016	Reverse SI <1: adults 18-65	Blood transfusion in ED	9.19% (6.09 to 13.17) calculated	96.84% (96.58 to 97.10) calculated	4.44% (3.10 to 6.34) calculated
Lai, 2016	Reverse SI <1, EMS	Blood transfusion	14.39% (8.89 to 21.56) calculated	96.48% (95.83 to 97.06) calculated	13.10% (8.77 to 19.13) calculated
Lai, 2016	Reverse SI <1, ED	Blood transfusion	27.27% (19.89 to 35.71) calculated	97.32% (96.74 to 97.82) calculated	27.27% (21.04 to 34.54) calculated
Lai, 2016	Reverse SI <1, EMS	ISS ≥16	5.94% (4.38 to 7.85) calculated	96.63% (95.92 to 97.26) calculated	31.72% (24.84 to 39.51) calculated
Lai, 2016	Reverse SI <1, EMS	Mortality	6.52% (1.37 to 17.90) calculated	96.13% (95.45 to 96.73) calculated	2.07% (0.69 to 6.00) calculated
Lai, 2016	Reverse SI <1, ED	ISS ≥16	7.88% (6.08 to 10.01) calculated	97.59% (96.96 to 98.11) calculated	46.21% (38.11 to 54.51) calculated
Lai, 2016	Reverse SI <1, ED	Mortality	28.26% (15.99 to 43.46) calculated	96.76% (96.13 to 97.31) calculated	9.85% (6.25 to 15.17) calculated
Lalezarzadeh, 2009	SBP ≤80, EMS	ICU admission	5.33% (4.33 to 6.49) calculated	96.48% (95.95 to 96.97) calculated	33.94% (28.72 to 39.57) calculated
Lalezarzadeh, 2009	SBP ≤100, EMS	ICU admission	16.74% (15.03 to 18.57) calculated	86.74% (85.78 to 87.65) calculated	29.95% (27.39 to 32.64) calculated
Lalezarzadeh, 2009	SBP ≤90, ED	ICU admission	3.92% (3.06 to 4.93) calculated	97.96% (97.54 to 98.33) calculated	39.43% (32.57 to 46.73) calculated
Lalezarzadeh, 2009	SBP ≤80, EMS	Mortality	24.04% (18.40 to 30.43) calculated	96.64% (96.18 to 97.06) calculated	18.05% (14.35 to 22.45) calculated

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Kuo, 2016	99.69% (99.66 to 99.72) calculated	5.88 (1.96 to 17.62) calculated	0.93 (0.85 to 1.02) Calculated	NR	NR
Kuo, 2016	91.23% (91.13 to 91.33) calculated	3.77 (2.67 to 5.32) calculated	0.97 (0.96 to 0.98) Calculated	NR	NR
Kuo, 2016	98.52% (98.47 to 98.58) calculated	2.91 (2.00 to 4.24) calculated	0.94 (0.90 to 0.97) Calculated	NR	NR
Lai, 2016	96.83% (96.61 to 97.04) calculated	4.09 (2.61 to 6.42) calculated	0.89 (0.83 to 0.95) Calculated	NR	NR
Lai, 2016	97.32% (97.03 to 97.58) calculated	10.18 (7.23 to 14.32) calculated	0.75 (0.67 to 0.83) Calculated	NR	NR
Lai, 2016	79.61% (79.30 to 79.91) calculated	1.77 (1.26 to 2.48) calculated	0.97 (0.96 to 0.99) Calculated	NR	NR
Lai, 2016	98.80% (98.70 to 98.88) calculated	1.69 (0.56 to 5.09) calculated	0.97 (0.90 to 1.05) Calculated	NR	NR
Lai, 2016	80.10% (79.76 to 80.44) calculated	3.26 (2.34 to 4.55) calculated	0.94 (0.92 to 0.96) Calculated	NR	NR
Lai, 2016	99.08% (98.90 to 99.23) calculated	8.71 (5.32 to 14.27) calculated	0.74 (0.62 to 0.89) Calculated	NR	NR
Lalezarzadeh, 2009	75.06% (74.83 to 75.28) calculated	1.52 (1.19 to 1.93) calculated	0.98 (0.97 to 0.99) Calculated	NR	NR
Lalezarzadeh, 2009	75.46% (75.03 to 75.90) calculated	1.26 (1.11 to 1.43) calculated	0.96 (0.94 to 0.98) Calculated	NR	NR
Lalezarzadeh, 2009	75.06% (74.87 to 75.25) calculated	1.92 (1.43 to 2.59) calculated	0.98 (0.97 to 0.99) Calculated	NR	NR
Lalezarzadeh, 2009	97.64% (97.45 to 97.81) calculated	7.15 (5.44 to 9.40) calculated	0.79 (0.73 to 0.85) Calculated	NR	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Lalezarzadeh, 2009	SBP ≤100, EMS	Mortality	38.46% (31.82 to 45.44) calculated	86.6% (85.77 to 87.41) calculated	8.12% (6.86 to 9.59) calculated
Lalezarzadeh, 2009	SBP ≤90, ED	Mortality	23.56% (17.97 to 29.92) calculated	98.13% (97.78 to 98.44) Calculated	28% (22.37 to 34.42) calculated
Lalezarzadeh, 2009	SBP ≤80, EMS	Operative intervention	9.6% (7.96 to 11.45) calculated	97.14% (96.68 to 97.56) Calculated	40.07% (34.65 to 45.75) calculated
Lalezarzadeh, 2009	SBP ≤100, EMS	Operative intervention	23.1% (20.70 to 25.64) calculated	87.64% (86.76 to 88.47) Calculated	27.11% (24.70 to 29.66) calculated
Lalezarzadeh, 2009	SBP ≤90, ED	Operative intervention	6.23% (4.90 to 7.78) calculated	98.23% (97.85 to 98.55) Calculated	41.14% (34.24 to 48.41) calculated
Lee, 2014	Abnormal RR (age-specific)	Major trauma	53.8% (NR)	60.6% (NR)	35% (NR)
Lee, 2014	Combined criteria (PTS ≤8, GCS ≤10, Abnormal RR)	Major trauma	69.2% (NR)	53% (NR)	36.7% (NR)
Lee, 2014	GCS ≤10	Major trauma	26.9% (NR)	100% (NR)	100% (NR)
Lee, 2014	PTS ≤8	Major trauma	61.5% (NR)	77.3% (NR)	51.6% (NR)
Lee, 2014	Abnormal RR (age-specific)	Receipt of resuscitation in the ED	76.2% (NR)	66.2% (NR)	40% (NR)
Lee, 2014	Combined criteria (PTS ≤8, GCS ≤10, Abnormal RR)	Receipt of resuscitation in the ED	90.5% (NR)	57.7% (NR)	38.8% (NR)
Lee, 2014	GCS ≤10	Receipt of resuscitation in the ED	28.6% (NR)	98.6% (NR)	85.7% (NR)
Lee, 2014	PTS ≤8	Receipt of resuscitation in the ED	90.5% (NR)	83.1% (NR)	61.3% (NR)
Lehmann, 2007	SBP <90, ED	Emergent intervention	20.74% (15.19 to 27.25) calculated	95.96% (94.66 to 97.02) Calculated	45.35% (35.84 to 55.21) calculated
Lehmann, 2007	EMS HR <60 or >110 bpm	Emergent intervention	23.94% (18.03 to 30.69) calculated	82.98% (80.69 to 85.09) Calculated	18.52% (14.60 to 23.20) calculated
Lehmann, 2007	SBP <100, EMS	Emergent intervention	10.11% (6.20 to 15.33) calculated	98.97% (98.20 to 99.47) Calculated	61.29% (43.87 to 76.24) calculated
Lerner, 2017	Physiologic criteria of Field Triage Guidelines (GCS ≤13, SBP <90, and RR <10 or >29)	Trauma center need	49.10% (43.10 to 55.13) calculated	82.41% (81.36 to 83.42) Calculated	12.78% (11.37 to 14.34) calculated

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Lalezarzadeh, 2009	97.86% (97.62 to 98.07) calculated	2.87 (2.39 to 3.45) calculated	0.71 (0.64 to 0.79) calculated	NR	NR
Lalezarzadeh, 2009	97.66% (97.48 to 97.82) calculated	12.63 (9.36 to 17.05) calculated	0.78 (0.72 to 0.84) calculated	NR	NR
Lalezarzadeh, 2009	84.37% (84.12 to 84.63) calculated	3.36 (2.66 to 4.24) calculated	0.93 (0.91 to 0.95) calculated	NR	NR
Lalezarzadeh, 2009	85.13% (84.71 to 85.54) calculated	1.87 (1.65 to 2.12) calculated	0.88 (0.85 to 0.91) calculated	NR	NR
Lalezarzadeh, 2009	84.03% (83.83 to 84.24) calculated	3.51 (2.62 to 4.71) Calculated	0.95 (0.94 to 0.97) calculated	NR	NR
Lee, 2014	76.9% (NR)	NR	NR	NR	NR
Lee, 2014	81.4% (NR)	NR	NR	NR	NR
Lee, 2014	77.6% (NR)	NR	NR	NR	NR
Lee, 2014	83.6% (NR)	NR	NR	NR	NR
Lee, 2014	90.4% (NR)	NR	NR	NR	NR
Lee, 2014	95.3% (NR)	NR	NR	NR	NR
Lee, 2014	82.4% (NR)	NR	NR	NR	NR
Lee, 2014	96.7% (NR)	NR	NR	NR	NR
Lehmann, 2007	88.22% (87.43 to 88.97) calculated	5.13 (3.46 to 7.62) Calculated	0.83 (0.77 to 0.89) calculated	NR	NR
Lehmann, 2007	87.09% (86.12 to 88.01) calculated	1.41 (1.06 to 1.87) Calculated	0.92 (0.84 to 1.00) calculated	NR	NR
Lehmann, 2007	87.20% (86.65 to 87.73) calculated	9.79 (4.83 to 19.85) Calculated	0.91 (0.87 to 0.95) calculated	NR	NR
Lerner, 2017	96.86% (96.49 to 97.19) calculated	2.8 (2.4 to 3.2) reported 2.79 (2.44 to 3.19) Calculated	0.62 (0.55 to 0.69) calculated	NR	51% under-triage rate 18% over-triage rate

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Lerner, 2017	RR <10 or >29	Trauma center need	NR	NR	NR
Lerner, 2017	SBP <90	Trauma center need	NR	NR	NR
Lin, 2011	SBP ≤90, EMS	Emergency surgery	53.85% (37.18 to 69.91) calculated	91.64% (89.03 to 93.79) calculated	30.88% (23.06 to 39.98) calculated
Lin, 2011	SBP ≤90, EMS	ISS ≥25	29.37% (21.59 to 38.14) calculated	93.47% (90.86 to 95.52) calculated	54.41% (43.59 to 64.84) calculated
Lin, 2011	SBP ≤90, EMS	Major trauma	22.63% (17.53 to 28.42) calculated	96.37% (93.87 to 98.05) calculated	80.88% (71.27 to 88.33) calculated
Lin, 2011	SBP ≤90, ED	Major trauma	18.11% (13.48 to 23.54) calculated	95.81% (93.18 to 97.64) calculated	74.58% (62.56 to 83.74) calculated
Lipsky, 2006	SBP: hypotensive in field; normotensive in ED	Emergent therapeutic operation	19.26% (12.98 to 26.93) calculated	94.96% (93.31 to 96.30) calculated	36.62% (26.97 to 47.48) calculated
Lipsky, 2006	SBP: hypotensive in field; normotensive in ED	Mortality	14.29% (4.03 to 32.67) calculated	93.29% (91.56 to 94.76) calculated	5.63% (2.29 to 13.22) calculated
Lipsky, 2006	SBP: hypotensive in field; normotensive in ED	Emergent surgery within 6 hours	16.07% (10.87 to 22.51) calculated	94.88% (93.19 to 96.26) calculated	38.03% (28.13 to 49.03) calculated
Liu, 2014a	RR ≥20	Life-saving intervention in field or ED	37.88% (26.22 to 50.66) calculated	67.60% (60.21 to 74.39) calculated	30.12% (22.86 to 38.53) calculated
Liu, 2014a	HR > 105	Life-saving intervention in field or ED	41.67% (32.25 to 51.55) calculated	84.07% (77.92 to 89.06) calculated	60.81% (50.95 to 69.86) calculated
Liu, 2014b	HR ≥110	Life-saving intervention in field or ED	41.94% (24.55 to 60.92) calculated	88.57% (78.72 to 94.93) calculated	61.90% (42.87 to 77.87) calculated
Liu, 2014b	RR ≥20	Life-saving intervention in field or ED	26.67% (7.79 to 55.10) calculated	74.65% (62.92 to 84.23) calculated	18.18% (8.07 to 36.01) calculated

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Lerner, 2017	NR	2.2 (1.8 to 2.6)	NR	NR	69% under-triage rate 14% over-triage rate
Lerner, 2017	NR	3.5 (2.5 to 5.1)	NR	NR	87% under-triage rate 4% over-triage rate
Lin, 2011	96.62% (95.32 to 97.57) calculated	6.44 (4.32 to 9.60) calculated	0.50 (0.36 to 0.71) calculated	NR	NR
Lin, 2011	83.30% (81.64 to 84.84) calculated	4.50 (2.91 to 6.95) calculated	0.76 (0.67 to 0.85) calculated	NR	NR
Lin, 2011	64.73% (63.09 to 66.33) calculated	6.23 (3.48 to 11.16) calculated	0.80 (0.75 to 0.86) calculated	NR	NR
Lin, 2011	63.28% (61.81 to 64.73) calculated	4.32 (2.46 to 7.59) calculated	0.85 (0.80 to 0.91) calculated	NR	NR
Lipsky, 2006	88.61% (97.74 to 89.43) calculated	3.82 (2.44 to 5.98) calculated	0.85 (0.78 to 0.92) calculated	NR	NR
Lipsky, 2006	97.49% (97.09 to 97.84)	2.13 (0.84 to 5.43) calculated	0.92 (0.79 to 1.07) calculated	NR	NR
Lipsky, 2006	85.27% (84.39 to 86.10) calculated	3.14 (2.00 to 4.93) calculated	0.88 (0.83 to 0.95) calculated	NR	NR
Liu, 2014a	74.69% (70.44 to 78.52) calculated	1.17 (0.80 to 1.70) calculated	0.92 (0.74 to 1.14) calculated	NR	NR
Liu, 2014a	70.83% (67.17 to 74.25) calculated	2.61 (1.75 to 3.91) calculated	0.69 (0.58 to 0.82) calculated	NR	NR
Liu, 2014b	77.50% (71.63 to 82.46) calculated	3.67 (1.69 to 7.95) calculated	0.66 (0.48 to 0.89) calculated	NR	NR
Liu, 2014b	82.81% (77.53 to 87.06) calculated	1.05 (0.42 to 2.66) calculated	0.98 (0.70 to 1.37) calculated	NR	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Liu, 2014c	Machine learning model using vital signs: Multilayer perceptron with 24 features - within 5 minutes; true positive ≥30% probability	Life-saving intervention	89.8% (NR) reported 89.83% (79.17 to 96.18) calculated	98.31% (94.01 to 99.79) calculated	96.4% (NR) reported 96.36% (86.99 to 99.06) calculated
Liu, 2014c	Machine learning model using vital signs: Multilayer perceptron with 24 features - within 60 seconds; true positive ≥30% probability	Life-saving intervention	76.27% (63.41 to 86.38) calculated	95.76% (90.39 to 98.61) calculated	90.00% (79.05 to 95.55) calculated
Liu, 2014c	Machine learning model using vital signs: Multilayer perceptron with 24 features - within 3 minutes; true positive ≥30% probability	Life-saving intervention	88.14% (77.07 to 95.09) calculated	97.46% (92.75 to 99.47) calculated	94.55% (84.96 to 98.15) calculated
Liu, 2014c	Machine learning model using vital signs: Multilayer perceptron with 24 features - at recorded time; true positive ≥30% probability	Life-saving intervention	69.49% (56.13 to 80.81) calculated	91.53% (84.97 to 95.86) calculated	80.39% (68.88 to 88.37) calculated
Liu, 2014c	SBP <80: Training database	Life-saving intervention	58.18% (44.11 to 71.35) calculated	66.67% (44.68 to 84.37) calculated	80.00% (68.52 to 88.03) calculated
Liu, 2014c	RR* ≤10: Training database *Using patients with known values only (n=59/79)	Life-saving intervention	22.86% (10.42 to 40.14) calculated	100.00% (76.84 to 100.00) calculated	100.00% calculated
Liu, 2014c	HR* >105: Both databases *Using patients with known values only (n=322/384)	Life-saving intervention	47.33% (38.55 to 56.23) calculated	83.77% (77.76 to 88.70) calculated	66.67% (58.02 to 74.32) calculated
Mackenzie, 2015 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	Pulse oximeter (PPG) algorithm to predict blood transfusion	Blood transfusion within 6 hours	100% (NR)	70% (NR)	NR

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Liu, 2014c	95.08% (90.05 to 97.64) calculated	53.00 (13.38 to 210.00) calculated	0.10 (0.05 to 0.22) calculated	NR	NR
Liu, 2014c	88.98% (83.61 to 92.74) calculated	18.00 (7.54 to 42.94) calculated	0.25 (0.16 to 0.39) calculated	NR	NR
Liu, 2014c	94.26% (89.12 to 97.05) calculated	34.67 (11.30 to 106.36) calculated	0.12 (0.06 to 0.24) calculated	NR	NR
Liu, 2014c	85.71% (80.26 to 89.85) calculated	8.20 (4.43 to 15.19) calculated	0.33 (0.23 to 0.49) calculated	NR	NR
Liu, 2014c	41.03% (31.35 to 51.45) calculated	1.75 (0.95 to 3.21) calculated	0.63 (0.41 to 0.96) calculated	NR	NR
Liu, 2014c	34.15% (30.21 to 38.31) calculated	Undefined (specificity = 100%)	0.77 (0.64 to 0.92) calculated	NR	NR
Liu, 2014c	69.87% (66.09 to 73.40) calculated	2.92 (2.02 to 4.22) calculated	0.63 (0.53 to 0.75) calculated	NR	NR
Mackenzie, 2015 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	NR	NR	NR	0.92 (NR)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Mackenzie, 2015 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	Pulse oximeter (PPG) algorithm to predict surgical intervention	Surgical intervention within 6 hours	NR	NR	NR
Mackenzie, 2015 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	Pulse oximeter (PPG) algorithm to predict endotracheal intubation	Endotracheal intubation within 1 hour	NR	NR	NR
McManus, 2005	Radial pulse character, weak	ICU admission	14.04% (8.24 to 21.79) Calculated	97.00% (93.58 to 98.89) calculated	72.73% (51.78 to 86.88) calculated
McManus, 2005	Radial pulse character, weak	Intubation	26.67% (16.07 to 39.66) Calculated	95.37% (92.22 to 97.51) calculated	55.17% (38.48 to 70.77) calculated
McManus, 2005	Radial pulse character: weak	Mortality	50.00% (24.65 to 75.35) Calculated	93.83% (90.63 to 96.19) calculated	28.57% (17.30 to 43.34) calculated
Miller, 2017	modified REMS (mREMS)	Mortality: in-hospital	NR	NR	NR
Miller, 2017	MGAP	Mortality: in-hospital	NR	NR	NR
Miller, 2017	RTS	Mortality: in-hospital	NR	NR	NR
Miller, 2017	SI	Mortality: in-hospital	NR	NR	NR
Mizushima, 2011	BD < -10	Mortality	32.67% (25.24 to 40.79(Calculated	96.80% (95.81 to 97.61) calculated	49.00% (40.26 to 57.80) calculated

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Mackenzie, 2015 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	NR	NR	NR	0.74 (NR)	NR
Mackenzie, 2015 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	NR	NR	NR	0.92 (NR)	NR
McManus, 2005	66.44% (64.68 to 68.16) calculated	4.68 (1.88 to 11.62) calculated	0.89 (0.82 to 0.96) calculated	NR	NR
McManus, 2005	85.90% (83.92 to 87.67) calculated	5.76 (2.93 to 11.34) calculated	0.77 (0.66 to 0.90) calculated	NR	NR
McManus, 2005	97.44% (95.88 to 98.41) calculated	8.10 (4.24 to 15.49) calculated	0.53 (0.33 to 0.87) calculated	NR	NR
Miller, 2017	NR	NR	NR	0.967 (0.963 to 0.971)	NR
Miller, 2017	NR	NR	NR	0.964 (0.959 to 0.968)	NR
Miller, 2017	NR	NR	NR	0.959 (0.955 to 0.964)	NR
Miller, 2017	NR	NR	NR	0.670 (0.650 to 0.690)	NR
Mizushima, 2011	93.85% (93.17 to 94.46) calculated	10.20 (7.15 to 14.54) calculated	0.70 (0.62 to 0.78) calculated	NR	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Mizushima, 2011	BD < -5	Mortality	56.00% (47.67 to 64.09) Calculated	87.75% (86.04 to 89.32) calculated	30.11% (26.20 to 34.33) calculated
Mizushima, 2011	Lactate >2.5	Mortality	82.00% (74.90 to 87.79) Calculated	56.78% (54.31 to 59.23) calculated	15.17% (14.00 to 16.41) calculated
Mizushima, 2011	Lactate >5	Mortality	52.67% (44.36 to 60.87) Calculated	88.38% (86.70 to 89.91) calculated	29.92% (25.84 to 34.36) calculated
Montoya, 2015	SI > 0.9	Mortality: 24-hour	79.52% (69.24 to 87.59) Calculated	92.28% (89.81 to 94.31) calculated	59.46% (52.04 to 66.47) calculated
Moront, 1996	GCS <12 and HR>160	Need for immediate transport to trauma center	98.9% (CI NR)	90.1% (CI NR)	NR
Mutschler, 2013	SI > 1.0	Mortality: in-hospital	32.90% (31.16 to 34.67) Calculated	87.67% (87.19 to 88.13) calculated	28.31% (27.01 to 29.65) calculated
Mutschler, 2013	SI	Blood transfusion	NR	NR	NR
Mutschler, 2013	BD	Blood transfusion	NR	NR	NR
Newgard, 2009	RR <10 or >29	Death or LOS >2 days	44.13% (36.73 to 51.73) Calculated	53.09% (49.51 to 56.65) calculated	17.83% (15.33 to 20.64) calculated
Newgard, 2009	SBP ≤90	Death or LOS >2 days	24.02% (17.96 to 30.96) Calculated	53.99% (50.41 to 57.55) calculated	10.75% (8.41 to 13.65) calculated
Newgard, 2009	Out-of-hospital Pediatric Clinical Decision Tree, physiologic measures only (ventilatory assistance, GCS <11, SaO2 <95%, SBP >96): validation group	Death or LOS >2 days	76.5% (66.4 to 86.6)	71.7% (66.7 to 76.6)	36.9% (28.9 to 44.8)
Newgard, 2014 *Newgard, 2016 study population is included in Newgard, 2014	SBP <90, EMS	Serious injury	4.08% (3.31 to 4.97) Calculated	98.52% (98.40 to 98.63) calculated	13.10% (10.88 to 15.71) calculated

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Mizushima, 2011	95.49% (94.64 to 96.21) calculated	4.57 (3.77 to 5.55) calculated	0.50 (0.42 to 0.60) calculated	NR	NR
Mizushima, 2011	97.10% (95.96 to 97.93) calculated	1.90 (1.73 to 2.08) calculated	0.32 (0.22 to 0.45) calculated	NR	NR
Mizushima, 2011	95.20% (94.36 to 95.92) calculated	4.53 (3.70 to 5.55) calculated	0.54 (0.45 to 0.63) calculated	NR	NR
Montoya, 2015	96.94% (95.39 to 97.98) calculated	10.30 (7.62 to 13.92) calculated	0.22 (0.15 to 0.34) calculated	NR	NR
Moront, 1996	NR	NR	NR	NR	NR
Mutschler, 2013	89.82% (89.58 to 90.06) calculated	2.67 (2.50 to 2.85) calculated	0.77 (0.75 to 0.79) calculated	NR	NR
Mutschler, 2013	NR	NR	NR	0.719 (0.710 to 0.728)	NR
Mutschler, 2013	NR	NR	NR	0.711 (0.703 to 0.720)	NR
Newgard, 2009	80.47% (78.07 to 82.66) calculated	0.94 (0.79 to 1.13) calculated	1.05 (0.91 to 1.22) calculated	NR	NR
Newgard, 2009	75.50% (73.50 to 77.38) calculated	0.52 (0.40 to 0.69) calculated	1.41 (1.27 to 1.56) calculated	NR	NR
Newgard, 2009	93.4% (90.2 to 96.5)	2.70 (2.11 to 3.29)	0.33 (0.19 to 0.47)	NR	NR
Newgard, 2014 *Newgard, 2016 study population is included in Newgard, 2014	94.94% (94.90 to 94.98) calculated	2.76 (2.23 to 3.41) calculated	0.97 (0.97 to 0.98) calculated	NR	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Newgard, 2014 *Newgard, 2016 study population is included in Newgard, 2014	RR <10 or >29, EMS	Serious injury	6.31% (5.36 to 7.38) Calculated	98.63% (98.51 to 98.73) calculated	20.08% (17.41 to 23.05) calculated
Newgard, 2014 *Newgard, 2016 study population is included in Newgard, 2014	Assisted ventilation, EMS	Serious injury	7.90% (6.84 to 9.08) Calculated	99.60% (99.53 to 99.66) calculated	51.83% (46.74 to 56.89) calculated
Newgard, 2016 *Newgard, 2016 study population is included in Newgard, 2014	Alternative elderly-specific triage guidelines	Serious injury	92.1% (89.8 to 94.5)	41.5% (40.6 to 42.4)	NR
Newgard, 2016 *Newgard, 2016 study population is included in Newgard, 2014	Current triage guidelines	Serious injury	75.9% (72.5 to 79.3)	77.8% (77.1 to 78.5)	NR
Ocak, 2009	ACS-COT field triage protocol - physiologic component (EMS) - any of: GCS <14, SBP <90, RR <10 or >29	Major trauma	62.91% (54.69 to 70.63) Calculated	93.38% (88.16 to 96.78) calculated	90.48% (83.75 to 94.60) calculated
Ocak, 2009	SBP <90, EMS	Major trauma	9.27% (5.16 to 15.07) Calculated	99.34% (96.37 to 99.98) calculated	93.33% (65.09 to 99.06) calculated
Ocak, 2009	RR <10 or >29, EMS	Major trauma	15.23% (9.91 to 21.97) Calculated	99.34% (96.37 to 99.98) calculated	95.83% (75.88 to 99.41) calculated
Pal, 2006	Lactate >2.0	Mortality: 48-hour	85% (CI NR)	38% (CI NR)	4% (CI NR)
Pal, 2006	Lactate: patients with GCS ≥7	Mortality: 48-hour	NR	NR	20% (CI NR)
Pal, 2006	Lactate	Mortality: 48-hour	NR	NR	NR
Pal, 2006	Lactate: age >50 years	Mortality: 48-hour	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Newgard, 2014 *Newgard, 2016 study population is included in Newgard, 2014	95.06% (95.01 to 95.11) calculated	4.59 (3.85 to 5.48) calculated	0.95 (0.94 to 0.96) calculated	NR	NR
Newgard, 2014 *Newgard, 2016 study population is included in Newgard, 2014	95.19% (95.13 to 95.24) calculated	19.67 (16.04 to 24.12) calculated	0.92 (0.91 to 0.94) calculated	NR	NR
Newgard, 2016 *Newgard, 2016 study population is included in Newgard, 2014	NR	NR	NR	0.67 (0.66 to 0.68)	NR
Newgard, 2016 *Newgard, 2016 study population is included in Newgard, 2014	NR	NR	NR	0.77 (0.75 to 0.79)	NR
Ocak, 2009	71.57% (67.07 to 75.68) calculated	9.50 (5.16 to 17.51) calculated	0.40 (0.32 to 0.49) Calculated	NR	NR
Ocak, 2009	52.26% (50.95 to 53.58) calculated	14.00 (1.86 to 105.14) calculated	0.91 (0.87 to 0.96) Calculated	NR	NR
Ocak, 2009	53.96% (52.24 to 55.66) calculated	23.00 (3.15 to 168.16) calculated	0.85 (0.80 to 0.91) Calculated	NR	NR
Pal, 2006	NR	NR	NR	NR	NR
Pal, 2006	NR	NR	NR	0.71 (CI NR)	NR
Pal, 2006	NR	NR	NR	0.72 (CI NR)	NR
Pal, 2006	NR	NR	NR	0.65 (CI NR)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Pal, 2006	Lactate: age >60 years	Mortality: 48-hour	NR	NR	NR
Pal, 2006	Lactate: age >70 years	Mortality: 48-hour	NR	NR	NR
Paladino, 2008	Combination, any of: lactate >2.2, BD < -2.0, HR >100 or SBP <90	Major injury	76.4% (71.1-81.8)	48% (45-51)	NR
Paladino, 2008	Combination: HR >100 or SBP <90	Major injury	40.9% (34.7-47.1)	75% (72-77)	NR
Paladino, 2008	BD < -1.3: subgroup with normal vital signs	Major injury	56% (NR)	71% (NR)	NR
Paladino, 2008	BD: subgroup with normal vital signs	Major injury	NR	NR	NR
Paladino, 2008	HR >100	Major injury	37.6% (31.5 to 43.7)	NR	NR
Paladino, 2008	Lactate >2.5: subgroup with normal vital signs	Major injury	76% (CI NR)	49% (CI NR)	NR
Paladino, 2008	Lactate: subgroup with normal vital signs	Major injury	NR	NR	NR
Paladino, 2008	SBP <90	Major injury	NR	99.4% (99 to 99.8)	NR
Paladino, 2010a	BD	Major injury	NR	NR	NR
Paladino, 2010a	DBP	Major injury	NR	NR	NR
Paladino, 2010a	HR	Major injury	NR	NR	NR
Paladino, 2010a	Lactate	Major injury	NR	NR	NR
Paladino, 2010a	SBP	Major injury	NR	NR	NR
Paladino, 2010b	BD	Major injury	NR	NR	NR
Paladino, 2010b	Lactate	Major injury	NR	NR	NR
Paladino, 2010b	RTS	Major injury	NR	NR	NR
Paladino, 2011	BD, ED	Major injury	NR	NR	NR
Paladino, 2011	HR, ED	Major injury	NR	NR	NR
Paladino, 2011	Lactate, ED	Major injury	NR	NR	NR
Paladino, 2011	SBP, ED	Major injury	NR	NR	NR
Paladino, 2011	SI ≥ 0.70, ED	Major injury	56% (50 to 63)	61% (59 to 65)	NR
Paladino, 2011	SI ≥ 0.80, ED	Major injury	36% (30 to 43)	81% (79 to 83)	NR
Paladino, 2011	SI ≥ 0.90, ED	Major injury	24% (19 to 30)	92% (90 to 93)	NR
Paladino, 2011	SI ≥ 1.0, ED	Major injury	18% (13 to 23)	96% (95 to 97)	NR
Paladino, 2011	SI, ED	Major injury	NR	NR	NR
Paladino, 2011	SI, ED: subgroup with normal vital signs (SBP ≥90, HR ≤100)	Major injury	NR	NR	NR
Pandit, 2014	SI ≥1, ED (study limited to elderly)	Blood transfusion	5.80% (5.44 to 6.17) calculated	97.19% (97.11 to 97.26) calculated	14.08% (13.28 to 14.91) calculated

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Pal, 2006	NR	NR	NR	0.63 (CI NR)	NR
Pal, 2006	NR	NR	NR	0.62 (CI NR)	NR
Paladino, 2008	90.9% (NR)	1.47 (1.34 to 1.6)	0.49 (0.39 to 0.62)	NR	NR
Paladino, 2008	86.2% (NR)	1.62 (1.35 to 1.93)	0.79 (0.71 to 0.88)	NR	NR
Paladino, 2008	NR	NR	NR	NR	NR
Paladino, 2008	NR	NR	NR	0.68 (0.63 to 0.73), p<0.0001	NR
Paladino, 2008	NR	NR	NR	NR	NR
Paladino, 2008	NR	NR	NR	NR	NR
Paladino, 2008	NR	NR	NR	0.64 (0.58 to 0.69), p<0.0001	NR
Paladino, 2008	NR	11.3 (CI NR)	NR	NR	NR
Paladino, 2010a	NR	NR	NR	0.69 (0.63 to 0.74)	SE 0.028
Paladino, 2010a	NR	NR	NR	0.49 (CI NR)	NR
Paladino, 2010a	NR	NR	NR	0.61 (CI NR)	NR
Paladino, 2010a	NR	NR	NR	0.66 (0.60 to 0.71)	SE 0.028
Paladino, 2010a	NR	NR	NR	0.51 (CI NR)	NR
Paladino, 2010b	NR	NR	NR	0.72 (0.68 to 0.76)	SE 0.018
Paladino, 2010b	NR	NR	NR	0.71 (0.67 to 0.75)	SE 0.018
Paladino, 2010b	NR	NR	NR	0.63 (0.60 to 0.67)	NR
Paladino, 2011	NR	NR	NR	0.72 (0.69 to 0.76)	NR
Paladino, 2011	NR	NR	NR	0.58 (0.54 to 0.62)	NR
Paladino, 2011	NR	NR	NR	0.69 (0.65 to 0.73)	NR
Paladino, 2011	NR	NR	NR	0.61 (0.56 to 0.65)	NR
Paladino, 2011	NR	1.48 (1.29 to 1.68)	0.7 (0.61 to 0.82)	NR	NR
Paladino, 2011	NR	1.90 (1.55 to 2.33)	0.79 (0.71 to 0.86)	NR	NR
Paladino, 2011	NR	2.91 (2.17 to 3.89)	0.83 (0.77 to 0.89)	NR	NR
Paladino, 2011	NR	4.71 (3.17 to 6.98)	0.85 (0.81 to 0.91)	NR	NR
Paladino, 2011	NR	NR	NR	0.63 (0.59 to 0.67)	NR
Paladino, 2011	NR	NR	NR	0.56 (0.51 to 0.61)	NR
Pandit, 2014	92.85% (92.83 to 92.88) calculated	2.06 (1.93 to 2.21) calculated	0.97 (0.97 to 0.97) calculated	NR	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Pandit, 2014	SI ≥1, ED (study limited to elderly)	Exploratory laparotomy	7.54% (6.84 to 8.29) calculated	97.08% (97.01 to 97.15) calculated	6.00% (5.47 to 6.58) calculated
Pandit, 2014	SI ≥1, ED (study limited to elderly)	Mortality	45% (CI NR) reported 12.7% (12.0 to 13.4) calculated	97% (CI NR) reported 97.4% (97.3 to 97.5) calculated	82% (CI NR) reported 17.2% (16.4 to 18.1) calculated
Parimi, 2016	Continuous vital signs, 10-minute model	Massive transfusion (MT1): 4 units in 4 hours	80% (NR)	87% (NR)	14% (NR)
Parimi, 2016	Continuous vital signs, 15-minute model	Massive transfusion (MT1): 4 units in 4 hours	82% (NR)	87% (NR)	15% (NR)
Parimi, 2016	Continuous vital signs, 5-minute model	Massive transfusion (MT1): 4 units in 4 hours	78% (NR)	85% (NR)	12% (NR)
Parimi, 2016	Admission vital signs model: HR, SBP, and SI	Massive transfusion (MT1): 4 units in 4 hours	71% (NR)	87% (NR)	13% (NR)
Parimi, 2016	Preadmission vital signs model: HR, SBP and SI	Massive transfusion (MT1): 4 units in 4 hours	72% (NR)	84% (NR)	10% (NR)
Parimi, 2016	Continuous vital signs, 10-minute model	Massive transfusion (MT2): 10 units in 24 hours	83% (NR)	88% (NR)	10% (NR)
Parimi, 2016	Continuous vital signs, 15-minute model	Massive transfusion (MT2): 10 units in 24 hours	87% (NR)	89% (NR)	11% (NR)
Parimi, 2016	Continuous vital signs, 5-minute model	Massive transfusion (MT2): 10 units in 24 hours	83% (NR)	85% (NR)	8%(NR)
Parimi, 2016	Admission vital signs model: HR, SBP, and SI	Massive transfusion (MT2): 10 units in 24 hours	77% (NR)	87% (NR)	10% (NR)
Parimi, 2016	Preadmission vital signs model: HR, SBP and SI	Massive transfusion (MT2): 10 units in 24 hours	77% (NR)	83% (NR)	7% (NR)
Parsikia, 2014	Lactate	Mortality	NR	NR	NR
Perel, 2012	Simple prognostic model (age, SBP, GCS score): Development data set Chart stratified by low-, middle-, or high-income country	Mortality: in-hospital	NR	NR	NR
Perel, 2012	Simple prognostic model (age, SBP, GCS score): Development data set Chart stratified by low-, middle-, or high-income country	Mortality: in-hospital	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Pandit, 2014	97.70% (97.68 to 97.72) calculated	2.58 (2.34 to 2.85) calculated	0.95 (0.95 to 0.96) calculated	NR	NR
Pandit, 2014	67% (CI NR) reported 96.3% (96.3 to 96.3) calculated	NR 4.83 (4.55 to 5.14) calculated	NR 0.90 (0.89 to 0.90) calculated	NR	Accuracy = 85%
Parimi, 2016	99% (NR)	NR	NR	0.87 (0.86-0.88)	NR
Parimi, 2016	99% (NR)	NR	NR	0.89 (0.88-0.90)	NR
Parimi, 2016	99% (NR)	NR	NR	0.85 (0.84-0.86)	NR
Parimi, 2016	99% (NR)	NR	NR	0.82 (0.81-0.83)	NR
Parimi, 2016	99% (NR)	NR	NR	0.81 (0.80-0.81)	NR
Parimi, 2016	99% (NR)	NR	NR	0.88 (0.87-0.90)	NR
Parimi, 2016	99% (NR)	NR	NR	0.91 (0.91-0.92)	NR
Parimi, 2016	99% (NR)	NR	NR	0.86 (0.85-0.88)	NR
Parimi, 2016	99% (NR)	NR	NR	0.85 (0.83-0.86)	NR
Parimi, 2016	99% (NR)	NR	NR	0.82 (0.81-0.84)	NR
Parsikia, 2014	NR	NR	NR	0.634 (NR)	NR
Perel, 2012	NR	NR	NR	0.82 (NR)	NR
Perel, 2012	NR	NR	NR	0.86 (NR)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Potoka, 2001	RTS <12: test data set	ISS >20	64.86% (NR)	77.71% (NR)	NR
Potoka, 2001	T-ASPTS <10: test data set	ISS >20	49.43% (NR)	91.83 %(NR)	NR
Potoka, 2001	RTS <12: test data set	Mortality	100.00%(NR)	74.05% (NR)	NR
Potoka, 2001	T-ASPTS <10: test data set	Mortality	96.97% (NR)	88.83%(NR)	NR
Potoka, 2001	T-ASPTS <10: study data set	ISS >20	68.06% (NR)	75.18% (NR)	NR
Potoka, 2001	T-ASPTS <10: study data set	Mortality	98.84% (NR)	89.02% (NR)	NR
Pottecher, 2016	PP/HR ratio	Massive transfusion (≥10 units in 24 hours)	NR	NR	NR
Pottecher, 2016	PP/HR ratio	Massive transfusion (≥3 units in 1 hour)	NR	NR	NR
Pottecher, 2016	PP/HR ratio <0.443	Massive transfusion (≥10 units in 24 hours)	75% (NR)	74% (NR)	NR
Pottecher, 2016	PP/HR ratio <0.443	Massive transfusion (≥3 units in 1 hour)	75% (NR)	62% (NR)	NR
Pottecher, 2016	PP/HR ratio: Grade A or B patients (higher severity)	Massive transfusion (≥10 units in 24 hours)	NR	NR	NR
Pottecher, 2016	PP/HR ratio: Grade A or B patients (higher severity)	Massive transfusion (≥3 units in 1 hour)	NR	NR	NR
Pottecher, 2016	PP/HR ratio: Grade C patients (lower severity)	Massive transfusion (≥10 units in 24 hours)	NR	NR	NR
Pottecher, 2016	PP/HR ratio: Grade C patients (lower severity)	Massive transfusion (≥3 units in 1 hour)	NR	NR	NR
Pottecher, 2016	SBP	Massive transfusion (≥10 units in 24 hours)	NR	NR	NR
Pottecher, 2016	SBP	Massive transfusion (≥3 units in 1 hour)	NR	NR	NR
Pottecher, 2016	SI	Massive transfusion (≥10 units in 24 hours)	NR	NR	NR
Pottecher, 2016	SI	Massive transfusion (≥3 units in 1 hour)	NR	NR	NR
Pottecher, 2016	SI >0.933	Massive transfusion (≥3 units in 1 hour)	53% (NR)	85% (NR)	NR
Pottecher, 2016	SI >0.967	Massive transfusion (≥10 units in 24 hours)	68% (NR)	86% (NR)	NR
Pottecher, 2016	SI: Grade A or B patients (higher severity)	Massive transfusion (≥10 units in 24 hours)	NR	NR	NR
Pottecher, 2016	SI: Grade A or B patients (higher severity)	Massive transfusion (≥3 units in 1 hour)	NR	NR	NR
Pottecher, 2016	SI: Grade C patients (lower severity)	Massive transfusion (≥10 units in 24 hours)	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Potoka, 2001	NR	NR	NR	NR	NR
Potoka, 2001	NR	NR	NR	NR	NR
Potoka, 2001	NR	NR	NR	NR	NR
Potoka, 2001	NR	NR	NR	NR	NR
Potoka, 2001	NR	NR	NR	NR	NR
Potoka, 2001	NR	NR	NR	NR	NR
Pottecher, 2016	NR	NR	NR	0.767 (0.70 to 0.84)	NR
Pottecher, 2016	NR	NR	NR	0.713 (0.67 to 0.76)	NR
Pottecher, 2016	NR	2.94 (NR)	0.35 (NR)	NR	Gray zone: 0.330 to 0.681 61% of patients
Pottecher, 2016	NR	1.95 (NR)	0.41 (NR)	NR	Gray zone: 0.336 to 0.701 62% of patients
Pottecher, 2016	NR	NR	NR	0.72 (0.65 to 0.73)	NR
Pottecher, 2016	NR	NR	NR	0.69 (0.64 to 0.73)	NR
Pottecher, 2016	NR	NR	NR	0.91 (0.82 to 1.00)	NR
Pottecher, 2016	NR	NR	NR	0.72 (0.59 to 0.84)	NR
Pottecher, 2016	NR	NR	NR	0.61 (0.57 to 0.64)	NR
Pottecher, 2016	NR	NR	NR	0.62 (0.56 to 0.67)	NR
Pottecher, 2016	NR	NR	NR	0.802 (0.74 to 0.87)	NR
Pottecher, 2016	NR	NR	NR	0.722 (0.68 to 0.77)	NR
Pottecher, 2016	NR	3.54 (NR)	0.56 (NR)	NR	Gray zone: 0.547 to 1.000) 71% of patients
Pottecher, 2016	NR	4.74 (NR)	0.39 (NR)	NR	Gray zone: 0.694 to 1.029) 40% of patients
Pottecher, 2016	NR	NR	NR	0.76 (0.65 to 0.79)	NR
Pottecher, 2016	NR	NR	NR	0.70 (0.66 to 0.73)	NR
Pottecher, 2016	NR	NR	NR	0.87 (0.79 to 1.00)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Pottecher, 2016	SI: Grade C patients (lower severity)	Massive transfusion (≥3 units in 1 hour)	NR	NR	NR
Rahmani, 2017	GAP	Need for surgery	NR	NR	NR
Rahmani, 2017	GAP ≤21	Need for surgery	75% (NR)	57% (NR)	64% (NR)
Rahmani, 2017	GAP	Mortality: ED	NR	NR	NR
Rahmani, 2017	GAP ≤18	Mortality: ED	88% (NR)	85% (NR)	85% (NR)
Rahmani, 2017	GAP	Mortality: in-hospital	NR	NR	NR
Rahmani, 2017	GAP ≤14	Mortality: in-hospital	98% (NR)	91% (NR)	91% (NR)
Rahmani, 2017	MGAP	Need for surgery	NR	NR	NR
Rahmani, 2017	MGAP ≤25	Need for surgery	74% (NR)	60% (NR)	65% (NR)
Rahmani, 2017	MGAP	Mortality: ED	NR	NR	NR
Rahmani, 2017	MGAP ≤22	Mortality: ED	87% (NR)	85% (NR)	85% (NR)
Rahmani, 2017	MGAP	Mortality: in-hospital	NR	NR	NR
Rahmani, 2017	MGAP ≤18	Mortality: in-hospital	98% (NR)	91% (NR)	91% (NR)
Rainer, 2011	SBP ≤90	Massive transfusion	38.04% (28.12 to 48.76) calculated	97.05% (96.16 to 97.79) calculated	39.77% (31.28 to 48.93) calculated
Rainer, 2011	HR ≥120	Massive transfusion	26.09% (17.48 to 36.29) calculated	95.50% (94.43 to 96.41) calculated	22.86% (16.51 to 30.75) calculated
Rainer, 2011	BD < -5	Massive transfusion	41.30% (31.13 to 52.05) calculated	94.16% (92.98 to 95.20) calculated	26.57% (21.04 to 32.96) calculated
Rainer, 2011	pH <7.33	Massive transfusion	35.87% (26.13 to 46.54) calculated	95.16% (94.07 to 96.11) calculated	27.50% (21.23 to 34.80) calculated
Rainer, 2011	Predictive model for massive transfusion, score ≥6: uses SBP, GCS, HR, BD, hemoglobin, pelvic fracture and abdominal free fluid	Massive transfusion	31.5% (22.2 to 42.0)	99.7% (99.3 to 99.9)	82.9% (66.4 to 93.4)
Rainer, 2011	Predictive model for massive transfusion: uses SBP, GCS, HR, BD, hemoglobin, pelvic fracture and abdominal free fluid	Massive transfusion	NR	NR	NR
Ramanathan, 2015	Lactate >2.0	ICU admission	77.9% (67.0-86.6)	58.5% (50.4-66.2)	47.6% (38.6-56.7)
Ramanathan, 2015	BD < -5	ISS >15	25.0% (13.2-40.3)	98.3% (95.1-99.6)	78.6% (49.2-95.1)
Ramanathan, 2015	Lactate >2.0 and pH <7.30	ISS >15	55.6% (40.0-70.3)	95.1% (91.0-97.7)	73.5% (55.6-87.1)
Ramanathan, 2015	Lactate >4.7	ISS >15	26.7% (14.6-41.9)	95.8% (91.9-98.2)	60.0% (36.1-80.8)

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Pottecher, 2016	NR	NR	NR	0.54 (0.33 to 0.74)	NR
Rahmani, 2017	NR	NR	NR	0.74 (NR)	NR
Rahmani, 2017	70% (NR)	NR	NR	NR	Youden Index: 0.32
Rahmani, 2017	NR	NR	NR	0.93 (NR)	NR
Rahmani, 2017	87% (NR)	NR	NR	NR	Youden Index: 0.73
Rahmani, 2017	NR	NR	NR	0.99 (NR)	NR
Rahmani, 2017	98% (NR)	NR	NR	NR	Youden Index: 0.89
Rahmani, 2017	NR	NR	NR	0.75 (NR)	NR
Rahmani, 2017	70% (NR)	NR	NR	NR	Youden Index: 0.34
Rahmani, 2017	NR	NR	NR	0.93 (NR)	NR
Rahmani, 2017	88% (NR)	NR	NR	NR	Youden Index: 0.72
Rahmani, 2017	NR	NR	NR	0.99 (NR)	NR
Rahmani, 2017	98% (NR)	NR	NR	NR	Youden Index: 0.89
Rainer, 2011	96.84% (96.31 to 97.29) calculated	12.91 (8.90 to 18.73) calculated	0.64 (0.54 to 0.75) calculated	NR	NR
Rainer, 2011	96.19% (95.72 to 96.61) calculated	5.79 (3.87 to 8.68) calculated	0.77 (0.69 to 0.87) calculated	NR	NR
Rainer, 2011	96.91% (96.35 to 97.39) calculated	7.08 (5.21 to 9.61) calculated	0.62 (0.52 to 0.74) calculated	NR	NR
Rainer, 2011	96.67% (96.14 to 97.13) calculated	7.42 (5.27 to 10.44) calculated	0.67 (0.58 to 0.79) calculated	NR	NR
Rainer, 2011	96.6% (95.7 to 97.4)	94.5 (69.9 to 127.7)	NR	NR	Overall correct classification: 96.9%
Rainer, 2011	NR	NR	NR	0.889 (NR)	NR
Ramanathan, 2015	84.5% (76.4-90.7)	NR	NR	NR	NR
Ramanathan, 2015	84.0% (78.2-88.7)	NR	NR	NR	NR
Ramanathan, 2015	89.8% (84.7-93.6)	NR	NR	NR	NR
Ramanathan, 2015	84.7% (79.2-89.2)	NR	NR	0.7056 (NR)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Ramanathan, 2015	Lactate ≥2.0: age 0-18 months	ISS >15	6.7% (1.5-18.3)	92.1% (87.4-95.5)	16.7% (3.8-41.4)
Ramanathan, 2015	Lactate ≥2.0: age 13-14 years	ISS >15	35.6% (21.9-51.2)	67.5% (60.4-74.1)	20.5% (12.2-31.2)
Ramanathan, 2015	Lactate ≥2.0: age 19 months to 5 years	ISS >15	17.8% (8.0-32.1)	82.2% (76.0-87.3)	19.1% (8.6-34.1)
Ramanathan, 2015	Lactate ≥2.0: age 6-12 years	ISS >15	40.0% (25.7-55.7)	58.1% (50.8-65.2)	18.4% (11.3-27.5)
Ramanathan, 2015	Lactate ≥2.0: overall	ISS >15	86.7% (73.2-94.9)	54.4% (47.1-61.6)	30.9% (23.0-39.8)
Ramanathan, 2015	pH <7.30	ISS >15	56.8% (41.0-71.6)	94.3% (89.9-97.2)	71.4% (53.7-85.3)
Ramanathan, 2015	Lactate >2.0	Major procedure	70.6% (56.2-82.5)	51.3% (43.9-58.7)	28.6% (20.9-37.3)
Raux, 2006	RR, EMS	Mortality	NR	NR	NR
Raux, 2006	SpO2	Mortality	NR	NR	NR
Raux, 2011	MGAP: National cohort	Emergency procedure	NR	NR	NR
Raux, 2011	RTS: National cohort	Emergency procedure	NR	NR	NR
Raux, 2011	Triage Revised Trauma Score (T-RTS): National cohort	Emergency procedure	NR	NR	NR
Raux, 2011	MGAP: Lyon cohort	ICU LOS >2 days	NR	NR	NR
Raux, 2011	RTS: Lyon cohort	ICU LOS >2 days	NR	NR	NR
Raux, 2011	Triage Revised Trauma Score (T-RTS): Lyon cohort	ICU LOS >2 days	NR	NR	NR
Raux, 2011	MGAP: National cohort	Massive hemorrhage	NR	NR	NR
Raux, 2011	RTS: National cohort	Massive hemorrhage	NR	NR	NR
Raux, 2011	Triage Revised Trauma Score (T-RTS): National cohort	Massive hemorrhage	NR	NR	NR
Raux, 2011	MGAP: National cohort	Mortality	NR	NR	NR
Raux, 2011	RTS: National cohort	Mortality	NR	NR	NR
Raux, 2011	Triage Revised Trauma Score (T-RTS): National cohort	Mortality	NR	NR	NR
Raux, 2011	MGAP: National cohort	Severe trauma	NR	NR	NR
Raux, 2011	RTS: National cohort	Severe trauma	NR	NR	NR
Raux, 2011	Triage Revised Trauma Score (T-RTS): National cohort	Severe trauma	NR	NR	NR
Raux, 2011	Mechanical ventilation: National cohort	Emergency procedure	44.74% (40.97 to 48.55) calculated	61.09% (57.30 to 64.79) calculated	53.78% (50.64 to 56.89) calculated
Raux, 2017	BD	Mortality, 30-day in-hospital	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Ramanathan, 2015	80.7% (74.9-85.7)	NR	NR	NR	NR
Ramanathan, 2015	81.6% (74.7-87.3)	NR	NR	NR	NR
Ramanathan, 2015	80.9% (74.7-86.2)	NR	NR	NR	NR
Ramanathan, 2015	80.4% (72.8-86.7)	NR	NR	NR	NR
Ramanathan, 2015	94.5% (88.5-97.9)	NR	NR	0.6515 (NR)	NR
Ramanathan, 2015	89.7% (84.4-93.7)	NR	NR	NR	NR
Ramanathan, 2015	86.4% (78.5-92.2)	NR	NR	NR	NR
Raux, 2006	NR	NR	NR	0.691 (SD 0.024)	NR
Raux, 2006	NR	NR	NR	0.747 (SD 0.022)	NR
Raux, 2011	NR	NR	NR	0.53 (0.44 to 0.50)	NR
Raux, 2011	NR	NR	NR	0.51 (0.48 to 0.54)	NR
Raux, 2011	NR	NR	NR	0.52 (0.49 to 0.54)	NR
Raux, 2011	NR	NR	NR	0.85 (0.79 to 0.88)	NR
Raux, 2011	NR	NR	NR	0.83 (0.81 to 0.86)	NR
Raux, 2011	NR	NR	NR	0.83 (0.81 to 0.86)	NR
Raux, 2011	NR	NR	NR	0.70 (0.66 to 0.73)	NR
Raux, 2011	NR	NR	NR	0.72 (0.69 to 0.73)	NR
Raux, 2011	NR	NR	NR	0.73 (0.70 to 0.77)	NR
Raux, 2011	NR	NR	NR	0.90 (0.88 to 0.92)	NR
Raux, 2011	NR	NR	NR	0.90 (0.88 to 0.92)	NR
Raux, 2011	NR	NR	NR	0.88 (0.86 to 0.92)	NR
Raux, 2011	NR	NR	NR	0.75 (0.73 to 0.78)	NR
Raux, 2011	NR	NR	NR	0.75 (0.73 to 0.78)	NR
Raux, 2011	NR	NR	NR	0.74 (0.71 to 0.76)	NR
Raux, 2011	52.21% (49.95 to 54.46) calculated	1.15 (1.01 to 1.30) calculated	0.90 (0.83 to 0.99) calculated	NR	NR
Raux, 2017	NR	NR	NR	0.75 (0.70 to 0.80)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Raux, 2017	BD	Mortality: 48-hour	NR	NR	NR
Raux, 2017	BD	Severe trauma: ISS >15	NR	NR	NR
Raux, 2017	BD	Massive hemorrhage	NR	NR	NR
Raux, 2017	BD	Emergency procedure	NR	NR	NR
Raux, 2017	BD	ICU LOS >2 days or in-hospital mortality	NR	NR	NR
Raux, 2017	BD; normotensive subgroup	Mortality, 30-day in-hospital	NR	NR	NR
Raux, 2017	BD; TRISS >0.9 subgroup	Mortality, 30-day in-hospital	NR	NR	NR
Raux, 2017	Lactate	Mortality, 30-day in-hospital	NR	NR	NR
Raux, 2017	Lactate	Mortality: 48-hour	NR	NR	NR
Raux, 2017	Lactate	Severe trauma: ISS >15	NR	NR	NR
Raux, 2017	Lactate	Massive hemorrhage	NR	NR	NR
Raux, 2017	Lactate	Emergency procedure	NR	NR	NR
Raux, 2017	Lactate	ICU LOS >2 days or in-hospital mortality	NR	NR	NR
Raux, 2017	Lactate; normotensive subgroup	Mortality: 30-day in-hospital	NR	NR	NR
Raux, 2017	Lactate; TRISS >0.9 subgroup	Mortality: 30-day in-hospital	NR	NR	NR
Raux, 2017	MGAP	Mortality: 30-day in-hospital	NR	NR	NR
Raux, 2017	RTS	Mortality: 30-day in-hospital	NR	NR	NR
Regnier, 2012	Lactate ≥2.2	Mortality: 30-day	78.21% (67.41 to 86.76) calculated	47.64% (43.22 to 52.08) calculated	18.65% (16.57 to 20.93) calculated
Regnier, 2012	Lactate	ICU stay >2 days or death	NR	NR	NR
Regnier, 2012	Lactate clearance (corrected)	ICU stay >2 days or death	NR	NR	NR
Regnier, 2012	Lactate	ISS >15	NR	NR	NR
Regnier, 2012	Lactate clearance (corrected)	ISS >15	NR	NR	NR
Regnier, 2012	Lactate	Massive hemorrhage	NR	NR	NR
Regnier, 2012	Lactate clearance (corrected)	Massive hemorrhage	NR	NR	NR
Regnier, 2012	Lactate	Mortality: 30-day	NR	NR	NR
Regnier, 2012	Lactate clearance (corrected)	Mortality: 30-day	NR	NR	NR
Regnier, 2012	Lactate clearance: 0-4 hours	Mortality: 30-day	NR	NR	NR
Regnier, 2012	Lactate clearance: 2-4 hours	Mortality: 30-day	NR	NR	NR
Regnier, 2012	Lactate	Mortality within 48 hours	NR	NR	NR
Regnier, 2012	Lactate clearance (corrected)	Mortality within 48 hours	NR	NR	NR
Regnier, 2012	Lactate: normotensive subgroup	Mortality: 30-day	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Raux, 2017	NR	NR	NR	0.82 (0.75 to 0.87)	NR
Raux, 2017	NR	NR	NR	0.67 (0.63 to 0.70)	NR
Raux, 2017	NR	NR	NR	0.85 (0.81 to 0.89)	NR
Raux, 2017	NR	NR	NR	0.74 (0.68 to 0.80)	NR
Raux, 2017	NR	NR	NR	0.70 (0.67 to 0.73)	NR
Raux, 2017	NR	NR	NR	0.58 (0.45 to 0.69)	NR
Raux, 2017	NR	NR	NR	0.64 (0.56 to 0.79)	NR
Raux, 2017	NR	NR	NR	0.77 (0.72 to 0.81)	NR
Raux, 2017	NR	NR	NR	0.83 (0.77 to 0.88)	NR
Raux, 2017	NR	NR	NR	0.66 (0.63 to 0.70)	NR
Raux, 2017	NR	NR	NR	0.83 (0.78 to 0.86)	NR
Raux, 2017	NR	NR	NR	0.72 (0.65 to 0.77)	NR
Raux, 2017	NR	NR	NR	0.65 (0.62 to 0.69)	NR
Raux, 2017	NR	NR	NR	0.68 (0.59 to 0.76)	NR
Raux, 2017	NR	NR	NR	0.74 (0.62 to 0.82)	NR
Raux, 2017	NR	NR	NR	0.90 (0.87 to 0.92)	NR
Raux, 2017	NR	NR	NR	0.89 (0.85 to 0.92)	NR
Regnier, 2012	93.44% (90.25 to 95.63) calculated	1.49 (1.29 to 1.72) calculated	0.46 (0.30 to 0.70) calculated	NR	NR
Regnier, 2012	NR	NR	NR	0.70 (0.65 to 0.74)	NR
Regnier, 2012	NR	NR	NR	0.63 (0.58 to 0.68)	NR
Regnier, 2012	NR	NR	NR	0.61 (0.55 to 0.65)	NR
Regnier, 2012	NR	NR	NR	0.59 (0.54 to 0.64)	NR
Regnier, 2012	NR	NR	NR	0.86 (0.80 to 0.90)	NR
Regnier, 2012	NR	NR	NR	0.69 (0.62 to 0.74)	NR
Regnier, 2012	NR	NR	NR	0.78 (0.73 to 0.83)	NR
Regnier, 2012	NR	NR	NR	0.70 (0.66 to 0.74)	NR
Regnier, 2012	NR	NR	NR	0.52 (0.41 to 0.62)	NR
Regnier, 2012	NR	NR	NR	0.52 (0.39 to 0.61)	NR
Regnier, 2012	NR	NR	NR	0.84 (0.77 to 0.90)	NR
Regnier, 2012	NR	NR	NR	0.75 (0.66 to 0.82)	NR
Regnier, 2012	NR	NR	NR	0.63 (0.51 to 0.87)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Regnier, 2012	Lactate clearance (corrected): normotensive subgroup	Mortality: 30-day	NR	NR	NR
Regnier, 2012	Lactate: subgroup with lactate ≥5	Mortality: 30-day	NR	NR	NR
Regnier, 2012	Lactate clearance (corrected): subgroup with lactate ≥5	Mortality: 30-day	NR	NR	NR
Regnier, 2012	Lactate	Need for emergency procedure	NR	NR	NR
Regnier, 2012	Lactate clearance (corrected)	Need for emergency procedure	NR	NR	NR
Reisner, 2016	HR, ED	Hemorrhagic injury requiring blood transfusion ≥3 units PRBCs	NR	NR	NR
Reisner, 2016	Muscle oxygen saturation (SmO_2)	Hemorrhagic injury requiring blood transfusion ≥3 units PRBCs	NR	NR	NR
Reisner, 2016	Pulse pressure (SBP - DBP), ED	Hemorrhagic injury requiring blood transfusion ≥3 units PRBCs	NR	NR	NR
Reisner, 2016	SBP, ED	Hemorrhagic injury requiring blood transfusion ≥3 units PRBCs	NR	NR	NR
Reisner, 2016	SI, ED	Hemorrhagic injury requiring blood transfusion ≥3 units PRBCs	NR	NR	NR
Ryan, 2011b	Heart rate variability: VLF (using mean-rank score)	Mortality	NR	NR	NR
Ryan, 2011b	Heart rate variability: LF/HF (using mean-rank score)	Mortality	NR	NR	NR
Ryan, 2011b	Mechanical ventilation	Mortality	32.14% (15.88 to 52.35) calculated	95.21% (91.11 to 97.79) calculated	50.00% (30.27 to 69.73) calculated
Sammour, 2009	Lactate	Mortality	NR	NR	NR
Sammour, 2009	Lactate >2.0	Mortality	81.0% (CI NR)	56.8% (CI NR)	13.0% (CI NR)
Sammour, 2009	Lactate: subgroup of patients with ICU admission	Mortality	NR	NR	NR
Sartorius, 2010	Revised trauma score (RTS) <7.5: derivation cohort	Mortality: 30-day all cause	95% (92-97)	38% (35-41)	26% (23-29)

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Regnier, 2012	NR	NR	NR	0.65 (0.53 to 0.75)	NR
Regnier, 2012	NR	NR	NR	0.77 (0.60 to 0.87)	NR
Regnier, 2012	NR	NR	NR	0.67 (0.51 to 0.78)	NR
Regnier, 2012	NR	NR	NR	0.65 (0.59 to 0.70)	NR
Regnier, 2012	NR	NR	NR	0.64 (0.58 to 0.69)	NR
Reisner, 2016	NR	NR	NR	0.70 (0.56 to 0.81)	NR
Reisner, 2016	NR	NR	NR	0.76 (0.65 to 0.84)	NR
Reisner, 2016	NR	NR	NR	0.68 (0.54 to 0.80)	NR
Reisner, 2016	NR	NR	NR	0.62 (0.47 to 0.75)	NR
Reisner, 2016	NR	NR	NR	0.75 (0.61 to 0.85)	NR
Ryan, 2011b	NR	NR	NR	0.67 (NR) univariate regression analysis	NR
Ryan, 2011b	NR	NR	NR	0.68 (NR) univariate regression analysis	NR
Ryan, 2011b	90.40% (87.93 to 92.41) calculated	6.71 (2.92 to 15.46) calculated	0.71 (0.55 to 0.92) calculated	NR	NR
Sammour, 2009	NR	NR	NR	0.716 (NR)	NR
Sammour, 2009	97.4% (CI NR)	NR	NR	NR	NR
Sammour, 2009	NR	NR	NR	0.637 (NR)	NR
Sartorius, 2010	97% (95-98)	1.54 (1.46-1.63)	0.12 (0.07-0.22)	NR	Accuracy: 32% (30-35)

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Sartorius, 2010	Revised trauma score (RTS)	Mortality: 30-day all cause	NR	NR	NR
Sartorius, 2010	Triage-Revised trauma score (T-RTS) <12: derivation cohort	Mortality: 30-day all cause	96% (93-98)	42% (39-45)	27% (24-30)
Sartorius, 2010	Triage-Revised trauma score (T-RTS)	Mortality: 30-day all cause	NR	NR	NR
Sartorius, 2010	Mechanism, GCS, Age and Arterial Pressure (MGAP) <23: derivation cohort	Mortality: 30-day all cause	95% (91-97)	70% (67-73)	47% (43-52)
Sartorius, 2010	Mechanism, GCS, Age and Arterial Pressure (MGAP)	Mortality: 30-day all cause	NR	NR	NR
Sartorius, 2010	Mechanical ventilation, prehospital: derivation cohort	Mortality: 30-day all cause	39.02% (34.99 to 43.16) calculated	96.46% (94.92 to 97.64) calculated	88.80% (84.45 to 92.05) calculated
Schenarts, 2008	SBP <90, EMS	In-hospital mortality	7.78% (3.18 to 15.37) calculated	98.19% (97.51 to 98.72) calculated	15.91% (7.98 to 29.21) calculated
Schenarts, 2008	SBP <90, EMS	ISS >16	4.95% (3.23 to 7.22) calculated	98.83% (98.18 to 99.29) calculated	56.82% (42.22 to 70.32) calculated
Schenarts, 2008	SBP <90, EMS	ICU, OR, or death in E	4.43% (3.01 to 6.27) calculated	99.04% (98.39 to 99.47) calculated	68.18% (53.35 to 80.06) calculated
Shah, 2013	EMS lactate, POC = 2 mmol/L; normal EMS vital signs and GCS	Need for critical care	64% (NR)	66% (NR)	NR
Shoemaker, 2005	Cardiac Index, data over first 4 hours	Mortality	NR	NR	NR
Shoemaker, 2005	Cardiac Index, initial value	Mortality	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Sartorius, 2010	NR	NR	NR	AUC (95% CI) Derivation cohort: 0.90 (0.88-0.92) Validation cohort: 0.88 (0.85-0.91)	NR
Sartorius, 2010	98% (96-99)	1.65 (1.56-1.75)	0.09 (0.05-0.18)	NR	Accuracy: 35% (32-38)
Sartorius, 2010	NR	NR	NR	AUC (95% CI) Derivation cohort: 0.88 (0.86-0.92) Validation cohort: 0.88 (0.85-0.91)	NR
Sartorius, 2010	98% (96-99)	3.13 (2.82-3.48)	0.07 (0.04-0.13)	NR	Accuracy: 45% (43-48)
Sartorius, 2010	NR	NR	NR	AUC (95% CI) Derivation cohort: 0.90 (0.88-0.92) Validation cohort:0.91 (0.88-0.93)	NR
Sartorius, 2010	68.74% (67.28 to 70.16) calculated	11.02 (7.55 to 16.09) calculated	0.63 (0.59 to 0.68) calculated	NR	NR
Schenarts, 2008	96.02% (95.78 to 96.25) calculated	4.29 (1.97 to 9.35) calculated	0.94 (0.88 to 1.00) calculated	NR	NR
Schenarts, 2008	76.99% (76.62 to 77.35) calculated	4.23 (2.35 to 7.62) calculated	0.96 (0.94 to 0.98) calculated	NR	NR
Schenarts, 2008	68.98% (68.62 to 69.35) calculated	4.60 (2.45 to 8.62) calculated	0.96 (0.95 to 0.98) calculated	NR	NR
Shah, 2013	NR	NR	NR	NR	NR
Shoemaker, 2005	NR	NR	NR	0.68 (NR)	NR
Shoemaker, 2005	NR	NR	NR	0.61 (NR)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Shoemaker, 2005	Oxygen delivery (DO2), initial value	Mortality	NR	NR	NR
Shoemaker, 2005	HR, initial value	Mortality	NR	NR	NR
Shoemaker, 2005	MAP, data over first 4 hours	Mortality	NR	NR	NR
Shoemaker, 2005	MAP, initial value	Mortality	NR	NR	NR
Shoemaker, 2005	Survival prediction model, data over first 4 hours - uses noninvasive hemodynamic monitoring and diagnosis variables	Mortality	NR	NR	NR
Shoemaker, 2005	Survival prediction model, initial values - uses noninvasive hemodynamic monitoring and diagnosis variables	Mortality	NR	NR	NR
Shoemaker, 2005	Transcutaneous oxygen tension/FIO2 ratio (PtcO2/FIO2), data over first 4 hours	Mortality	NR	NR	NR
Shoemaker, 2005	Transcutaneous oxygen tension/FIO2 ratio (PtcO2/FIO2), initial value	Mortality	NR	NR	NR
Tamim, 2002	Prehospital Index (PHI) ≥4	Major injury (mortality, surgical intervention, ICU care)	35% (32 to 38)	91% (90 to 93)	77% (74 to 79)
Tamim, 2002	Prehospital Index (PHI) ≥7	Major injury (mortality, surgical intervention, ICU care)	17% (15 to 19)	97% (96 to 98)	83% (81 to 85)
Tamim, 2002	Prehospital Index (PHI) ≥1	Major injury (mortality, surgical intervention, ICU care)	55% (52 to 57)	71% (69 to 74)	60% (58 to 63)
Tamim, 2002	Prehospital Index (PHI)	Major injury (mortality, surgical intervention, ICU care)	NR	NR	NR
Van Haren, 2014	Vital signs, combined: HR >100, SBP <90, SaO2 <95%	LSI	44% (NR)	75% (NR)	64% (NR)
Van Haren, 2014	HR >100	LSI	30% (NR)	79% (NR)	58% (NR)
Van Haren, 2014	Murphy Factor >3 (over entire transport time)	LSI	39% (NR)	81% (NR)	68% (NR)
Van Haren, 2014	Murphy Factor (continuous)	LSI	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Shoemaker, 2005	NR	NR	NR	0.41 (NR)	NR
Shoemaker, 2005	NR	NR	NR	0.63 (NR)	NR
Shoemaker, 2005	NR	NR	NR	0.73 (NR)	NR
Shoemaker, 2005	NR	NR	NR	0.67 (NR)	NR
Shoemaker, 2005	NR	NR	NR	0.88 (NR)	NR
Shoemaker, 2005	NR	NR	NR	0.81 (NR)	NR
Shoemaker, 2005	NR	NR	NR	0.74 (NR)	NR
Shoemaker, 2005	NR	NR	NR	0.77 (NR)	NR
Tamim, 2002	64% (61 to 66)	NR	NR	NR	NR
Tamim, 2002	59% (57 to 62)	NR	NR	NR	NR
Tamim, 2002	66% (63 to 69)	NR	NR	NR	NR
Tamim, 2002	NR	NR	NR	0.66 (SE 0.02)	NR
Van Haren, 2014	57% (NR)	NR	NR	0.607 (NR), p=0.119	NR
Van Haren, 2014	54% (NR)	NR	NR	0.535 (NR), p=0.612	NR
Van Haren, 2014	57% (NR)	NR	NR	0.620 (NR), p=0.081	NR
Van Haren, 2014	NR	NR	NR	0.619 (NR), p=0.075	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Van Haren, 2014	SaO2 <95%	LSI	13% (NR)	94% (NR)	67% (NR)
Van Haren, 2014	SBP <90	LSI	8% (NR)	96% (NR)	67% (NR)
Vandromme, 2010	Lactate (ED POC test): group with ED SBP 90-110	Mortality	NR	NR	NR
Vandromme, 2010	Lactate (ED POC test): Group with EMS and ED SBP 90-110	Mortality	NR	NR	NR
Vandromme, 2010	SBP (ED): Group with ED SBP 90-110	Mortality	NR	NR	NR
Vandromme, 2010	SBP (ED): Group with EMS and ED SBP 90-110	Mortality	NR	NR	NR
Vandromme, 2010	Lactate >2.5 (ED)	Mortality, in-hospital	81.98% (75.40 to 87.41) calculated	56.78% (54.69 to 58.85) calculated	12.81% (11.89 to 13.78) calculated
Vandromme, 2010	Lactate >5 (ED)	Mortality, in-hospital	42.80% (36.76 to 90.06) calculated	88.73% (87.30 to 90.06) calculated	32.47% (28.57 to 36.63) calculated
Vandromme, 2010	Lactate (ED POC test): group with ED SBP 90-110	Significant transfusion	NR	NR	NR
Vandromme, 2010	Lactate (ED POC test): Group with EMS and ED SBP 90-110	Significant transfusion	NR	NR	NR
Vandromme, 2010	Lactate >2.5 (ED)	Significant transfusion	77.27% (71.74 to 82.19) calculated	57.05% (54.89 to 59.18) calculated	18.55% (17.34 to 19.82) calculated
Vandromme, 2010	Lactate >5 (ED)	Significant transfusion	43.02% (35.51 to 50.78) calculated	87.66% (86.22 to 89.00) calculated	21.26% (18.04 to 24.89) calculated
Vandromme, 2010	SBP (ED): Group with ED SBP 90-110	Significant transfusion	NR	NR	NR
Vandromme, 2010	SBP (ED): Group with EMS and ED SBP 90-110	Significant transfusion	NR	NR	NR
Vandromme, 2011	SI >0.9, EMS	Mortality	25.00% (18.98 to 31.82) calculated	81.77% (80.91 to 82.62) calculated	3.15% (2.47 to 4.02) calculated
Vandromme, 2011	SI >0.9, EMS	Massive transfusion	34.89% (29.30 to 40.81) calculated	82.20% (81.34 to 83.04) calculated	6.51% (5.56 to 7.60) calculated
Vandromme, 2011b	Lactate ≥ 5: developmental cohort	Massive transfusion	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Van Haren, 2014	53% (NR)	NR	NR	0.530 (NR), p=0.660	NR
Van Haren, 2014	52% (NR)	NR	NR	0.544 (NR), p=0.524	NR
Vandromme, 2010	NR	NR	NR	0.76 (CI NR)	NR
Vandromme, 2010	NR	NR	NR	0.74 (CI NR)	NR
Vandromme, 2010	NR	NR	NR	0.61 (CI NR)	NR
Vandromme, 2010	NR	NR	NR	0.60 (CI NR)	NR
Vandromme, 2010	97.60% (96.72 to 98.25) calculated	1.90 (1.74 to 2.06) calculated	0.32 (0.23 to 0.44) calculated	NR	NR
Vandromme, 2010	92.46% (91.69 to 93.16) calculated	3.80 (3.16 to 4.57) calculated	0.64 (0.58 to 0.72) calculated	NR	NR
Vandromme, 2010	NR	NR	NR	0.76 (CI NR)	NR
Vandromme, 2010	NR	NR	NR	0.72 (CI NR)	NR
Vandromme, 2010	95.20% (94.06 to 96.13) calculated	1.80 (1.66 to 1.95) calculated	0.40 (0.32 to 0.50) calculated	NR	NR
Vandromme, 2010	95.21% (94.57 to 95.77) calculated	3.49 (2.84 to 4.28) calculated	0.65 (0.57 to 0.74) calculated	NR	NR
Vandromme, 2010	NR	NR	NR	0.60 (CI NR)	NR
Vandromme, 2010	NR	NR	NR	0.61 (CI NR)	NR
Vandromme, 2011	97.87% (97.69 to 98.04) calculated	1.37 (1.07 to 1.76) calculated	0.92 (0.84 to 1.00) calculated	NR	NR
Vandromme, 2011	97.27% (97.03 to 97.49) calculated	1.96 (1.66 to 2.32) calculated	0.79 (0.73 to 0.86) calculated	NR	NR
Vandromme, 2011b	NR	NR	NR	0.71 (NR)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Vandromme, 2011b	SBP < 110: developmental cohort	Massive transfusion	NR	NR	NR
Vandromme, 2011b	HR > 105: developmental cohort	Massive transfusion	NR	NR	NR
Vassallo, 2015	SI ≥ 0.90	Life-saving intervention or death in ED	52.7% (45.8 to 59.6)	93.0% (88.7 to 97.2)	NR
Vassallo, 2015	SI ≥ 1.0	Life-saving intervention or death in ED	41.9% (35.1 to 48.7)	94.4% (90.6 to 98.2)	NR
Vassallo, 2015	SI ≥ 0.75	Life-saving intervention or death in ED	70.0% (63.6 to 76.3)	74.6% (67.5 to 81.8)	NR
Vassallo, 2015	Triage Sort (TSO) ≤10: uses GCS, RR, SBP	Life-saving intervention or death in ED	58.6% (51.8 to 65.4)	88.7% (83.5 to 93.9)	NR
Vassallo, 2017	Careflight (uses SBP, GCS)	Life-saving intervention	33.5% (31.3 to 35.8)	98.4% (97.7 to 98.9)	95.0% (NR)
Vassallo, 2017	Modified Physiological Triage Tool (MPTT) (uses HR, GCS, RR)	Life-saving intervention	69.9% (67.7 to 72.0)	65.3% (63.2 to 67.5)	64.8% (NR)
Vassallo, 2017	Military Sieve (uses HR, RR, GCS)	Life-saving intervention	43.8% (41.5 to 46.2)	93.6% (92.4 to 94.6)	86.2% (NR)
Vassallo, 2017	Modified Military Sieve (uses HR, RR, GCS)	Life-saving intervention	50.9% (48.6 to 53.3)	87.5% (85.9 to 88.9)	78.8% (NR)
Vassallo, 2017	START (Simple triage and rapid treatment): RR≥30, SBP<90, GCS<13	Life-saving intervention	38.7% (36.5 to 41.1)	96.9% (96.0 to 97.6)	91.9% (NR)
Vassallo, 2017	Triage Sieve (uses HR, RR)	Life-saving intervention	24.8% (22.8 to 26.9)	94.7% (93.6 to 95.7)	81.2% (NR)
Vettorello, 2013	HR >99	Blood transfusion or bleeding Control	100% (NR)	64.4% (NR)	NR
Vettorello, 2013	HR	Blood transfusion or bleeding Control	NR	NR	NR
Vettorello, 2013	SBP <125	Blood transfusion or bleeding Control	100% (NR)	66.7% (NR)	NR
Vettorello, 2013	SBP	Blood transfusion or bleeding Control	NR	NR	NR
Vettorello, 2013	Heart rate variability: heart-to-arm time index (iHAT) >58.78%	Blood transfusion or bleeding Control	90.9% (58.7 to 99.8)	100% (94.9 to 100)	NR
Vettorello, 2013	Heart rate variability: heart-to-arm time index (iHAT)	Blood transfusion or bleeding Control	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Vandromme, 2011b	NR	NR	NR	0.72 (NR)	NR
Vandromme, 2011b	NR	NR	NR	0.65 (NR)	NR
Vassallo, 2015	NR	NR	NR	NR	NR
Vassallo, 2015	NR	NR	NR	NR	NR
Vassallo, 2015	NR	NR	NR	NR	NR
Vassallo, 2015	NR	NR	NR	NR	NR
Vassallo, 2017	NR	NR	NR	NR	Under triage: 66.5% Over triage: 5.0%
Vassallo, 2017	NR	NR	NR	NR	Under triage: 30.1% Over triage: 35.2%
Vassallo, 2017	NR	NR	NR	NR	Under triage: 56.2% Over triage: 13.8%
Vassallo, 2017	NR	NR	NR	NR	Under triage: 49.1% Over triage: 21.2%
Vassallo, 2017	NR	NR	NR	NR	Under triage: 61.3% Over triage: 8.1%
Vassallo, 2017	NR	NR	NR	NR	Under triage: 75.2% Over triage: 18.8%
Vettorello, 2013	NR	2.81 (2.40 to 3.30)	NR	NR	NR
Vettorello, 2013	NR	NR	NR	0.835 (0.734 to 0.909)	NR
Vettorello, 2013	NR	3.00 (2.50-3.50)	NR	NR	NR
Vettorello, 2013	NR	NR	NR	0.911 (0.824 to 0.963)	NR
Vettorello, 2013	NR	Infinite	NR	NR	NR
Vettorello, 2013	NR	NR	NR	0.952 (0.880 to 0.987)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Williams, 2016	End-tidal CO2 ($ETCO_2$) ≤30	Blood transfusion	62.50% (24.49 to 91.48) calculated	67.28% (59.48 to 74.44) calculated	8.62% (5.02 to 14.42) calculated
Williams, 2016	End-tidal CO2 ($ETCO_2$) ≤30	ICU or OR admission	63.64% (40.66 to 82.80) calculated	70.27% (62.21 to 77.50) calculated	24.14% (17.56 to 32.22) calculated
Williams, 2016	End-tidal CO2 ($ETCO_2$) ≤30	Invasive procedure	47.22% (30.41 to 64.51) calculated	69.40% (60.86 to 77.07) calculated	29.31% (21.25 to 38.91) calculated
Williams, 2016	End-tidal CO2 ($ETCO_2$) ≤30	Severe injury composite	52.73% (38.80 to 66.35) calculated	74.78% (65.83 to 82.42) calculated	50.00% (40.08 to 59.92) calculated
Woodford, 2012	HR (automated), EMS (mean, all values)	Mortality	63% (CI NR)	85% (CI NR)	NR
Woodford, 2012	HR >110 (automated), EMS (mean, abnormal values only)	Mortality	38% (CI NR)	93% (CI NR)	NR
Woodford, 2012	HR >110 (standard, all values), EMS	Mortality	50% (CI NR)	88% (CI NR)	NR
Woodford, 2012	HR >110, EMS (standard, abnormal values only)	Mortality	63% (CI NR)	79% (CI NR)	NR
Woodford, 2012	Oxygen saturation (SpO_2) (mean), EMS (continuous)	Mortality	63% (CI NR)	85% (CI NR)	NR
Woodford, 2012	Oxygen saturation (SpO_2) <90, EMS (standard, all values)	Mortality	38% (CI NR)	99% (CI NR)	NR
Woodford, 2012	Oxygen saturation (SpO_2) <90% (mean), EMS (continuous)	Mortality	50% (CI NR)	96% (CI NR)	NR
Woodford, 2012	Oxygen saturation (SpO_2), EMS (abnormal values only)	Mortality	38% (CI NR)	99% (CI NR)	NR
Woodford, 2012	RTS, threshold not specified	Mortality	63% (NR)	83% (NR)	NR
Woodford, 2012	SBP <90 (mean), EMS (continuous)	Mortality	25% (CI NR)	99% (CI NR)	NR
Woodford, 2012	SBP <90, EMS (standard, all values)	Mortality	13% (CI NR)	98% (CI NR)	NR
Woodford, 2012	SBP, EMS (standard, abnormal values only)	Mortality	63% (CI NR)	76% (CI NR)	NR
Woodford, 2012	SI, ED	Mortality	63% (CI NR)	96% (CI NR)	NR

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Williams, 2016	97.32% (93.65 to 98.89) calculated	1.91 (1.07 to 3.41) calculated	0.56 (0.23 to 1.37) calculated	NR	NR
Williams, 2016	92.86% (88.10 to 95.80) calculated	2.14 (1.43 to 3.20) calculated	0.52 (0.29 to 0.91) calculated	NR	NR
Williams, 2016	83.04% (77.89 to 87.18) calculated	1.54 (1.00 to 2.37) calculated	0.76 (0.55 to 1.06) calculated	NR	NR
Williams, 2016	76.79% (71.05 to 81.68) calculated	2.09 (1.40 to 3.13) calculated	0.63 (0.47 to 0.85) calculated	NR	NR
Woodford, 2012	NR	NR	NR	0.70 (0.50 to 0.91), p=0.03	NR
Woodford, 2012	NR	NR	NR	0.65 (0.44 to 0.86), p=0.08	NR
Woodford, 2012	NR	NR	NR	0.69 (0.48 to 0.90), p=0.04	NR
Woodford, 2012	NR	NR	NR	0.60 (0.38 to 0.81), p=0.19	NR
Woodford, 2012	NR	NR	NR	0.76 (0.56 to 0.96), p=0.005	NR
Woodford, 2012	NR	NR	NR	0.68 (0.47 to 0.89), p=0.04	NR
Woodford, 2012	NR	NR	NR	0.73 (0.53 to 0.94), p=0.01	NR
Woodford, 2012	NR	NR	NR	0.59 (0.38 to 0.81), p=0.20	NR
Woodford, 2012	NR	NR	NR	0.73 (0.53 to 0.94)	NR
Woodford, 2012	NR	NR	NR	0.62 (0.41 to 0.83), p=0.14	NR
Woodford, 2012	NR	NR	NR	0.55 (0.34 to 0.77), p=0.31	NR
Woodford, 2012	NR	NR	NR	0.71 (0.50 to 0.92), p=0.02	NR
Woodford, 2012	NR	NR	NR	0.63 (0.42 to 0.85), p=0.11	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Reported Sensitivity (95% CI)	Reported Specificity (95% CI)	Reported PPV (95% CI)
Yuen, 2016	RTS	Mortality	NR	NR	NR
Yuen, 2016	Simplified emergency trauma score (SETS) = 60 SETS uses GCS, RR, mechanism of injury, and age	Mortality	64% (CI NR)	98.1% (CI NR)	64% (CI NR)
Yuen, 2016	Simplified emergency trauma score (SETS): uses GCS, RR, mechanism of injury, and age	Mortality	NR	NR	NR
Zarzaur, 2008	SI ≥0.83: overall	Mortality: 48-hour	73% (NR)	79% (NR)	NR
Zarzaur, 2008	Age x SI ≥ 32.3: overall	Mortality: 48-hour	78% (NR)	74% (NR)	NR
Zarzaur, 2008	Age x SI ≥ 52.1: elderly (≥55)	Mortality: 48-hour	72% (NR)	81% (NR)	NR
Zarzaur, 2008	HR: overall	Mortality: 48-hour	NR	NR	NR
Zarzaur, 2008	SBP: overall	Mortality: 48-hour	NR	NR	NR
Zarzaur, 2008	SI: overall	Mortality: 48-hour	NR	NR	NR
Zarzaur, 2008	Age x SI: overall	Mortality: 48-hour	NR	NR	NR
Zarzaur, 2008	HR: young (<55)	Mortality: 48-hour	NR	NR	NR
Zarzaur, 2008	SBP: young (<55)	Mortality: 48-hour	NR	NR	NR
Zarzaur, 2008	SI: young (<55)	Mortality: 48-hour	NR	NR	NR
Zarzaur, 2008	Age x SI: young (<55)	Mortality: 48-hour	NR	NR	NR
Zarzaur, 2008	HR: elderly (≥55)	Mortality: 48-hour	NR	NR	NR
Zarzaur, 2008	SBP: elderly (≥55)	Mortality: 48-hour	NR	NR	NR
Zarzaur, 2008	SI: elderly (≥55)	Mortality: 48-hour	NR	NR	NR
Zarzaur, 2008	Age x SI: elderly (≥55)	Mortality: 48-hour	NR	NR	NR
Zarzaur, 2008	HR: overall	Blood transfusion	NR	NR	NR
Zarzaur, 2008	SBP: overall	Blood transfusion	NR	NR	NR
Zarzaur, 2008	SI: overall	Blood transfusion	NR	NR	NR
Zarzaur, 2008	Age x SI: overall	Blood transfusion	NR	NR	NR
Zarzaur, 2008	HR: young (<55)	Blood transfusion	NR	NR	NR
Zarzaur, 2008	SBP: young (<55)	Blood transfusion	NR	NR	NR
Zarzaur, 2008	SI: young (<55)	Blood transfusion	NR	NR	NR
Zarzaur, 2008	Age x SI: young (<55)	Blood transfusion	NR	NR	NR
Zarzaur, 2008	HR: elderly (≥55)	Blood transfusion	NR	NR	NR
Zarzaur, 2008	SBP: elderly (≥55)	Blood transfusion	NR	NR	NR
Zarzaur, 2008	SI: elderly (≥55)	Blood transfusion	NR	NR	NR
Zarzaur, 2008	Age x SI: elderly (≥55)	Blood transfusion	NR	NR	NR

Author, Year (See Appendix B for complete reference)	Reported NPV (95% CI)	Reported PLR	Reported NLR	AUROC Univariate AUC (95% CI)	Other Measures of Diagnostic Accuracy
Yuen, 2016	NR	NR	NR	0.85 (CI NR)	NR
Yuen, 2016	NR	NR	NR	NR	NR
Yuen, 2016	NR	NR	NR	0.94 (CI NR)	NR
Zarzaur, 2008	NR	NR	NR	NR	NR
Zarzaur, 2008	NR	NR	NR	NR	NR
Zarzaur, 2008	NR	NR	NR	NR	NR
Zarzaur, 2008	NR	NR	NR	0.717 (0.675 to 0.760)	NR
Zarzaur, 2008	NR	NR	NR	0.753 (0.711 to 0.795)	NR
Zarzaur, 2008	NR	NR	NR	0.813 (0.776 to 0.849)	NR
Zarzaur, 2008	NR	NR	NR	0.831 (0.800 to 0.862)	NR
Zarzaur, 2008	NR	NR	NR	0.767 (0.716 to 0.817)	NR
Zarzaur, 2008	NR	NR	NR	0.770 (0.719 to 0.821)	NR
Zarzaur, 2008	NR	NR	NR	0.856 (0.818 to 0.900)	NR
Zarzaur, 2008	NR	NR	NR	0.808 (0.765 to 0.851)	NR
Zarzaur, 2008	NR	NR	NR	0.660 (0.589 to 0.731)	NR
Zarzaur, 2008	NR	NR	NR	0.761 (0.695 to 0.827)	NR
Zarzaur, 2008	NR	NR	NR	0.789 (0.730 to 0.848)	NR
Zarzaur, 2008	NR	NR	NR	0.830 (0.780 to 0.880)	NR
Zarzaur, 2008	NR	NR	NR	0.713 (0.696 to 0.731)	NR
Zarzaur, 2008	NR	NR	NR	0.711 (0.693 to 0.719)	NR
Zarzaur, 2008	NR	NR	NR	0.783 (0.767 to 0.799)	NR
Zarzaur, 2008	NR	NR	NR	0.759 (0.743 to 0.775)	NR
Zarzaur, 2008	NR	NR	NR	0.743 (0.724 to 0.762)	NR
Zarzaur, 2008	NR	NR	NR	0.708 (0.687 to 0.729)	NR
Zarzaur, 2008	NR	NR	NR	0.797 (0.779 to 0.815)	NR
Zarzaur, 2008	NR	NR	NR	0.749 (0.731 to 0.768)	NR
Zarzaur, 2008	NR	NR	NR	0.642 (0.604 to 0.681)	NR
Zarzaur, 2008	NR	NR	NR	0.762 (0.730 to 0.793)	NR
Zarzaur, 2008	NR	NR	NR	0.789 (0.758 to 0.819)	NR
Zarzaur, 2008	NR	NR	NR	0.805 (0.776 to 0.834)	NR

See Appendix B. Included Studies for full study references.

ABG = arterial blood gas: ACS-COT = American College of Surgeons Committee on Trauma; AIS = Abbreviated Injury Scale; AOR = adjusted odds ratio; APACHE II = Acute Physiology and Chronic Health Evaluation II; AUROC = area under the receiver operating characteristic curve; BD = base deficit; BP = blood pressure; CHAID = chi-square automatic interaction detection; CI = confidence interval; CNS = central nervous system; CPR = cardiopulmonary resuscitation; CRAMS = Circulation, Respiration, Abdomen, Motor, and Speech; CT = computed tomography; DBP = diastolic blood pressure; ECG = electrocardiogram; ED = emergency department; EHR = electronic health record; EMS = emergency medical services; EMT = emergency medical technician; EMTRAS = Emergency Trauma Score; ETCO2 = end-tidal carbon dioxide; FTS = Field Triage Score; GAP = Glasgow Coma Scale, Age, and Arterial Pressure; GCS = Glasgow Coma Scale; HR = heart rate; HRC = heart rate complexity; HRV = heart rate variability; ICD-9 = International Classification of Diseases 9th Revision; ICU = intensive care unit; INR = international normalized ratio; IQR = interquartile range; ISS = Injury Severity Score; IV = intravenous; LOS = length of stay; LSI = life-saving intervention; MAP = mean arterial pressure; MGAP = Mechanism, Glasgow Coma Scale, Age, and Arterial Pressure; MOD = multiple organ dysfunction; MPTT = Modified Physiological Triage Tool; NA = not applicable; NIRS = near-infrared spectrometry; NLR = negative likelihood ratio; NPV = negative predictive value; NR = not reported; NTDB = National Trauma Data Bank; NTTP = National Trauma Triage Protocol: OH = out-of-hospital; OR = operating room; pCO_2 = partial pressure of carbon dioxide; PHI = Prehospital Index; PLR = positive likelihood ratio; POC = point of care; PP = pulse pressure; PPG = photoplethysmography, photoplethysmogram;

PPV = positive predictive value; PRBC = packed red blood cell; PTS = Pediatric Trauma Score; RBC = red blood cell; REMS = Rapid Emergency Medicine Score; ROC = receiver operating characteristic; RR = respiratory rate; RTS = Revised Trauma Score; SaO2 = oxygen saturation; SBP = systolic blood pressure; SD = standard deviation; Sen = sensitivity; SETS = Simplified Emergency Trauma Score; SI = shock index; SLCO2 = sublingual partial pressure of carbon dioxide; SmO2 = muscle oxygen saturation; Sp = specificity; SpHb = noninvasive continuous hemoglobin concentration; SpO2 = peripheral oxygen saturation; START = Simple Triage and Rapid Treatment; StO2 = tissue oxygen saturation; TARN = Trauma Audit and Research Network; T-ASPTS = Triage Age-Specific Pediatric Trauma Score; TBI = traumatic brain injury; TRISS = Trauma and Injury Severity Score; T-RTS = Revised Trauma Score for Triage; ViEWS-L = VitalPAC Early Warning Score-Lactate; vs. = versus; VSDR = vital signs data and event recorder; WVSM = wireless vital signs monitor

Table D3. Multivariate results

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Allen, 2014	BD < 0	Blood transfusion	Multivariate logistic regression. Results of univariate analyses were used to identify variables for inclusion in the regression. Variables included age-specific hypotension, base deficit, age-specific tachycardia, altered mental status and hematocrit.	AOR (95% CI): 4.14 (1.38 to 12.39)	NR
Aslar, 2004	APACHE II score	Mortality, 30-day in-hospital	Multivariate logistic regression. Candidate variables were those with p<0.15 on univariate test. Analysis was confirmed by using LogXact test. Pearson's and Spearman's correlation coefficients were used for degree of association between variables (parametric and non-parametric, respectively). Final model included APACHE II and lactate.	AOR (95% CI): 26.17 (3.99 to 171.59) Beta regression coefficient: 3.26 (SE 0.96), p=0.0007	NR
Aslar, 2004	Lactate	Mortality, 30-day in-hospital	Multivariate logistic regression. Candidate variables were those with p<0.15 on univariate test. Analysis was confirmed by using LogXact test. Pearson's and Spearman's correlation coefficients were used for degree of association between variables (parametric and non-parametric, respectively). Final model included APACHE II and lactate.	AOR (95% CI): 10.58 (1.88 to 59.24) Beta regression coefficient: 2.36 (SE 0.88), p=0.0073	NR
Aslar, 2004	Multivariate model: APACHE II score and lactate	Mortality, 30-day in-hospital	Multivariate logistic regression. Candidate variables were those with p<0.15 on univariate test. Analysis was confirmed by using LogXact test. Pearson's and Spearman's correlation coefficients were used for degree of association between variables (parametric and non-parametric, respectively). Final model included APACHE II and lactate.	NR	AUC: NR Sensitivity: 79.2% Specificity: 94.6%
Batchinsky, 2007 * Batchinsky 2007 and Batchinsky 2009 analyze the same ECGs, but differ in measures evaluated.	Prehospital model 1: approximate entropy, distribution of symbol 2 and GCS motor component	Mortality	Multiple logistic regressions to identify independent predictors of mortality, using stepwise selection and likelihood ratio tests. Candidate variables were ECG-derived metrics, GCS motor component, and ISS. Models were constructed with three overlapping phases to represent a diagnostic problem: 1) "remote triage" using only R-to-R interval metrics; 2) "prehospital care" using R-to-R interval metrics plus field data including motor component of GCS; 3) "definitive care" using data available during hospitalization, including the ISS. Variables with p value of 0.2 by univariate analysis were chosen as candidates for the logistic regression. Model fit estimated using the Hosmer- Lemeshow goodness-of-fit test, and ROC curves constructed to assess diagnostic performance, with repeat analysis excluding outliers. Final predictive models - in the prehospital predictive model, distribution of symbol 2 was no longer retained after excluding outliers ("model 2") Remote triage model: approximate entropy and distribution of symbol 2 Prehospital model 1: approximate entropy, distribution of symbol 2 and GCS motor component Prehospital model 2: approximate entropy and GCS motor component	NR	0.886 (0.75 to 1.0)

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Batchinsky, 2007 * Batchinsky 2007 and Batchinsky 2009 analyze the same ECGs, but differ in measures evaluated.	Prehospital model 2: approximate entropy and GCS motor component excluding outliers	Mortality	Multiple logistic regressions to identify independent predictors of mortality, using stepwise selection and likelihood ratio tests. Candidate variables were ECG-derived metrics, GCS motor component, and ISS. Models were constructed with three overlapping phases to represent a diagnostic problem: 1) "remote triage" using only R-to-R interval metrics; 2) "prehospital care" using R-to-R interval metrics plus field data including motor component of GCS; 3) "definitive care" using data available during hospitalization, including the ISS. Variables with p value of 0.2 by univariate analysis were chosen as candidates for the logistic regression. Model fit estimated using the Hosmer- Lemeshow goodness-of-fit test, and ROC curves constructed to assess diagnostic performance, with repeat analysis excluding outliers. Final predictive models - in the prehospital predictive model, distribution of symbol 2 was no longer retained after excluding outliers ("model 2") Remote triage model: approximate entropy and distribution of symbol 2 Prehospital model 1: approximate entropy, distribution of symbol 2 and GCS motor component Prehospital model 2: approximate entropy and GCS motor component	NR	0.92 (0.80 to 1.0)
Batchinsky, 2007 * Batchinsky 2007 and Batchinsky 2009 analyze the same ECGs, but differ in measures evaluated.	Remote triage model: approximate entropy and distribution of symbol 2	Mortality	Multiple logistic regressions to identify independent predictors of mortality, using stepwise selection and likelihood ratio tests. Candidate variables were ECG-derived metrics, GCS motor component, and ISS. Models were constructed with three overlapping phases to represent a diagnostic problem: 1) "remote triage" using only R-to-R interval metrics; 2) "prehospital care" using R-to-R interval metrics plus field data including motor component of GCS; 3) "definitive care" using data available during hospitalization, including the ISS. Variables with p value of 0.2 by univariate analysis were chosen as candidates for the logistic regression. Model fit estimated using the Hosmer- Lemeshow goodness-of-fit test, and ROC curves constructed to assess diagnostic performance, with repeat analysis excluding outliers. Final predictive models - in the prehospital predictive model, distribution of symbol 2 was no longer retained after excluding outliers ("model 2") Remote triage model: approximate entropy and distribution of symbol 2 Prehospital model 1: approximate entropy, distribution of symbol 2 and GCS motor component Prehospital model 2: approximate entropy and GCS motor component	NR	0.86 (0.71 to 1.0)

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Batchinsky, 2007 * Batchinsky 2007 and Batchinsky 2009 analyze the same ECGs, but differ in measures evaluated.	Remote triage model: approximate entropy and distribution of symbol 2 excluding outliers	Mortality	Multiple logistic regressions to identify independent predictors of mortality, using stepwise selection and likelihood ratio tests. Candidate variables were ECG-derived metrics, GCS motor component, and ISS. Models were constructed with three overlapping phases to represent a diagnostic problem: 1) "remote triage" using only R-to-R interval metrics; 2) "prehospital care" using R-to-R interval metrics plus field data including motor component of GCS; 3) "definitive care" using data available during hospitalization, including the ISS. Variables with p value of 0.2 by univariate analysis were chosen as candidates for the logistic regression. Model fit estimated using the Hosmer- Lemeshow goodness-of-fit test, and ROC curves constructed to assess diagnostic performance, with repeat analysis excluding outliers. Final predictive models - in the prehospital predictive model, distribution of symbol 2 was no longer retained after excluding outliers ("model 2") Remote triage model: approximate entropy and distribution of symbol 2 Prehospital model 1: approximate entropy, distribution of symbol 2 and GCS motor component Prehospital model 2: approximate entropy and GCS motor component	NR	0.956 (0.86 to 1.0)
Batchinsky, 2009 * Batchinsky 2009 and Batchinsky 2007 analyze the same ECGs, but differ in measures evaluated.	ECG complexity, sample entropy (SampEn): 800 beat data set	Mortality	Multiple logistic regressions with stepwise selection and likelihood ratio tests with candidate variables of all available ECG-derived metrics with a p value <0.2 by univariate analysis (SampEn used instead of ApEn in analysis). Estimation of model fit was by the Hosmer-Lemeshow goodness-of-fit test and estimated odds ratios by the maximum likelihood method. Final models: in all data sets, SampEn was retained as the only independent predictor of death.	AOR (95% CI): 0.00007 (0 to 0.124)	0.895 (0.780 to 1.010)
Batchinsky, 2009 * Batchinsky 2009 and Batchinsky 2007 analyze the same ECGs, but differ in measures evaluated.	ECG complexity, sample entropy (SampEn): 200 beat data set	Mortality	Multiple logistic regressions with stepwise selection and likelihood ratio tests with candidate variables of all available ECG-derived metrics with a p value <0.2 by univariate analysis (SampEn used instead of ApEn in analysis). Estimation of model fit was by the Hosmer-Lemeshow goodness-of-fit test and estimated odds ratios by the maximum likelihood method. Final models: in all data sets, SampEn was retained as the only independent predictor of death.	AOR (95% CI): 0.00045 (0 to 0.159)	0.895 (0.781 to 1.000)

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Batchinsky, 2009 * Batchinsky 2009 and Batchinsky 2007 analyze the same ECGs, but differ in measures evaluated.	ECG complexity, sample entropy (SampEn): 100 beat data set	Mortality	Multiple logistic regressions with stepwise selection and likelihood ratio tests with candidate variables of all available ECG-derived metrics with a p value <0.2 by univariate analysis (SampEn used instead of ApEn in analysis). Estimation of model fit was by the Hosmer-Lemeshow goodness-of-fit test and estimated odds ratios by the maximum likelihood method. Final models: in all data sets, SampEn was retained as the only independent predictor of death.	AOR (95% CI): 0.024 (0.001 to 0.494)	0.821 (0.662 to 0.980)
Batchinsky, 2009b	HRC: Artificial neural network using ECG-derived new vital signs	Life-saving intervention	Artificial neural network model to identify patients who received a life-saving intervention using 16 ECG-derived new vital signs. ROC curves for models after 3-fold, 5-fold, and 10-fold cross validation; the set of variables differed by a few between the cross validation models.	NR	AUC (95% CI) 3-fold cross validation: 0.864 (NR) 5-fold cross validation: 0.861 (NR) 10-fold cross validation: 0.868 (0.812 to 0.924)
Beekley, 2010	BD	LSI	Multivariate logistic regression using stepwise backward elimination technique retaining INR, hematocrit, BD, and DBP.	AOR (95% CI): 1.54 (1.1 to 2.2), for change of -2 mEq/L	NR
Beekley, 2010	DBP	LSI	Multivariate logistic regression using stepwise backward elimination technique retaining INR, hematocrit, BD, and DBP.	AOR (95% CI): 1.54 (1.1 to 2.2), for change of -2	NR
Beekley, 2010	Multivariate model to predict blood transfusion: SBP, INR, tissue hemoglobin index, and hematocrit	LSI	Multivariate logistic regression using stepwise backward elimination technique to predict any blood transfusion; variables retained were SBP, INR, tissue hemoglobin index, and hematocrit.	NR	0.90 (0.84 to 0.96)
Beekley, 2010	Multivariate model to predict LSI: INR, Hematocrit, BD, DBP	LSI	Multivariate logistic regression using stepwise backward elimination technique to predict LSI; variables retained were INR, hematocrit, BD, and DBP.	NR	0.85 (0.79 to 0.91)
Beekley, 2010	SBP	Blood Transfusion	Multivariate logistic regression using stepwise backward elimination technique retaining SBP, INR, tissue hemoglobin index, and hematocrit.	AOR (95% CI): 1.40 (1.1 to 1.8) for change of -10 mmHg	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Brown, 2011	SBP <90	ICU admission	Stepwise logistical regression analysis using all physiologic and anatomic criteria (NTTP steps 1 and 2). Entry of an individual triage criterion into the model was set at p<0.1; confidence intervals calculated as 99%, with p<0.01 considered significant.	AOR (99% CI): 0.80 (0.79–0.82), p<0.01	NR
Brown, 2011	RR <10 or >29	ICU admission	Stepwise logistical regression analysis using all physiologic and anatomic criteria (NTTP steps 1 and 2). Entry of an individual triage criterion into the model was set at p<0.1; confidence intervals calculated as 99%, with p<0.01 considered significant.	AOR (99% CI): 1.45 (1.43-1.46), p<0.01	NR
Brown, 2011	SBP <90	Trauma center need	Stepwise logistical regression analysis using all physiologic and anatomic criteria (NTTP steps 1 and 2). Entry of an individual triage criterion into the model was set at p<0.1; confidence intervals calculated as 99%, with p<0.01 considered significant.	AOR (99% CI): 1.32 (1.29-1.34), p<0.01	NR
Brown, 2011	RR <10 or >29	Trauma center need	Stepwise logistical regression analysis using all physiologic and anatomic criteria (NTTP steps 1 and 2). Entry of an individual triage criterion into the model was set at p<0.1; confidence intervals calculated as 99%, with p<0.01 considered significant.	AOR (99% CI): 1.59 (1.56-1.61), p<0.01	NR
Brown, 2011	SBP <90	ISS >15	Stepwise logistical regression analysis using all physiologic and anatomic criteria (NTTP steps 1 and 2). Entry of an individual triage criterion into the model was set at p<0.1; confidence intervals calculated as 99%, with p<0.01 considered significant.	AOR (99% CI): 1.50 (1.48-1.53), p<0.01	NR
Brown, 2011	RR <10 or >29	ISS >15	Stepwise logistical regression analysis using all physiologic and anatomic criteria (NTTP steps 1 and 2). Entry of an individual triage criterion into the model was set at p<0.1; confidence intervals calculated as 99%, with p<0.01 considered significant.	AOR (99% CI): 1.63 (1.61-1.65), p<0.01	NR
Brown, 2011	SBP <90	Urgent surgery	Stepwise logistical regression analysis using all physiologic and anatomic criteria (NTTP steps 1 and 2). Entry of an individual triage criterion into the model was set at p<0.1; confidence intervals calculated as 99%, with p<0.01 considered significant.	AOR (99% CI): 1.17 (1.15-1.19), p<0.01	NR
Brown, 2011	RR <10 or >29	Urgent surgery	Stepwise logistical regression analysis using all physiologic and anatomic criteria (NTTP steps 1 and 2). Entry of an individual triage criterion into the model was set at p<0.1; confidence intervals calculated as 99%, with p<0.01 considered significant.	AOR (99% CI): 1.05 (1.04-1.07), p<0.01	NR
Cancio, 2008	HRC and motor GCS model: Sample Entropy (SampEn) and Detrended Fluctuations	LSI	Multiple logistic regressions with stepwise selection and likelihood ratio tests using R to-R interval time series variables, GCS motor component, and BP. Maximum likelihood method was used to estimate the odds ratios and confidence intervals.	NR	0.897 (0.839 to 0.956)
Cancio, 2008	HRC model: Sample Entropy (SampEn) and Detrended Fluctuations Analysis (DFA)	LSI	Multiple logistic regressions with stepwise selection and likelihood ratio tests using R-to-R interval time series variables, GCS motor component, and BP. Maximum likelihood method was used to estimate the odds ratios and confidence intervals.	NR	0.760 (0.682 to 0.838)

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Cancio, 2008	HRC: Detrended Fluctuations Analysis (DFA)	LSI	Multiple logistic regressions with stepwise selection and likelihood ratio tests using R to-R interval time series variables, GCS motor component, and BP. Maximum likelihood method was used to estimate the odds ratios and confidence intervals.	AOR (95% CI) SampEn and DFA model: 0.186 (0.081 to 0.428) SampEn, DFA and GCS motor model: 0.142 (0.045 to 0.445)	NR
Cancio, 2008	HRC: Sample Entropy (SampEn)	LSI	Multiple logistic regressions with stepwise selection and likelihood ratio tests using R-to-R interval time series variables, GCS motor component, and BP. Maximum likelihood method was used to estimate the odds ratios and confidence intervals.	AOR (95% CI) SampEn and DFA model: 0.081 (0.026 to 0.251) SampEn, DFA and GCS motor model: 0.077 (0.016 to 0.362)	NR
Cancio, 2008a	DBP	Massive transfusion	Logistic regression analysis using backwards likelihood ratio method with candidate variables different on univariate analysis by p<0.10. The probability of an outcome is given by logistic regression analysis, where $p=e^k/(1+e^k)$. DBP as variable in multivariate model with FTS_{07} for massive transfusion: k = -0.740 - 0.376 x FTS_{07} - 0.011 x DBP	AOR (95% CI): 0.989 (0.979 to 1.000)	NR
Cancio, 2008a	DBP	Massive transfusion	Logistic regression analysis using backwards likelihood ratio method with candidate variables different on univariate analysis by p<0.10. The probability of an outcome is given by logistic regression analysis, where $p=e^k/(1+e^k)$. DBP as variable in RTS-based model for massive transfusion: k = 0.638 - 0.115 x RTS - 0.011 x DBP + 0.358 X SI	AOR (95% CI): 0.989 (0.978 to 0.999)	NR
Cancio, 2008a	FTS_{07} (new Field Triage Score): uses GCS <8 and SBP <100	Mortality, in-hospital	Logistic regression analysis using backwards likelihood ratio method with candidate variables different on univariate analysis by p<0.10. The probability of an outcome is given by logistic regression analysis, where $p=e^k/(1+e^k)$. Model with FTS_{07} for mortality: k = -0.716 - 1.009 x FTS_{07}	AOR (95% CI): 0.365 (0.255 to 0.521)	NR
Cancio, 2008a	FTS_{07} (new Field Triage Score): uses GCS <8 and SBP <100	Massive transfusion	Logistic regression analysis using backwards likelihood ratio method with candidate variables different on univariate analysis by p<0.10. The probability of an outcome is given by logistic regression analysis, where $p=e^k/(1+e^k)$. Model with FTS_{07} for massive transfusion: k = -0.740 - 0.376 x FTS_{07} - 0.011 x DBP	AOR (95% CI): 0.687 (0.524 to 0.900)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Cancio, 2008a	FTS_{07}-based prediction model for massive transfusion: uses FTS_{07} (GCS <8 and SBP <100) and DBP	Massive transfusion	Logistic regression analysis using backwards likelihood ratio method with candidate variables different on univariate analysis by p<0.10. The probability of an outcome is given by logistic regression analysis, where $p=e^k/(1+e^k)$. Model with FTS_{07} for massive transfusion: k = -0.740 - 0.376 x FTS_{07} - 0.011 x DBP	NR	AUC (95% CI): 0.618 (0.569 to 0.666) Accuracy: 61.1%
Cancio, 2008a	FTS_{07}-based prediction model for mortality: FTS_{07} uses GCS <8 and SBP <100	Mortality, in-hospital	Logistic regression analysis using backwards likelihood ratio method with candidate variables different on univariate analysis by p<0.10. The probability of an outcome is given by logistic regression analysis, where $p=e^k/(1+e^k)$. Model with FTS_{07} for mortality: k = -0.716 - 1.009 x FTS_{07}	NR	AUC (95% CI): 0.687 (0.620 to 0.754) Accuracy: 86.8%
Cancio, 2008a	RTS	Massive transfusion	Logistic regression analysis using backwards likelihood ratio method with candidate variables different on univariate analysis by p<0.10. The probability of an outcome is given by logistic regression analysis, where $p=e^k/(1+e^k)$. RTS for massive transfusion: k = 0.638 - 0.115 x RTS - 0.011 x DBP + 0.358 X SI	AOR (95% CI): 0.891 (0.808 to 0.983)	NR
Cancio, 2008a	RTS	Mortality, in-hospital	Logistic regression analysis using backwards likelihood ratio method with candidate variables different on univariate analysis by p<0.10. The probability of an outcome is given by logistic regression analysis, where $p=e^k/(1+e^k)$. RTS for mortality: k = 0.616 - 0.438 x RTS	AOR (95% CI): 0.645 (0.560 to 0.744)	NR
Cancio, 2008a	RTS-based prediction model for massive transfusion	Massive transfusion	Logistic regression analysis using backwards likelihood ratio method with candidate variables different on univariate analysis by p<0.10. The probability of an outcome is given by logistic regression analysis, where $p=e^k/(1+e^k)$. RTS for massive transfusion: k = 0.638 - 0.115 x RTS - 0.011 x DBP + 0.358 X SI	NR	AUC (95% CI): 0.638 (0.590 to 0.686) Accuracy: 61.7%
Cancio, 2008a	RTS-based prediction model for mortality	Mortality, in-hospital	Logistic regression analysis using backwards likelihood ratio method with candidate variables different on univariate analysis by p<0.10. The probability of an outcome is given by logistic regression analysis, where $p=e^k/(1+e^k)$. RTS for mortality: k = 0.616 - 0.438 x RTS	NR	AUC (95% CI): 0.708 (0.643 to 0.774) Accuracy: 86.9%
Cancio, 2008a	SI	Massive transfusion	Logistic regression analysis using backwards likelihood ratio method with candidate variables different on univariate analysis by p<0.10. The probability of an outcome is given by logistic regression analysis, where $p=e^k/(1+e^k)$. SI as variable in RTS-based model for massive transfusion: k = 0.638 - 0.115 x RTS 0.011 x DBP + 0.358 X SI	AOR (95% CI): 1.431 (0.962 to 2.128)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Chen, 2007	Linear classifier using HR and SBP	Major hemorrhage	Simulation was performed 100 times (trials) and the results averaged. Trials used randomly selected testing datasets, each consisting of 54 casualties with balanced outcome classes of 27 casualties per hemorrhage/no hemorrhage class. The ROC curve describes sensitivity and specificity of the classifier as a function of decision threshold Θ. The area under the ROC curve was calculated through trapezoidal integration of 50 evenly-spaced decision thresholds spanning the entire output range.	NR	0.75 (0.745 to 0.755)
Chen, 2007	Linear classifier using HR, SBP and SaO2	Major hemorrhage	Simulation was performed 100 times (trials) and the results averaged. Trials used randomly selected testing datasets, each consisting of 54 casualties with balanced outcome classes of 27 casualties per hemorrhage/no hemorrhage class. The ROC curve describes sensitivity and specificity of the classifier as a function of decision threshold Θ. The area under the ROC curve was calculated through trapezoidal integration of 50 evenly-spaced decision thresholds spanning the entire output range.	NR	0.76 (0.756 to 0.764)
Chen, 2007	Linear classifier using all 5 vital signs: DBP, HR, RR, SaO2 and SBP	Major hemorrhage	Simulation was performed 100 times (trials) and the results averaged. Trials used randomly selected testing datasets, each consisting of 54 casualties with balanced outcome classes of 27 casualties per hemorrhage/no hemorrhage class. The ROC curve describes sensitivity and specificity of the classifier as a function of decision threshold Θ. The area under the ROC curve was calculated through trapezoidal integration of 50 evenly-spaced decision thresholds spanning the entire output range.	NR	0.74 (0.735 to 0.745)
Chen, 2010	Photoplethysmogram (PPG) model: Amplitude IQR and reliable vital signs	Major hemorrhage	Multivariate regression routine stepwise fit in MATLAB (version 7.0; The MathWorks, Natick, Mass) to compare the discriminatory power of models with and without each investigational PPG metric, in addition to the five basic vital signs (i.e., HR, RR, SpO2, SBP, and DBP). The routine uses an F statistic to evaluate additional discriminatory power provided by the investigative PPG metric and decides whether the PPG metric should be included based on a significance threshold of p<0.05.	NR	0.82 (CI NR)
Chen, 2010	Photoplethysmogram (PPG) model: Amplitude max-min and reliable vital signs	Major hemorrhage	Multivariate regression routine stepwise fit in MATLAB (version 7.0; The MathWorks, Natick, Mass) to compare the discriminatory power of models with and without each investigational PPG metric, in addition to the five basic vital signs (i.e., HR, RR, SpO2, SBP, and DBP). The routine uses an F statistic to evaluate additional discriminatory power provided by the investigative PPG metric and decides whether the PPG metric should be included based on a significance threshold of p<0.05.	NR	0.81 (CI NR)
Chen, 2010	Photoplethysmogram (PPG) model: Peak height IQR and reliable vital signs	Major hemorrhage	Multivariate regression routine stepwise fit in MATLAB (version 7.0; The MathWorks, Natick, Mass) to compare the discriminatory power of models with and without each investigational PPG metric, in addition to the five basic vital signs (i.e., HR, RR, SpO2, SBP, and DBP). The routine uses an F statistic to evaluate additional discriminatory power provided by the investigative PPG metric and decides whether the PPG metric should be included based on a significance threshold of p<0.05.	NR	0.81 (CI NR)

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Chen, 2010	Photoplethysmogram (PPG) model: Peak height max-min and reliable vital signs	Major hemorrhage	Multivariate regression routine stepwise fit in MATLAB (version 7.0; The MathWorks, Natick, Mass) to compare the discriminatory power of models with and without each investigational PPG metric, in addition to the five basic vital signs (i.e., HR, RR, SpO2, SBP, and DBP). The routine uses an F statistic to evaluate additional discriminatory power provided by the investigative PPG metric and decides whether the PPG metric should be included based on a significance threshold of p<0.05.	NR	0.79 (CI NR)
Chen, 2010	Reliable vital signs model: HR, RR, SpO2, SBP, and DBP	Major hemorrhage	Multivariate regression routine stepwise fit in MATLAB (version 7.0; The MathWorks, Natick, Mass) to compare the discriminatory power of models with and without each investigational PPG metric, in addition to the five basic vital signs (i.e., HR, RR, SpO2, SBP, and DBP). The routine uses an F statistic to evaluate additional discriminatory power provided by the investigative PPG metric and decides whether the PPG metric should be included based on a significance threshold of p<0.05.	NR	0.79 (CI NR)
Cherry, 2007	SBP <90, ED	Mortality	Piecewise proportional hazards model. Variables: ED SBP <90, out of hospital RR >29 or <10, intubation status, and ED GCS <8.	Hazard ratio (95% CI): 6.6 (2.8 to 15.8)	NR
Cooke, 2006a	Heart rate variability: HF/LF	Mortality	Multivariate model: The between group difference seen in HF/LF (R-R spectral power at the high frequency/R-R spectral power at the low frequency) was adjusted for variables that also indicated between group differences (from univariate analysis). These covariates included age, GCS score, and RRI (interbeat R-R interval).	Likelihood ratio (χ^2 HF/LF) HF/LF, no covariate: 9.96, p=0.0016 HF/LF, covariate age: 5.19, p=0.0227 HF/LF, covariate RRI: 7.06, p=0.007 HF/LF, covariate GCS: 1.96, p=0.1619 HF/LF, covariates age,	NR
Cudnik, 2012	Author-derived model: age >44 years, SBP <90 mmHg, flail chest, and GCS <14	Mortality	Multivariable logistic regression with forward stepwise selection with a p-value >0.05 for removal of variables, but forced variables considered to have significant clinical relevance back into the model. Model fit was assessed using the Hosmer-Lemeshow goodness-of-fit test.	NR	AUC (95% CI): 0.9213 (NR) Sensitivity: 100% (84-100) Specificity: 50% (49-51)
Dinh, 2014	Vital signs: any abnormal (HR <50 or >110, SBP <90 or >180, RR <10 or >24)	Major trauma	Multivariable logistic regression model. Age (≥65), abnormal vital signs (HR <50 or >110, SBP <90 or >180, RR <10 or >24), abnormal GCS (≤13), and penetrating injury were entered a priori, with other mechanisms of injury entered as indicator variables using a stepwise selection algorithm with an entry and selection criterion p<0.05. All first-order interactions between age, mechanism of injury and regions of injury were fed into the model to test for effect modification.	AOR (95% CI): 3.72 (2.64 to 5.25), p<0.001	NR
Edla, 2015b	HRV and vital signs model: HRV (rate of sinus arrhythmia), HR,	Blood transfusion ≥1 pRBC unit in 24 hours	Multivariate logistic regression models consisting of different combinations of routine vital signs and rate of sinus arrhythmia (RSA).	NR	0.79 (NR)

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Edla, 2015b	HRV and vital signs model: HRV (rate of sinus arrhythmia), HR,	Blood transfusion ≥5 pRBC units in 24 hours	Multivariate logistic regression models consisting of different combinations of routine vital signs and rate of sinus arrhythmia (RSA).	NR	0.86 (NR)
Edla, 2015b	HRV and vital signs model: HRV (rate of sinus arrhythmia), HR,	Blood transfusion ≥9 pRBC units in 24 hours	Multivariate logistic regression models consisting of different combinations of routine vital signs and rate of sinus arrhythmia (RSA).	NR	0.88 (NR)
Edla, 2015b	Vital signs model: HR, RR, SBP, pulse pressure	Blood transfusion ≥1 pRBC unit in 24 hours	Multivariate logistic regression models consisting of different combinations of routine vital signs and rate of sinus arrhythmia (RSA).	NR	0.79 (0.70 to 0.85)
Edla, 2015b	Vital signs model: HR, RR, SBP, pulse pressure	Blood transfusion ≥5 pRBC units in 24 hours	Multivariate logistic regression models consisting of different combinations of routine vital signs and rate of sinus arrhythmia (RSA).	NR	0.85 (0.73 to 0.92)
Edla, 2015b	Vital signs model: HR, RR, SBP, pulse pressure	Blood transfusion ≥9 pRBC units in 24 hours	Multivariate logistic regression models consisting of different combinations of routine vital signs and rate of sinus arrhythmia (RSA).	NR	0.86 (0.73 to 0.94)
Garner, 2001	Capillary refill >2 seconds	Critical injury	Logistic regression model using physiologic variables predicting critical injury. The Hosmer-Lemeshow test was used to determine goodness of fit, and means of correlation among independent factors and the variance inflate factor were used to assess colinearity. A jackknife technique was used to validate the model. Model 1 variables: RR ≥30 vs. <30 breaths/min, GCS-motor component ≤5 vs. 6, SBP <80 vs. ≥80 mm Hg, capillary refill >2 vs. ≤2 seconds, and HR >120 vs. ≤120 bpm. Model 2 variables: RR <10 or >29 vs. 10-29 breaths/min, GCS-motor component ≤5 vs. 6, SBP <80 vs. ≥80 mm Hg, capillary refill >2 vs. ≤2 seconds, and HR >120 vs. ≤120 bpm. *Models 1 & 2 use different respiratory rate variables, but the other variables are the same.	AOR (95% CI) Model 1: 3.56 (1.31 to 9.67) Model 2: 3.39 (1.22 to 9.44)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Garner, 2001	HR >120	Critical injury	Logistic regression model using physiologic variables predicting critical injury. The Hosmer-Lemeshow test was used to determine goodness of fit, and means of correlation among independent factors and the variance inflate factor were used to assess colinearity. A jackknife technique was used to validate the model. Model 1 variables: RR ≥30 vs. <30 breaths/min, GCS-motor component ≤5 vs. 6, SBP <80 vs. ≥80 mm Hg, capillary refill >2 vs. ≤2 seconds, and HR >120 vs. ≤120 bpm. Model 2 variables: RR <10 or >29 vs. 10-29 breaths/min, GCS-motor component ≤5 vs. 6, SBP <80 vs. ≥80 mm Hg, capillary refill >2 vs. ≤2 seconds, and HR >120 vs. ≤120 bpm. *Models 1 & 2 use different respiratory rate variables, but the other variables are the same.	AOR (95% CI) Model 1: 2.53 (1.15–5.60) Model 2: 2.45 (1.10–5.48)	NR
Garner, 2001	RR <10 or >29	Critical injury	Logistic regression model using physiologic variables predicting critical injury. The Hosmer-Lemeshow test was used to determine goodness of fit, and means of correlation among independent factors and the variance inflate factor were used to assess colinearity. A jackknife technique was used to validate the model. Model 1 variables: RR ≥30 vs. <30 breaths/min, GCS-motor component ≤5 vs. 6, SBP <80 vs. ≥80 mm Hg, capillary refill >2 vs. ≤2 seconds, and HR >120 vs. ≤120 bpm. Model 2 variables: RR <10 or >29 vs. 10-29 breaths/min, GCS-motor component ≤5 vs. 6, SBP <80 vs. ≥80 mm Hg, capillary refill >2 vs. ≤2 seconds, and HR >120 vs. ≤120 bpm. *Models 1 & 2 use different respiratory rate variables, but the other variables are the same.	AOR (95% CI): 2.64 (1.21 to 5.76)	NR
Garner, 2001	RR ≥30	Critical injury	Logistic regression model using physiologic variables predicting critical injury. The Hosmer-Lemeshow test was used to determine goodness of fit, and means of correlation among independent factors and the variance inflate factor were used to assess colinearity. A jackknife technique was used to validate the model. Model 1 variables: RR ≥30 vs. <30 breaths/min, GCS-motor component ≤5 vs. 6, SBP <80 vs. ≥80 mm Hg, capillary refill >2 vs. ≤2 seconds, and HR >120 vs. ≤120 bpm. Model 2 variables: RR <10 or >29 vs. 10-29 breaths/min, GCS-motor component ≤5 vs. 6, SBP <80 vs. ≥80 mm Hg, capillary refill >2 vs. ≤2 seconds, and HR >120 vs. ≤120 bpm. *Models 1 & 2 use different respiratory rate variables, but the other variables are the same.	AOR (95% CI): 2.35 (0.99 to 5.61)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Garner, 2001	SBP <80	Critical injury	Logistic regression model using physiologic variables predicting critical injury. The Hosmer-Lemeshow test was used to determine goodness of fit, and means of correlation among independent factors and the variance inflate factor were used to assess colinearity. A jackknife technique was used to validate the model. Model 1 variables: RR ≥30 vs. <30 breaths/min, GCS-motor component ≤5 vs. 6, SBP <80 vs. ≥80 mm Hg, capillary refill >2 vs. ≤2 seconds, and HR >120 vs. ≤120 bpm. Model 2 variables: RR <10 or >29 vs. 10-29 breaths/min, GCS-motor component ≤5 vs. 6, SBP <80 vs. ≥80 mm Hg, capillary refill >2 vs. ≤2 seconds, and HR >120 vs. ≤120 bpm. *Models 1 & 2 use different respiratory rate variables, but the other variables are the same.	AOR (95% CI): Model 1: 31.73 (9.18 to 109.71) Model 2: 31.00 (8.74 to 110.01)	NR
Guyette, 2011	HR >110	Mortality	Multivariable logistic regression with candidate variables of age, sex, initial SBP <100, HR >110, RR ≥30 and GCS <15. Interactions between the variables were systematically searched, and colinearity was considered when r>0.8 (Spearman coefficient matrix correlation). Discrimination of the final models with and without serum lactate (>2.0 mmol/L) was assessed by the likelihood ratio χ2 statistics and the difference in the area under the ROC curves.	AOR (95% CI): 0.97 (0.96 to 0.98)	NR
Guyette, 2011	Lactate >2.0	Emergent surgery	Multivariable logistic regression with candidate variables of age, sex, initial SBP <100, HR >110, RR ≥30 and GCS <15. Interactions between the variables were systematically searched, and colinearity was considered when r>0.8 (Spearman coefficient matrix correlation). Discrimination of the final models with and without serum lactate (>2.0 mmol/L) was assessed by the likelihood ratio χ2 statistics and the difference in the area under the ROC curves.	AOR (95% CI): 1.13 (1.05 to 1.21)	NR
Guyette, 2011	Lactate >2.0	Mortality	Multivariable logistic regression with candidate variables of age, sex, initial SBP <100, HR >110, RR ≥30 and GCS <15. Interactions between the variables were systematically searched, and colinearity was considered when r>0.8 (Spearman coefficient matrix correlation). Discrimination of the final models with and without serum lactate (>2.0 mmol/L) was assessed by the likelihood ratio χ2 statistics and the difference in the area under the ROC curves.	AOR (95% CI): 1.23 (1.14 to 1.34)	NR
Guyette, 2011	Lactate >2.0	Multiple organ dysfunction	Multivariable logistic regression with candidate variables of age, sex, initial SBP <100, HR >110, RR ≥30 and GCS <15. Interactions between the variables were systematically searched, and colinearity was considered when r>0.8 (Spearman coefficient matrix correlation). Discrimination of the final models with and without serum lactate (>2.0 mmol/L) was assessed by the likelihood ratio χ2 statistics and the difference in the area under the ROC curves.	AOR (95% CI): 1.14 (1.03 to 1.23)	NR
Guyette, 2011	SBP <100	Emergent surgery	Multivariable logistic regression with candidate variables of age, sex, initial SBP <100, HR >110, RR ≥30 and GCS <15. Interactions between the variables were systematically searched, and colinearity was considered when r>0.8 (Spearman coefficient matrix correlation). Discrimination of the final models with and without serum lactate (>2.0 mmol/L) was assessed by the likelihood ratio χ2 statistics and the difference in the area under the ROC curves.	AOR (95% CI): 0.98 (0.97 to 0.99)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Guyette, 2011	Author-created model: Lactate >2, SI >0.8, HR >110, SBP <100, RR ≥30, and GCS <15	Emergent operation	Multivariable logistic regression with candidate variables of age, sex, initial SBP <100, HR >110, RR ≥30 and GCS <15. Interactions between the variables were systematically searched, and colinearity was considered when r>0.8 (Spearman coefficient matrix correlation). Discrimination of the final models with and without serum lactate (>2.0 mmol/L) was assessed by the likelihood ratio χ2 statistics and the difference in the area under the ROC curves.	NR	AUC: NR Sensitivity: 86% (77-93) Specificity: 25% (22-18)
Guyette, 2011	Author-created model: Lactate >2, GCS <15, HR >110, and SBP <100	Emergent surgery	Multivariable logistic regression with candidate variables of age, sex, initial SBP <100, HR >110, RR ≥30 and GCS <15. Interactions between the variables were systematically searched, and colinearity was considered when r>0.8 (Spearman coefficient matrix correlation). Discrimination of the final models with and without serum lactate (>2.0 mmol/L) was assessed by the likelihood ratio χ2 statistics and the difference in the area under the ROC curves.	NR	0.71 (CI NR)
Guyette, 2011	Author-created model: SI >0.8, HR >110, SBP <100, RR ≥30, and GCS <15	Emergent surgery	Multivariable logistic regression with candidate variables of age, sex, initial SBP <100, HR >110, RR ≥30 and GCS <15. Interactions between the variables were systematically searched, and colinearity was considered when r>0.8 (Spearman coefficient matrix correlation). Discrimination of the final models with and without serum lactate (>2.0 mmol/L) was assessed by the likelihood ratio χ2 statistics and the difference in the area under the ROC curves.	NR	AUC: NR Sensitivity: 64% (53-74) Specificity: 51% (48-54)
Guyette, 2011	Author-created model: Lactate >2, GCS <15, HR >110, and SBP <100	Mortality	Multivariable logistic regression with candidate variables of age, sex, initial SBP <100, HR >110, RR ≥30 and GCS <15. Interactions between the variables were systematically searched, and colinearity was considered when r>0.8 (Spearman coefficient matrix correlation). Discrimination of the final models with and without serum lactate (>2.0 mmol/L) was assessed by the likelihood ratio χ2 statistics and the difference in the area under the ROC curves.	NR	0.89 (CI NR)
Guyette, 2011	Author-created model: Lactate >2, SI >0.8, HR >110, SBP <100, RR ≥30, and GCS <15	Mortality	Multivariable logistic regression with candidate variables of age, sex, initial SBP <100, HR >110, RR ≥30 and GCS <15. Interactions between the variables were systematically searched, and colinearity was considered when r>0.8 (Spearman coefficient matrix correlation). Discrimination of the final models with and without serum lactate (>2.0 mmol/L) was assessed by the likelihood ratio χ2 statistics and the difference in the area under the ROC curves.	NR	AUC: NR Sensitivity: 97% (89-100) Specificity: 25% (23-28)
Guyette, 2011	Author-created model: SI >0.8, HR >110, SBP <100, RR ≥30, and GCS <15	Mortality	Multivariable logistic regression with candidate variables of age, sex, initial SBP <100, HR >110, RR ≥30 and GCS <15. Interactions between the variables were systematically searched, and colinearity was considered when r>0.8 (Spearman coefficient matrix correlation). Discrimination of the final models with and without serum lactate (>2.0 mmol/L) was assessed by the likelihood ratio χ2 statistics and the difference in the area under the ROC curves.	NR	AUC: NR Sensitivity: 88% (77-95) Specificity: 52% (49-55)
Guyette, 2011	Author-created model: Lactate >2, GCS <15, HR >110, and SBP <100	Multiple organ dysfunction	Multivariable logistic regression with candidate variables of age, sex, initial SBP <100, HR >110, RR ≥30 and GCS <15. Interactions between the variables were systematically searched, and colinearity was considered when r>0.8 (Spearman coefficient matrix correlation). Discrimination of the final models with and without serum lactate (>2.0 mmol/L) was assessed by the likelihood ratio χ2 statistics and the difference in the area under the ROC curves.	NR	0.81 (CI NR)

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Guyette, 2011	Author-created model: Lactate >2, SI >0.8, HR >110, SBP <100, RR ≥30, and GCS <15	Multiple organ dysfunction	Multivariable logistic regression with candidate variables of age, sex, initial SBP <100, HR >110, RR ≥30 and GCS <15. Interactions between the variables were systematically searched, and colinearity was considered when r>0.8 (Spearman coefficient matrix correlation). Discrimination of the final models with and without serum lactate (>2.0 mmol/L) was assessed by the likelihood ratio $\chi2$ statistics and the difference in the area under the ROC curves.	NR	AUC: NR Sensitivity: 99% (92-100) Specificity: 25% (23-28)
Guyette, 2011	Author-created model: SI >0.8, HR >110, SBP <100, RR ≥30, and GCS <15	Multiple organ dysfunction	Multivariable logistic regression with candidate variables of age, sex, initial SBP <100, HR >110, RR ≥30 and GCS <15. Interactions between the variables were systematically searched, and colinearity was considered when r>0.8 (Spearman coefficient matrix correlation). Discrimination of the final models with and without serum lactate (>2.0 mmol/L) was assessed by the likelihood ratio $\chi2$ statistics and the difference in the area under the ROC curves.	NR	AUC: NR Sensitivity: 94% (85-98) Specificity: 53% (50-56)
Guyette, 2012	Deoxygenation slope (DeO2)	Life-saving intervention	Multivariable logistic regression models using covariates of age, sex, vital signs, lactate, and mental status (GCS).	AOR (95% CI): 2.5 (1.3	NR
Guyette, 2012	Reoxygenation slope (ReO2)	Life-saving intervention	Multivariable logistic regression models using covariates of age, sex, vital signs, lactate, and mental status (GCS).	AOR (95% CI): 0.8 (0.6	NR
Guyette, 2012	SBP, lowest EMS	Life-saving intervention	Multivariable logistic regression models using covariates of age, sex, vital signs, lactate, and mental status (GCS).	AOR (95% CI): 0.97 (0.93 to 0.99), p=0.002	NR
Guyette, 2015	Airway or bag valve mask attempted	Need for resuscitative care	Multivariable logistic regression using: lactate (modeled as a linear spline with knots at 2.5 mmol/L and 4.0 mmol/L), age (modeled as spline with one knot at 45 years), male sex, penetrating injury, prehospital vital signs (SBP per 5 mmHg, SI per increment of 0.1, initial GCS score per increment of 1), airway status (any airway/bag valve mask attempted), and regional site (as a fixed effect). Two patients were missing SI and were excluded from the model.	AOR (95% CI): 4.55 (1.40 to 15.43)	NR
Guyette, 2015	Lactate (POC), EMS	Need for resuscitative care	Multivariable logistic regression using: lactate (modeled as a linear spline with knots at 2.5 mmol/L and 4.0 mmol/L), age (modeled as spline with one knot at 45 years), male sex, penetrating injury, prehospital vital signs (SBP per 5 mmHg, SI per increment of 0.1, initial GCS score per increment of 1), airway status (any airway/bag valve mask attempted), and regional site (as a fixed effect). Two patients were missing SI and were excluded from the model.	AOR (95% CI) Lactate: <2.5: 1.76 (0.41 to 12.93) 2.5-3.9: 3.61 (1.67 to 8.35)	NR
Guyette, 2015	SBP, EMS	Need for resuscitative care	Multivariable logistic regression using: lactate (modeled as a linear spline with knots at 2.5 mmol/L and 4.0 mmol/L), age (modeled as spline with one knot at 45 years), male sex, penetrating injury, prehospital vital signs (SBP per 5 mmHg, SI per increment of 0.1, initial GCS score per increment of 1), airway status (any airway/bag valve mask attempted), and regional site (as a fixed effect). Two patients were missing SI and were excluded from the model.	AOR (95% CI): 0.92 (0.73 to 1.15)	NR
Guyette, 2015	SI, EMS	Need for resuscitative care	Multivariable logistic regression using: lactate (modeled as a linear spline with knots at 2.5 mmol/L and 4.0 mmol/L), age (modeled as spline with one knot at 45 years), male sex, penetrating injury, prehospital vital signs (SBP per 5 mmHg, SI per increment of 0.1, initial GCS score per increment of 1), airway status (any airway/bag valve mask attempted), and regional site (as a fixed effect). Two patients were missing SI and were excluded from the model.	AOR (95% CI): 1.21 (1.06 to 1.38)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Henry, 1996	RR <10 or >29	ISS ≥16	Logistic regression model containing all ACS trauma triage criteria without regard to statistical significance. Includes SBP, GCS, RR, 3 anatomic criteria, age, known cardiac or respiratory disease and 8 mechanism criteria.	AOR (95% CI): 2.5 (0.6-9.8), not significant	NR
Henry, 1996	RR <10 or >29	Major non-orthopedic interventions or death	Logistic regression model containing all ACS trauma triage criteria without regard to statistical significance. Includes SBP, GCS, RR, 3 anatomic criteria, age, known cardiac or respiratory disease and 8 mechanism criteria.	AOR (95% CI): 5.0 (0.8-29.9), not significant	NR
Henry, 1996	SBP <90	ISS ≥16	Logistic regression model containing all ACS trauma triage criteria without regard to statistical significance. Includes SBP, GCS, RR, 3 anatomic criteria, age, known cardiac or respiratory disease and 8 mechanism criteria.	AOR (95% CI): 4.6 (1.0-19.9), not significant	NR
Henry, 1996	SBP <90	Major non-orthopedic interventions or death	Logistic regression model containing all ACS trauma triage criteria without regard to statistical significance. Includes SBP, GCS, RR, 3 anatomic criteria, age, known cardiac or respiratory disease and 8 mechanism criteria.	AOR (95% CI): 14.0 (2.3-84.0), significant p-value not reported	NR
Holcomb, 2005	Automated/Group 3: radial pulse character, eye and motor GCS, and SBP	Life-saving intervention	Multivariable analysis using a logistic regression model to determine the subset of variable that best predicted need for LSI. Variables included in analysis varied according to group. - Group 1 (manual): pulse character (radial, femoral, and carotid), capillary refill, GCS motor and verbal components, and demographics readily available in the field (sex, age, race, mechanism of injury) - Group 2 (semi automated): variables used in Group 1, plus pulse oximetry (SpO2) and GCS eye component - Group 3 (fully automated): variables used in Groups 1 & 2, plus all fully automated (monitor) vital signs (SBP, DBP, MAP, HR), RR, and end-tidal CO2 (EtCO2)	NR	AUC (95% CI) Prehospital LSI: 0.975 (NR) Hospital LSI: 0.717 (NR), p <0.05 Any LSI: 0.846 (NR)
Holcomb, 2005	Manual/Group 1: Radial pulse character, verbal and motor GCS	Life-saving intervention	Multivariable analysis using a logistic regression model to determine the subset of variable that best predicted need for LSI. Variables included in analysis varied according to group. - Group 1 (manual): pulse character (radial, femoral, and carotid), capillary refill, GCS motor and verbal components, and demographics readily available in the field (sex, age, race, mechanism of injury)	NR	AUC (95% CI) Prehospital LSI: 0.969 (NR) Hospital LSI: 0.619 (NR) Any LSI: 0.804 (NR)
Holcomb, 2005	Semi-automated/Group 2: Radial pulse character, eye and motor GCS	Life-saving intervention	Multivariable analysis using a logistic regression model to determine the subset of variable that best predicted need for LSI. Variables included in analysis varied according to group. - Group 1 (manual): pulse character (radial, femoral, and carotid), capillary refill, GCS motor and verbal components, and demographics readily available in the field (sex, age, race, mechanism of injury) - Group 2 (semi automated): variables used in Group 1, plus pulse oximetry (SpO2) and GCS eye component	NR	AUC (95% CI) Prehospital LSI: 0.970 (NR) Hospital LSI: 0.616 (NR), p <0.05 Any LSI: 0.807 (NR)
Holcomb, 2005b	SBP <90 and GCS motor score	Need for LSI	ROC curve derived from two-variable multivariate logistic regression model with indicator values for abnormal GCS motor score <6 and abnormal SBP <90.	NR	0.744 (CI NR)

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Holcomb, 2005b	SBP <90 and motor GCS <6	Need for LSI	Multivariate logistic regression models. Initial model evaluation using stepwise selection with subsequent best-subset regression. Only variables that were statistically significant and contributed to the stability of the regression estimates were retained in the final model. Multivariate probabilities were computed by standard transformation of the logistic regression odds. Used continuous variable cutoff points that are commonly used in the clinical arena.	Probability of LSI: 95%	NR
Holcomb, 2005b	SBP <90 and motor GCS = 6	Need for LSI	Multivariate logistic regression models. Initial model evaluation using stepwise selection with subsequent best-subset regression. Only variables that were statistically significant and contributed to the stability of the regression estimates were retained in the final model. Multivariate probabilities were computed by standard transformation of the logistic regression odds. Used continuous variable cutoff points that are commonly used in the clinical arena.	Probability of LSI: 77%	NR
Holcomb, 2005b	SBP ≥90 and motor GCS <6	Need for LSI	Multivariate logistic regression models. Initial model evaluation using stepwise selection with subsequent best-subset regression. Only variables that were statistically significant and contributed to the stability of the regression estimates were retained in the final model. Multivariate probabilities were computed by standard transformation of the logistic regression odds. Used continuous variable cutoff points that are commonly used in the clinical arena.	Probability of LSI: 61%	NR
Holcomb, 2005b	SBP ≥90 and motor GCS = 6	Need for LSI	Multivariate logistic regression models. Initial model evaluation using stepwise selection with subsequent best-subset regression. Only variables that were statistically significant and contributed to the stability of the regression estimates were retained in the final model. Multivariate probabilities were computed by standard transformation of the logistic regression odds. Used continuous variable cutoff points that are commonly used in the clinical arena.	Probability of LSI: 21%	NR
Imhoff, 2014	HR	Mortality, in-hospital	Multiple logistic regression including all parameters in REMS (age, MAP, HR, RR, oxygen saturation and GCS). Odds Ratios used to estimate relative strength of parameters in score.	AOR (95% CI): 0.996 (0.990 - 1.002),	NR
Imhoff, 2014	MAP	Mortality, in-hospital	Multiple logistic regression including all parameters in REMS (age, MAP, HR, RR, oxygen saturation and GCS). Odds Ratios used to estimate relative strength of parameters in score.	AOR (95% CI): 0.979 (0.973 -0.986),	NR
Imhoff, 2014	Oxygen saturation (SaO2)	Mortality, in-hospital	Multiple logistic regression including all parameters in REMS (age, MAP, HR, RR, oxygen saturation and GCS). Odds Ratios used to estimate relative strength of parameters in score.	AOR (95% CI): 0.961 (0.940-0.982),	NR
Imhoff, 2014	RR	Mortality, in-hospital	Multiple logistic regression including all parameters in REMS (age, MAP, HR, RR, oxygen saturation and GCS). Odds Ratios used to estimate relative strength of parameters in score.	AOR (95% CI): 1.001 (0.978-1.025),	NR
King, 2009	Heart rate variability (SDNN) ≤24 msec	Life-saving intervention in the OR	Multiple logistic regression model examining the marginal effect of heart rate variability (SDNN) and controlling for HR, SBP, GCS and subjective high suspicion of injury.	AOR (95% CI): 11.7 (2.1 to 65.4)	NR
King, 2009	Heart rate variability (SDNN) ≤39 msec	Serious injury	Multiple logistic regression model examining the marginal effect of heart rate variability (SDNN) and controlling for HR, SBP, GCS and subjective high suspicion of injury.	AOR (95% CI): 5.8 (1.9 to 17.1)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Kondo, 2011	SBP, ED	Mortality, in-hospital	Logistic regression model fit to the derivation data set to develop the GAP scoring system. Predictors categories as in development of MGAP: GCS entered into the model without modification; SBP as 3 categories (<60, 60-120, >120), age dichotomized (<60 or ≥60).	ß coefficient for SBP >120: -1.93 (SE 0.11) 60-120: -1.23 (SE 0.12) <60: reference	NR
Lehmann, 2007	HR <60, EMS	Emergent intervention	Stepwise logistic regression for dichotomous dependent variables for end point of requiring emergent intervention. Limits of entry into the regression were set at 0.05, and at 0.10 for the variable to be removed. Variables subjected to regression were key demographic and triage variables. Independent prehospital predictors were found to be GCS <14, labored or absent respiratory effort, penetrating truncal injury, and SBP <100 mmHg.	AOR (95% CI): 0.77 (0.225 to 2.6), p=0.675	NR
Lehmann, 2007	HR >110, EMS	Emergent intervention	Stepwise logistic regression for dichotomous dependent variables for end point of requiring emergent intervention. Limits of entry into the regression were set at 0.05, and at 0.10 for the variable to be removed. Variables subjected to regression were key demographic and triage variables. Independent prehospital predictors were found to be GCS <14, labored or absent respiratory effort, penetrating truncal injury, and SBP <100 mmHg.	AOR (95% CI): 1.06 (0.655 to 1.74), p=0.791	NR
Lehmann, 2007	SBP <100, ED	Emergent intervention	Stepwise logistic regression for dichotomous dependent variables for end point of requiring emergent intervention. Limits of entry into the regression were set at 0.05, and at 0.10 for the variable to be removed. Variables subjected to regression were key demographic and triage variables. Independent prehospital predictors were found to be GCS <14, labored or absent respiratory effort, penetrating truncal injury, and SBP <100 mmHg.	AOR (95% CI): 5.22 (2.55 to 10.67), p<0.001	NR
Lehmann, 2007	SBP <100, EMS	Emergent intervention	Stepwise logistic regression for dichotomous dependent variables for end point of requiring emergent intervention. Limits of entry into the regression were set at 0.05, and at 0.10 for the variable to be removed. Variables subjected to regression were key demographic and triage variables. Independent prehospital predictors were found to be GCS <14, labored or absent respiratory effort, penetrating truncal injury, and SBP <100 mmHg.	AOR (95% CI) EMS SBP <100 mmHg: 3.3 (1.6 to 6.8), p<0.01	NR
Liu, 2014a	HR: standard vital sign monitor	Life-saving intervention in ED	Multivariate logistic regression analyses were performed for control subjects (standard vital sign monitor) alone with independent variables of age, height, race, and weight and dependent variables of ED vital signs and GCS. Variables not significantly associated with ED LSIs were removed via backward elimination. The same analyses were also performed for wireless vital sign monitor (WVSM) subjects. The final models included dependent variables of HR, RR, and SBP.	AOR (95% CI), per unit increase: 1.02 (1.01-1.04), p=0.01	NR
Liu, 2014a	HR: wireless vital sign monitor	Life-saving intervention in ED	Multivariate logistic regression analyses were performed for control subjects (standard vital sign monitor) alone with independent variables of age, height, race, and weight and dependent variables of ED vital signs and GCS. Variables not significantly associated with ED LSIs were removed via backward elimination. The same analyses were also performed for wireless vital sign monitor (WVSM) subjects. The final models included dependent variables of HR, RR, and SBP.	AOR (95% CI), per unit increase: 1.02 (0.99-1.06), p=0.21	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Liu, 2014a	RR: standard vital sign monitor	Life-saving intervention in ED	Multivariate logistic regression analyses were performed for control subjects (standard vital sign monitor) alone with independent variables of age, height, race, and weight and dependent variables of ED vital signs and GCS. Variables not significantly associated with ED LSIs were removed via backward elimination. The same analyses were also performed for wireless vital sign monitor (WVSM) subjects. The final models included dependent variables of HR, RR, and SBP.	AOR (95% CI), per unit increase: 1.02 (0.99-1.04), p=0.16	NR
Liu, 2014a	RR: wireless vital sign monitor	Life-saving intervention in ED	Multivariate logistic regression analyses were performed for control subjects (standard vital sign monitor) alone with independent variables of age, height, race, and weight and dependent variables of ED vital signs and GCS. Variables not significantly associated with ED LSIs were removed via backward elimination. The same analyses were also performed for wireless vital sign monitor (WVSM) subjects. The final models included dependent variables of HR, RR, and SBP.	AOR (95% CI), per unit increase: 1.10 (1.01-1.21), p=0.02	NR
Liu, 2014a	SBP: standard vital sign monitor	Life-saving intervention in ED	Multivariate logistic regression analyses were performed for control subjects (standard vital sign monitor) alone with independent variables of age, height, race, and weight and dependent variables of ED vital signs and GCS. Variables not significantly associated with ED LSIs were removed via backward elimination. The same analyses were also performed for wireless vital sign monitor (WVSM) subjects. The final models included dependent variables of HR, RR, and SBP.	AOR (95% CI), per unit increase: 0.96 (0.94-0.97), p<0.0001	NR
Liu, 2014a	SBP: wireless vital sign monitor	Life-saving intervention in ED	Multivariate logistic regression analyses were performed for control subjects (standard vital sign monitor) alone with independent variables of age, height, race, and weight and dependent variables of ED vital signs and not significantly associated with ED LSIs were removed via backward elimination. The same analyses were also performed for wireless vital sign monitor (WVSM) subjects. The final models included dependent variables of HR, RR, and SBP.	AOR (95% CI), per unit increase: 0.94 (0.91-0.97), p=0.0007	NR
Liu, 2014a	Standard vital sign monitor using HR, RR, and SBP	Life-saving intervention in ED	Receiver operating characteristic curves were obtained to examine the discriminating power of multivariate logistic regression models for the outcome of ≥1 life-saving intervention in the ED. Final models included dependent variables of HR, RR, and SBP.	NR	0.81 (NR)
Liu, 2014a	Standard vital sign monitor using HR, RR, and SBP	Life-saving intervention, prehospital or ED	Receiver operating characteristic curves were obtained to examine the discriminating power of multivariate logistic regression models for the outcome of ≥1 life-saving intervention in the ED or field. Final models included dependent variables of HR, RR, and SBP.	NR	0.87 (NR)
Liu, 2014a	Wireless vital sign monitor using HR, RR, and SBP	Life-saving intervention in ED	Receiver operating characteristic curves were obtained to examine the discriminating power of multivariate logistic regression models for the outcome of ≥1 life-saving intervention in the ED. Final models included dependent variables of HR, RR, and SBP.	NR	0.86 (NR)
Liu, 2014a	Wireless vital sign monitor using HR, RR, and SBP	Life-saving intervention, prehospital or ED	Receiver operating characteristic curves were obtained to examine the discriminating power of multivariate logistic regression models for the outcome of ≥1 life-saving intervention in the ED or field. Final models included dependent variables of HR, RR, and SBP.	NR	0.94 (NR)

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Liu, 2014b	Heart rate complexity (HRC)	Life-saving intervention	Initial multivariate logistic regression analysis was done using independent demographic variables of age, height, race and weight, and dependent vital sign variables of HR, SBP, DBP, MAP, RR, and SI. Non-significant factors (p>0.05) were removed using backward elimination; these were age, height, race and weight. Further analyses were done for the dependent vital sign variables, with and without heart rate complexity (HRC), and with and without total GCS score.	*Multivariate model: Vital signs + minimum HRC vs. Vital signs + minimum HRC + total GCS score* AOR (95% CI), per unit increase: 0.00001 (0.00 to 0.05) vs. 0.002 (0.00 to 11.29)	NR
Liu, 2014b	HR	Life-saving intervention	Multivariate model with vital signs alone. Initial multivariate logistic regression analysis was done using independent demographic variables of age, height, race and weight, and dependent vital sign variables of HR, SBP, DBP, MAP, RR, and SI. Non-significant factors (p>0.05) were removed using backward elimination. Further analyses were done for the dependent vital sign variables, with and without heart rate complexity (HRC), and with and without total GCS score.	Multivariate model: Vital signs alone vs. Vital signs + minimum HRC vs. Vital signs + total GCS score AOR (95% CI), per beats/min increase: 1.05 (1.03 to 1.09) vs. 1.05 (1.02 to 1.08) vs. 1.05 (1.01 to 1.11)	NR
Liu, 2014b	Machine learning model using HR, GCS, and HRC	Life-saving intervention	Receiver operator characteristic curves were obtained to examine the discriminating power of the machine learning model, a three-layer perceptron model using inputs of mean HR, GCS score, and heart rate complexity, and 3 hidden nodes. This ML model yielded the best results out of multiple machine learning models including artificial neural networks. Outcome was at least one LSI.	NR	0.99 (NR)
Liu, 2014b	Vital signs + GCS + HRC model	Life-saving intervention	Multivariate model with vital signs, total GCS score and minimum HRC. Receiver operator characteristic curves were obtained to examine the discriminating power of the multivariate models. Models through multivariate logistic regression analyses with different combinations of vital signs (HR, SBP, DBP, MAP, RR, and SI), minimum heart rate complexity (HRC), and total GCS score.	NR	0.94 (NR)
Liu, 2014b	Vital signs + GCS model	Life-saving intervention	Multivariate model with vital signs and total GCS score. Receiver operator characteristic curves were obtained to examine the discriminating power of the multivariate models. Models through multivariate logistic regression analyses with different combinations of vital signs (HR, SBP, DBP, MAP, RR, and SI), minimum heart rate complexity (HRC), and total GCS score.	NR	0.92 (NR)
Liu, 2014b	Vital signs + HRC model	Life-saving intervention	Multivariate model with vital signs and minimum HRC. Receiver operator characteristic curves were obtained to examine the discriminating power of the multivariate models. Models through multivariate logistic regression analyses with different combinations of vital signs (HR, SBP, DBP, MAP, RR, and SI), minimum heart rate complexity (HRC), and total GCS score.	NR	0.81 (NR)

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Liu, 2014b	Vital signs model	Life-saving intervention	Multivariate model with vital signs only. Receiver operator characteristic curves were obtained to examine the discriminating power of the multivariate models. Models through multivariate logistic regression analyses with different combinations of vital signs (HR, SBP, DBP, MAP, RR, and SI), minimum heart rate complexity (HRC), and total GCS score.	NR	0.73 (NR)
Liu, 2015a	HR	LSI	Multivariate logistic regression modeling was performed to estimate the power of demographics, vital signs, HRV, HRC, and GCS scores to identify nonsurvivors and receipt of life-saving interventions. Initial analyses used independent variables of age, height, race and weight and dependent variables of HR, SBP, DBP, MAP, RR and SI; factors that were not significant (p>0.05) were removed via backward elimination. Further analyses were done for vital signs with and without HRC and HRV and with and without GCS scores.	*Multivariate model: Vital signs alone vs. Vital signs + minimum HRC* AOR (95% CI): 1.01 (0.99 to 1.04) vs. 1.00 (0.98 to 1.03)	NR
Liu, 2015a	HR	Mortality	Multivariate logistic regression modeling was performed to estimate the power of demographics, vital signs, HRV, HRC, and GCS scores to identify nonsurvivors and receipt of life-saving interventions. Initial analyses used independent variables of age, height, race and weight and dependent variables of HR, SBP, DBP, MAP, RR and SI; factors that were not significant (p>0.05) were removed via backward elimination. Further analyses were done for vital signs with and without HRC and HRV and with and without GCS scores.	*Multivariate model: Vital signs alone vs. Vital signs + minimum HRC vs. Vital signs + maximum HRV* AOR (95% CI): 1.04 (1.01 to 1.09) vs. 1.05 (1.01 to 1.09) vs. 1.06 (1.02 to 1.12)	NR
Liu, 2015a	Maximum HRV ratio	Mortality	Multivariate logistic regression modeling was performed to estimate the power of demographics, vital signs, HRV, HRC, and GCS scores to identify nonsurvivors and receipt of life-saving interventions. Initial analyses used independent variables of age, height, race and weight and dependent variables of HR, SBP, DBP, MAP, RR and SI; factors that were not significant (p>0.05) were removed via backward elimination. Further analyses were done for vital signs with and without HRC and HRV and with and without GCS scores.	*Multivariate model: Vital signs + maximum HRV* AOR (95% CI): 9.43 (1.68 to 76.7), p=0.011	NR
Liu, 2015a	Minimum HRC	LSI	Multivariate logistic regression modeling was performed to estimate the power of demographics, vital signs, HRV, HRC, and GCS scores to identify nonsurvivors and receipt of life-saving interventions. Initial analyses used independent variables of age, height, race and weight and dependent variables of HR, SBP, DBP, MAP, RR and SI; factors that were not significant (p>0.05) were removed via backward elimination. Further analyses were done for vital signs with and without HRC and HRV and with and without GCS scores.	*Multivariate model: Vital signs + minimum HRC vs. Vital signs + minimum HRC + GCS score* AOR (95% CI): 0.02 (0.00 to 0.14), p<0.0001 vs. 0.01 (0.00 to 0.10)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Liu, 2015a	Minimum HRC	Mortality	Multivariate logistic regression modeling was performed to estimate the power of demographics, vital signs, HRV, HRC, and GCS scores to identify nonsurvivors and receipt of life-saving interventions. Initial analyses used independent variables of age, height, race and weight and dependent variables of HR, SBP, DBP, MAP, RR and SI; factors that were not significant (p>0.05) were removed via backward elimination. Further analyses were done for vital signs with and without HRC and HRV and with and without GCS scores.	*Multivariate model: Vital signs + minimum HRC vs. Vital signs + minimum HRC + GCS score* AOR (95% CI): 0.01 (0.00 to 0.58) vs. 0.20 (0.01 to 1.98)	NR
Liu, 2015a	Vital signs + maximum HRV model	LSI	Multivariate logistic regression modeling was performed to estimate the power of demographics, vital signs, HRV, HRC, and GCS scores to identify nonsurvivors and receipt of life-saving interventions. Initial analyses used independent variables of age, height, race and weight and dependent variables of HR, SBP, DBP, MAP, RR and SI; factors that were not significant (p>0.05) were removed via backward elimination. Further analyses were done for vital signs with and without HRC and HRV and with and without GCS scores.	NR	0.73 (NR)
Liu, 2015a	Vital signs + maximum HRV model	Mortality	Multivariate logistic regression modeling was performed to estimate the power of demographics, vital signs, HRV, HRC, and GCS scores to identify nonsurvivors and receipt of life-saving interventions. Initial analyses used independent variables of age, height, race and weight and dependent variables of HR, SBP, DBP, MAP, RR and SI; factors that were not significant (p>0.05) were removed via backward elimination. Further analyses were done for vital signs with and without HRC and HRV and with and without GCS scores.	NR	0.86 (NR)
Liu, 2015a	Vital signs + minimum HRC + GCS model	LSI	Multivariate logistic regression modeling was performed to estimate the power of demographics, vital signs, HRV, HRC, and GCS scores to identify nonsurvivors and receipt of life-saving interventions. Initial analyses used independent variables of age, height, race and weight and dependent variables of HR, SBP, DBP, MAP, RR and SI; factors that were not significant (p>0.05) were removed via backward elimination. Further analyses were done for vital signs with and without HRC and HRV and with and without GCS scores.	NR	0.97 (NR)
Liu, 2015a	Vital signs + minimum HRC + GCS model	Mortality	Multivariate logistic regression modeling was performed to estimate the power of demographics, vital signs, HRV, HRC, and GCS scores to identify nonsurvivors and receipt of life-saving interventions. Initial analyses used independent variables of age, height, race and weight and dependent variables of HR, SBP, DBP, MAP, RR and SI; factors that were not significant (p>0.05) were removed via backward elimination. Further analyses were done for vital signs with and without HRC and HRV and with and without GCS scores.	NR	0.82 (NR)
Liu, 2015a	Vital signs + minimum HRC model	LSI	Multivariate logistic regression modeling was performed to estimate the power of demographics, vital signs, HRV, HRC, and GCS scores to identify nonsurvivors and receipt of life-saving interventions. Initial analyses used independent variables of age, height, race and weight and dependent variables of HR, SBP, DBP, MAP, RR and SI; factors that were not significant (p>0.05) were removed via backward elimination. Further analyses were done for vital signs with and without HRC and HRV and with and without GCS scores.	NR	0.86 (NR)

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Liu, 2015a	Vital signs + minimum HRC model	Mortality	Multivariate logistic regression modeling was performed to estimate the power of demographics, vital signs, HRV, HRC, and GCS scores to identify nonsurvivors and receipt of life-saving interventions. Initial analyses used independent variables of age, height, race and weight and dependent variables of HR, SBP, DBP, MAP, RR and SI; factors that were not significant (p>0.05) were removed via backward elimination. Further analyses were done for vital signs with and without HRC and HRV and with and without GCS scores.	NR	0.86 (NR)
Liu, 2015a	Vital signs alone model	LSI	Multivariate logistic regression modeling was performed to estimate the power of demographics, vital signs, HRV, HRC, and GCS scores to identify nonsurvivors and receipt of life-saving interventions. Initial analyses used independent variables of age, height, race and weight and dependent variables of HR, SBP, DBP, MAP, RR and SI; factors that were not significant (p>0.05) were removed via backward elimination. Further analyses were done for vital signs with and without HRC and HRV and with and without GCS scores.	NR	0.57 (NR)
Liu, 2015a	Vital signs alone model	Mortality	Multivariate logistic regression modeling was performed to estimate the power of demographics, vital signs, HRV, HRC, and GCS scores to identify nonsurvivors and receipt of life-saving interventions. Initial analyses used independent variables of age, height, race and weight and dependent variables of HR, SBP, DBP, MAP, RR and SI; factors that were not significant (p>0.05) were removed via backward elimination. Further analyses were done for vital signs with and without HRC and HRV and with and without GCS scores.	NR	0.79 (NR)
Liu, 2015b	HR	LSI	Initial multivariate logistic regression analysis was done using independent demographic variables of age, height, race and weight, and dependent vital sign variables of HR, SBP, DBP, MAP, RR, and SI. Non-significant factors (p>0.05) were removed using backward elimination. Analyses were done for the dependent vital sign variables, with and without data quality indices (percent valid values, deviation ratio).	*Multivariate models: Vital signs alone vs. Vital signs + data quality indices vs. Vital signs + total GCS score vs. Vital signs + data quality indices + total GCS score* AOR (95% CI), per unit increase: 1.05 (1.03 to 1.09) vs. 1.05 (1.02 to 1.08) vs. 1.05 (1.01 to 1.11) vs. 1.07 (1.02 to 1.15)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Liu, 2015b	HR data quality: % valid values	LSI	Initial multivariate logistic regression analysis was done using independent demographic variables of age, height, race and weight, and dependent vital sign variables of HR, SBP, DBP, MAP, RR, and SI. Non-significant factors (p>0.05) were removed using backward elimination. Analyses were done for the dependent vital sign variables, with and without data quality indices (percent valid values, deviation ratio).	*Multivariate models: Vital signs + data quality indices vs. Vital signs + data quality indices + total GCS score* AOR (95% CI), per unit increase: 0.97 (0.95 to 0.99) vs. 0.99 (0.95 to 1.03)	NR
Liu, 2015b	HR data quality: deviation ratio	LSI	Initial multivariate logistic regression analysis was done using independent demographic variables of age, height, race and weight, and dependent vital sign variables of HR, SBP, DBP, MAP, RR, and SI. Non-significant factors (p>0.05) were removed using backward elimination. Analyses were done for the dependent vital sign variables, with and without data quality indices (percent valid values, deviation ratio).	*Multivariate models: Vital signs + data quality indices vs. Vital signs + data quality indices + total GCS score* AOR (95% CI), per unit increase: 0.92 (0.86 to 0.97) vs. 0.91 (0.81 to 1.00)	NR
Liu, 2015b	Vital signs + data quality indices model	LSI	Multivariate model with vital signs and data quality indices. Receiver operating characteristic curves were obtained to examine the discriminating power of the multivariate logistic regression models. Initial multivariate logistic regression analysis was done using independent demographic variables of age, height, race and weight, and dependent vital sign variables of HR, SBP, DBP, MAP, RR, and SI. Non-significant factors (p>0.05) were removed using backward elimination. Analyses were done for the dependent vital sign variables, with and without data quality indices (percent valid values, deviation ratio).	NR	0.86 (NR)
Liu, 2015b	Vital signs + GCS + data quality indices model	LSI	Multivariate model with vital signs + total GCS score + data quality indices. Receiver operating characteristic curves were obtained to examine the discriminating power of the multivariate logistic regression models. Initial multivariate logistic regression analysis was done using independent demographic variables of age, height, race and weight, and dependent vital sign variables of HR, SBP, DBP, MAP, RR, and SI. Non-significant factors (p>0.05) were removed using backward elimination. Analyses were done for the dependent vital sign variables, with and without data quality indices (percent valid values, deviation ratio).	NR	0.99 (NR)

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Liu, 2015b	Vital signs + GCS model	LSI	Multivariate model with vital signs + total GCS score. Receiver operating characteristic curves were obtained to examine the discriminating power of the multivariate logistic regression models. Initial multivariate logistic regression analysis was done using independent demographic variables of age, height, race and weight, and dependent vital sign variables of HR, SBP, DBP, MAP, RR, and SI. Non-significant factors (p>0.05) were removed using backward elimination. Analyses were done for the dependent vital sign variables, with and without data quality indices (percent valid values, deviation ratio).	NR	0.92 (NR)
Liu, 2015b	Vital signs model	LSI	Multivariate model with vital signs alone. Receiver operating characteristic curves were obtained to examine the discriminating power of the multivariate logistic regression models. Initial multivariate logistic regression analysis was done using independent demographic variables of age, height, race and weight, and dependent vital sign variables of HR, SBP, DBP, MAP, RR, and SI. Non-significant factors (p>0.05) were removed using backward elimination. Analyses were done for the dependent vital sign variables, with and without data quality indices (percent valid values, deviation ratio).	NR	0.73 (NR)
Mackenzie, 2014 *Mackenzie, 2014 study population included in Shackelford, 2015	Automated prediction, Group 1: HR (EMS), age and sex	Blood transfusion (3 hours, 24 hours)	Multiple logistic regression models, always adjusted for age and sex, selecting best combination of vital signs features based on a stepwise procedure. Prediction models were cross-validated using leave-one-out method for training and testing. Sensitivity and specificity calculated for optimal thresholds determined by the Youden index.	NR	Transfusion in 3 hours AUC (95% CI): 0.62 (0.51 to 0.74) Sensitivity 94%, specificity 29% Transfusion in 24 hours AUC (95% CI): 0.57 (0.53 to 0.67) Sensitivity 38%,
Mackenzie, 2014 *Mackenzie, 2014 study population included in Shackelford, 2015	Automated prediction, Group 2: PPG waveform features, HR (EMS), age and sex 15 minutes PPG duration	Blood transfusion (3 hours, 24 hours)	Multiple logistic regression models, always adjusted for age and sex, selecting best combination of vital signs features based on a stepwise procedure. Prediction models were cross-validated using leave-one-out method for training and testing. Sensitivity and specificity calculated for optimal thresholds determined by the Youden index.	NR	Transfusion in 3 hours AUC (95% CI): 0.78 (0.65 to 0.92) Sensitivity 76%, specificity 78% Transfusion in 24 hours AUC (95% CI): 0.74 (0.65 to 0.84) Sensitivity 68%,

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Mackenzie, 2014 *Mackenzie, 2014 study population included in Shackelford, 2015	Automated prediction, Group 3: vital signs features (PPG, HR, SpO2), HR (EMS), age and sex 15 minutes PPG duration	Blood transfusion (3 hours, 24 hours)	Multiple logistic regression models, always adjusted for age and sex, selecting best combination of vital signs features based on a stepwise procedure. Prediction models were cross-validated using leave-one-out method for training and testing. Sensitivity and specificity calculated for optimal thresholds determined by the Youden index.	NR	Transfusion in 3 hours AUC (95% CI): 0.83 (0.72 to 0.95) Sensitivity 76%, specificity 83% Transfusion in 24 hours AUC (95% CI): 0.81 (0.72 to 0.90) Sensitivity 78%,
Mackenzie, 2014 *Mackenzie, 2014 study population included in Shackelford, 2015	Automated prediction, Group 3: vital signs features (PPG, HR, SpO2), HR (EMS), age and sex	Massive transfusion	Multiple logistic regression models, always adjusted for age and sex, selecting best combination of vital signs features based on a stepwise procedure. Prediction models were cross-validated using leave-one-out method for training and testing. Sensitivity and specificity calculated for optimal thresholds determined by the Youden index.	NR	0.92 (NR)
Mackenzie, 2014 *Mackenzie, 2014 study population included in Shackelford, 2015	Automated prediction, Group 3: vital signs features (PPG, HR, SpO2), HR (EMS), age and sex	Mortality: in-hospital	Multiple logistic regression models, always adjusted for age and sex, selecting best combination of vital signs features based on a stepwise procedure. Prediction models were cross-validated using leave-one-out method for training and testing. Sensitivity and specificity calculated for optimal thresholds determined by the Youden index.	NR	0.94 (NR)
Mackenzie, 2014 *Mackenzie, 2014 study population included in Shackelford, 2015	Automated prediction, Group 3: vital signs features (PPG, HR, SpO2), HR (EMS), age and sex	Hospital LOS >3 days	Multiple logistic regression models, always adjusted for age and sex, selecting best combination of vital signs features based on a stepwise procedure. Prediction models were cross-validated using leave-one-out method for training and testing. Sensitivity and specificity calculated for optimal thresholds determined by the Youden index.	NR	0.72 (NR)
Mackenzie, 2014 *Mackenzie, 2014 study population included in Shackelford, 2015	Automated prediction, Group 4: PPG waveform features, HR features, SpO2 features, SI (EMS), age and sex 15 minutes PPG duration	Blood transfusion (3 hours, 24 hours)	Multiple logistic regression models, always adjusted for age and sex, selecting best combination of vital signs features based on a stepwise procedure. Prediction models were cross-validated using leave-one-out method for training and testing. Sensitivity and specificity calculated for optimal thresholds determined by the Youden index.	NR	Transfusion in 3 hours AUC (95% CI): 0.80 (0.68 to 0.93) Sensitivity 76%, specificity 80% Transfusion in 24 hours AUC (95% CI): 0.81 (0.73 to 0.89) Sensitivity 81%,

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Mackenzie, 2014 *Mackenzie, 2014 study population included in Shackelford, 2015	Automated prediction, Group 4: PPG waveform features, HR features, SpO2 features, SI	Mortality: in-hospital	Multiple logistic regression models, always adjusted for age and sex, selecting best combination of vital signs features based on a stepwise procedure. Prediction models were cross-validated using leave-one-out method for training and testing. Sensitivity and specificity calculated for optimal thresholds determined by the Youden index.	NR	0.94 (NR)
Mackenzie, 2014 *Mackenzie, 2014 study population included in Shackelford, 2015	Automated prediction, Group 4: PPG waveform features, HR features, SpO2 features, SI	Hospital LOS >3 days	Multiple logistic regression models, always adjusted for age and sex, selecting best combination of vital signs features based on a stepwise procedure. Prediction models were cross-validated using leave-one-out method for training and testing. Sensitivity and specificity calculated for optimal thresholds determined by the Youden index.	NR	0.71 (NR)
Mackenzie, 2014 *Mackenzie, 2014 study population included in Shackelford, 2015	Automated prediction, Group 4: PPG waveform features, HR features, SpO2 features, SI	Massive transfusion	Multiple logistic regression models, always adjusted for age and sex, selecting best combination of vital signs features based on a stepwise procedure. Prediction models were cross-validated using leave-one-out method for training and testing. Sensitivity and specificity calculated for optimal thresholds determined by the Youden index.	NR	0.88 (NR)
Mackenzie, 2015 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	Pulse oximeter (PPG) algorithm to predict blood transfusion	Blood transfusion within 6 hours	Algorithms to predict each outcome using 30 features of the pulse oximeter signal: 12 features of the photoplethysmograph waveform, 9 features from the SpO2 signal, and 9 features from the HR signal. Cross-validation of the model using a leave-one-out methodology was used to assess the robustness of the algorithm versus clinical judgment.	NR	AUC (95% CI): 0.92 (NR) Sensitivity 100% (NR) Specificity 70% (NR)

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Mackenzie, 2015 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	Pulse oximeter (PPG) algorithm to predict surgical intervention	Surgical intervention within 6 hours	Algorithms to predict each outcome using 30 features of the pulse oximeter signal: 12 features of the photoplethysmograph waveform, 9 features from the SpO2 signal, and 9 features from the HR signal. Cross-validation of the model using a leave-one-out methodology was used to assess the robustness of the algorithm versus clinical judgment.	NR	0.74 (NR)
Matsushima, 2016	HR >100, EMS	Need for trauma center care	Multivariable analysis using a logistic regression model. Variables selected as clinically significant by authors, including age ≥65 years, male gender, EMS HR >100, EMS SBP <110, failure of airbag deployment, and use of seatbelt.	AOR (95% CI): 1.37 (1.13-1.66), p=0.001	NR
Matsushima, 2016	SBP <110, EMS	Need for trauma center care	Multivariable analysis using a logistic regression model. Variables selected as clinically significant by authors, including age ≥65 years, male gender, EMS HR >100, EMS SBP <110, failure of airbag deployment, and use of seatbelt.	AOR (95% CI): 2.41 (1.78-3.27), p <0.0001	NR
McNab, 2013	SI: increase from prehospital to trauma center	Mortality	Logistic regression analysis performed on 2 age groups to investigate increase in shock index (from out of hospital to ED) and relationship with mortality. Odds Ration are adjusted for age and sex	AOR (95% CI) Age 16-60: 0.941 (NR) Age ≥60.1: 1.826 (NR)	NR
Moore, 2006	SBP	Mortality	Logistic regression models using GCS, SBP, and RR as coded categories corresponding to the Revised Trauma Score (RTS) values. Missing values for GCS, SBP and RR were imputed using Multiple Imputation, with a set of indicator variables representing trauma center. There were 4 models evaluated: GCS (coded), SBP (coded), RR (coded), and RTS (GCS + SBP + RR, all coded). The models were repeated with fractional polynomial transformations (FP).	NR	AUC (95% CI) Coded for RTS model: 0.594 (NR) Fractional polynomial model: 0.666 (NR)
Moore, 2006	RR	Mortality	Logistic regression models using GCS, SBP, and RR as coded categories corresponding to the Revised Trauma Score (RTS) values. Missing values for GCS, SBP and RR were imputed using Multiple Imputation, with a set of indicator variables representing trauma center. There were 4 models evaluated: GCS (coded), SBP (coded), RR (coded), and RTS (GCS + SBP + RR, all coded). The models were repeated with fractional polynomial transformations (FP).	NR	AUC (95% CI) Coded for RTS model: 0.563 (NR) Fractional polynomial model: 0.655 (NR)
Moore, 2006	RTS	Mortality	Logistic regression models using GCS, SBP, and RR as coded categories corresponding to the Revised Trauma Score (RTS) values. Missing values for GCS, SBP and RR were imputed using Multiple Imputation, with a set of indicator variables representing trauma center. There were 4 models evaluated: GCS (coded), SBP (coded), RR (coded), and RTS (GCS + SBP + RR, all coded). The models were repeated with fractional polynomial transformations (FP). Fractional polynomial model used transformation of RTS components separately, and not a transformation of the RTS.	NR	AUC (95% CI) RTS coded: 0.841 (NR) Fractional polynomial of components: 0.874 (NR)

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Nabaweesi, 2014	HR <60 or >160 if < 5 years <50 or >140 if ≥ 5 years	Intense resource use	Multivariate logistic regression to identify potential associations between the prehospital trauma team activation criteria and ICU use, OR use, and death. Dependent variable was intense use of resources (ED disposition to the ICU, OR or morgue) and the following indicator variables: low SBP, respiratory distress, abnormal heart rate, GCS <9, chest injury, abdominal injury, spine injury, air vs. ground, health insurance, non-white vs. white, ages 5-9 vs. 0-4, and ages 10-14 vs. 0-4.	AOR (95% CI): 2.6 (1.04 to 6.27), p=0.039	NR
Nabaweesi, 2014	SBP <80 if < 5 years <90 if ≥ 5 years	Intense resource use	Multivariate logistic regression to identify potential associations between the prehospital trauma team activation criteria and ICU use, OR use, and death. Dependent variable was intense use of resources (ED disposition to the ICU, OR or morgue) and the following indicator variables: low SBP, respiratory distress, abnormal heart rate, GCS <9, chest injury, abdominal injury, spine injury, air vs. ground, health insurance, non-white vs. white, ages 5-9 vs. 0-4, and ages 10-14 vs. 0-4.	AOR (95% CI): 0.3 (0.298 to 3.425), p=0.334	NR
Nabaweesi, 2014	Respiratory distress RR <20 or >60 if < 1 year RR <10 or >40 if ≥ 1 year	Intense resource use	Multivariate logistic regression to identify potential associations between the prehospital trauma team activation criteria and ICU use, OR use, and death. Dependent variable was intense use of resources (ED disposition to the ICU, OR or morgue) and the following indicator variables: low SBP, respiratory distress, abnormal heart rate, GCS <9, chest injury, abdominal injury, spine injury, air vs. ground, health insurance, non-white vs. white, ages 5-9 vs. 0-4, and ages 10-14 vs. 0-4.	AOR (95% CI): 2.9 (0.72 to 11.8), p=0.133	NR
Newgard, 2014 *Newgard, 2016 study population is included in Newgard, 2014	Current physiologic triage criteria: validation sample	Serious injury	Multivariable regression models, fractional polynomials and binary recursive partitioning (CART analysis) to evaluate appropriate physiologic cut-points and the value of different physiologic triage criteria. Three CART analyses using different combinations of variables and high-sensitivity (95%) for decision tree generation were run on a derivation sample (60% of patients), with cross-validation methods employed to reduce over-fitting the dataset. Information from the fractional polynomial models and CART analyses were coupled to generate new physiologic triage criteria for older adults.	NR	AUC (95% CI): 0.77 (NR) Sensitivity: 78.6% (CI NR) Specificity: 75.5% (CI NR)
Newgard, 2014 *Newgard, 2016 study population is included in Newgard, 2014	Revised physiologic triage criteria: validation sample (current physiologic triage criteria, GCS ≤14, assisted	Serious injury	Multivariable regression models, fractional polynomials and binary recursive partitioning (CART analysis) to evaluate appropriate physiologic cut-points and the value of different physiologic triage criteria. Three CART analyses using different combinations of variables and high-sensitivity (95%) for decision tree generation were run on a derivation sample (60% of patients), with cross-validation methods employed to reduce over-fitting the dataset. Information from the fractional polynomial models and CART analyses were coupled to generate new physiologic triage criteria for older adults.	NR	AUC (95% CI): 0.73 (NR) Sensitivity: 86.3% (CI NR) Specificity: 60.7% (CI NR)

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Newgard, 2014 *Newgard, 2016 study population is included in Newgard, 2014	Decision tree 1 (CART analysis): derivation sample (7 physiologic measures)	Serious injury	Multivariable regression models, fractional polynomials and binary recursive partitioning (CART analysis) to evaluate appropriate physiologic cut-points and the value of different physiologic triage criteria. Three CART analyses using different combinations of variables and high-sensitivity (95%) for decision tree generation were run on a derivation sample (60% of patients), with cross-validation methods employed to reduce over-fitting the dataset. Information from the fractional polynomial models and CART analyses were coupled to generate new physiologic triage criteria for older adults. - Decision Tree 1: physiologic measures; GCS, RR, SBP, SI, assisted ventilation, intubation and HR	NR	0.68 (NR)
Newgard, 2014 *Newgard, 2016 study population is included in Newgard, 2014	Decision tree 2 (CART analysis): derivation sample (physiologic measures and current physiologic triage criteria; 11 variables)	Serious injury	Multivariable regression models, fractional polynomials and binary recursive partitioning (CART analysis) to evaluate appropriate physiologic cut-points and the value of different physiologic triage criteria. Three CART analyses using different combinations of variables and high-sensitivity (95%) for decision tree generation were run on a derivation sample (60% of patients), with cross-validation methods employed to reduce over-fitting the dataset. Information from the fractional polynomial models and CART analyses were coupled to generate new physiologic triage criteria for older adults. - Decision Tree 2: physiologic measures (GCS, RR, SBP, SI, HR, intubation and assisted ventilation) and current physiologic triage criteria (GCS ≤13, SBP <90, airway, RR <10 or >29)	NR	0.70 (NR)
Rainer, 2011	SBP ≤90	Massive transfusion	Multivariate logistic regression with variables significant on univariate analysis (p<0.05) as candidate variables. Non-significant variables were removed stepwise until only significant variables remained. Final model variables were used as the predictive model for massive transfusion, composed of SBP, GCS, HR, displaced pelvic fracture, positive CT or FAST scan, BD, and hemoglobin.	AOR (95% CI): 9.0 (NR)	NR
Rainer, 2011	HR ≥120	Massive transfusion	Multivariate logistic regression with variables significant on univariate analysis (p<0.05) as candidate variables. Non-significant variables were removed stepwise until only significant variables remained. Final model variables were used as the predictive model for massive transfusion, composed of SBP, GCS, HR, displaced pelvic fracture, positive CT or FAST scan, BD, and hemoglobin.	AOR (95% CI): 3.2 (NR)	NR
Rainer, 2011	BD < -5	Massive transfusion	Multivariate logistic regression with variables significant on univariate analysis (p<0.05) as candidate variables. Non-significant variables were removed stepwise until only significant variables remained. Final model variables were used as the predictive model for massive transfusion, composed of SBP, GCS, HR, displaced pelvic fracture, positive CT or FAST scan, BD, and hemoglobin.	AOR (95% CI): 4.8 (NR)	NR
Ramanathan, 2015	Lactate >2.0	ISS >15	Logistic regression using lactate, base deficit and pH as dichotomous variables and dichotomous outcome of ISS (≤15 vs. ISS >15).	AOR (95% CI): 3.89	NR
Ramanathan, 2015	BD < -5	ISS >15	Logistic regression using lactate, base deficit and pH as dichotomous variables and dichotomous outcome of ISS (≤15 vs. ISS >15).	AOR (95% CI): 3.09	NR
Ramanathan, 2015	pH <7.30	ISS >15	Logistic regression using lactate, base deficit and pH as dichotomous variables and dichotomous outcome of ISS (≤15 vs. ISS >15).	AOR (95% CI): 9.86	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Raux, 2006	RTS neutralized for RR (RTSn)	Mortality	Forced logistic models to predict death by adding RR and SpO2 to RTSn. RR and/or SpO2 were entered into the models in 3 different ways: dichotomous variables, 5 severity classes, and continuous variables.	AOR (95% CI): 0.424 (0.360 to 0.499), p<0.001	0.911 (CI NR)
Raux, 2011 *Raux 2011 and Sartorius 2010 analyze the same study population	HR ≥100: National cohort	Emergency procedure	Multiple forward stepwise logistic regression using a semiparimonious approach and only unbiased variables available on the injury scene. Interactions between the variables were systematically searched, and colinearity between variables was considered when r>0.8 (Spearman coefficient matrix correlation). Final model discrimination was assessed by c-statistics, and calibration by the Hosmer-Lemeshow statistic, with internal validation performed using 10-fold cross validation.	AOR (95% CI): 1.42 (1.12 to 1.79), p=0.004	NR
Raux, 2011 *Raux 2011 and Sartorius 2010 analyze the same study population	SBP <100: National cohort	Emergency procedure	Multiple forward stepwise logistic regression using a semiparimonious approach and only unbiased variables available on the injury scene. Interactions between the variables were systematically searched, and colinearity between variables was considered when r>0.8 (Spearman coefficient matrix correlation). Final model discrimination was assessed by c-statistics, and calibration by the Hosmer-Lemeshow statistic, with internal validation performed using 10-fold cross validation.	AOR (95% CI): 1.42 (1.10 to 1.84), p=0.006	NR
Raux, 2011 *Raux 2011 and Sartorius 2010 analyze the same study population	Model using prehospital predictors: penetrating trauma, IV colloid administration >750 mL, SBP	Emergency procedure	Multiple forward stepwise logistic regression using a semiparimonious approach and only unbiased variables available on the injury scene. Interactions between the variables were systematically searched, and colinearity between variables was considered when r>0.8 (Spearman coefficient matrix correlation). Final model discrimination was assessed by c-statistics, and calibration by the Hosmer-Lemeshow statistic, with internal validation performed using 10-fold cross validation.	NR	AUC (95% CI) Derivation cohort overall: 0.65 (SD 0.03) After cross validation: 0.65 (SD 0.03) observed difference
Raux, 2017	Model 1: RTS, lactate, BD	Mortality, 30-day in-hospital	Multiple logistic regressions to assess the predictive performances of blood lactate and base deficit knowing RTS or MGAP score. Discrimination was quantified by calculating the concordance statistic completed with optimism, the difference of AUC between the entire population and the cross validated population. Reclassification was conducted by calculating the net reclassification index. Blood lactate and base deficit were forced into the models and should be considered as competitors.	NR	0.88 (NR), optimism <0.01
Raux, 2017	RTS: model 1 (RTS)	Mortality, 30-day in-hospital	Multiple logistic regressions to assess the predictive performances of blood lactate and base deficit knowing RTS or MGAP score. Discrimination was quantified by calculating the concordance statistic completed with optimism, the difference of AUC between the entire population and the cross validated population. Reclassification was conducted by calculating the net reclassification index. Blood lactate and base deficit were forced into the models and should be considered as competitors.	AOR (95% CI): 2.55 (2.18 to 2.99), p<0.001 per 1-point decrease	NR
Raux, 2017	Lactate: model 1 (RTS)	Mortality, 30-day in-hospital	Multiple logistic regressions to assess the predictive performances of blood lactate and base deficit knowing RTS or MGAP score. Discrimination was quantified by calculating the concordance statistic completed with optimism, the difference of AUC between the entire population and the cross validated population. Reclassification was conducted by calculating the net reclassification index. Blood lactate and base deficit were forced into the models and should be considered as competitors.	AOR (95% CI): 1.21 (1.05 to 1.39), p=0.007 per 1-mmol/L increase	AUC (95% CI), with Lactate vs. baseline RTS model: 0.913 (NR) vs. 0.890 (NR), p=0.01 Net reclassification

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Raux, 2017	BD: model 1 (RTS)	Mortality, 30-day in-hospital	Multiple logistic regressions to assess the predictive performances of blood lactate and base deficit knowing RTS or MGAP score. Discrimination was quantified by calculating the concordance statistic completed with optimism, the difference of AUC between the entire population and the cross validated population. Reclassification was conducted by calculating the net reclassification index. Blood lactate and base deficit were forced into the models and should be considered as competitors.	AOR (95% CI): 1.00 (0.93 to 1.08), p=0.96 per 1-mmol/L increase	AUC (95% CI), with BD vs baseline RTS model: 0.902 (NR) vs. 0.890 (NR), p=0.17 Net reclassification index: 0.20 (SD 0.10),
Raux, 2017	Model 2: MGAP, lactate, BD	Mortality: 48-hour	Multiple logistic regressions to assess the predictive performances of blood lactate and base deficit knowing RTS or MGAP score. Discrimination was quantified by calculating the concordance statistic completed with optimism, the difference of AUC between the entire population and the cross validated population. Reclassification was conducted by calculating the net reclassification index. Blood lactate and base deficit were forced into the models and should be considered as competitors.	NR	0.88 (NR), optimism <0.01
Raux, 2017	MGAP: model 2 (MGAP)	Mortality: 48-hour	Multiple logistic regressions to assess the predictive performances of blood lactate and base deficit knowing RTS or MGAP score. Discrimination was quantified by calculating the concordance statistic completed with optimism, the difference of AUC between the entire population and the cross validated population. Reclassification was conducted by calculating the net reclassification index. Blood lactate and base deficit were forced into the models and should be considered as competitors.	AOR (95% CI): 1.37 (1.30 to 1.44), p<0.001 per 1-point decrease	NR
Raux, 2017	Lactate: model 2 (MGAP)	Mortality: 48-hour	Multiple logistic regressions to assess the predictive performances of blood lactate and base deficit knowing RTS or MGAP score. Discrimination was quantified by calculating the concordance statistic completed with optimism, the difference of AUC between the entire population and the cross validated population. Reclassification was conducted by calculating the net reclassification index. Blood lactate and base deficit were forced into the models and should be considered as competitors.	AOR (95% CI): 1.18 (1.03 to 1.35), p=0.018 per 1-mmol/L increase	AUC (95% CI), with Lactate vs. baseline MGAP model: 0.923 (NR) vs. 0.900, p=0.01 Net reclassification
Raux, 2017	BD: model 2 (MGAP)	Mortality: 48-hour	Multiple logistic regressions to assess the predictive performances of blood lactate and base deficit knowing RTS or MGAP score. Discrimination was quantified by calculating the concordance statistic completed with optimism, the difference of AUC between the entire population and the cross validated population. Reclassification was conducted by calculating the net reclassification index. Blood lactate and base deficit were forced into the models and should be considered as competitors.	AOR (95% CI): 1.06 (0.98 to 1.13), p=0.13 per 1-mmol/L increase	AUC (95% CI), with BD vs. baseline MGAP model: 0.920 (NR) vs. 0.900, p=0.03 Net reclassification
Raux, 2017	Lactate	Mortality: 48-hour	Multiple logistic regressions to assess the predictive performances of blood lactate and base deficit knowing RTS or MGAP score. Variable performances were reported (odd ratios), and discrimination comparison of models were conducted using paired nonparametric technique.	AOR (95% CI): 1.22 (1.07 to 1.42), p=0.004	NR
Raux, 2017	BD	Mortality: 48-hour	Multiple logistic regressions to assess the predictive performances of blood lactate and base deficit knowing RTS or MGAP score. Variable performances were reported (odd ratios), and discrimination comparison of models were conducted using paired nonparametric technique.	AOR (95% CI): 1.07 (0.99 to 1.16), p=0.09	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Raux, 2017	Lactate	Severe trauma: ISS >15	Multiple logistic regressions to assess the predictive performances of blood lactate and base deficit knowing RTS or MGAP score. Variable performances were reported (odd ratios), and discrimination comparison of models were conducted using paired nonparametric technique.	AOR (95% CI): 1.14 (1.02 to 1.27), p=0.02	NR
Raux, 2017	BD	Severe trauma: ISS >15	Multiple logistic regressions to assess the predictive performances of blood lactate and base deficit knowing RTS or MGAP score. Variable performances were reported (odd ratios), and discrimination comparison of models were conducted using paired nonparametric technique.	AOR (95% CI): 1.05 (0.99 to 1.11), p=0.06	NR
Raux, 2017	Lactate	Massive hemorrhage	Multiple logistic regressions to assess the predictive performances of blood lactate and base deficit knowing RTS or MGAP score. Variable performances were reported (odd ratios), and discrimination comparison of models were conducted using paired nonparametric technique.	AOR (95% CI): 1.25 (1.10 to 1.42), p<0.001	NR
Raux, 2017	BD	Massive hemorrhage	Multiple logistic regressions to assess the predictive performances of blood lactate and base deficit knowing RTS or MGAP score. Variable performances were reported (odd ratios), and discrimination comparison of models were conducted using paired nonparametric technique.	AOR (95% CI): 1.21 (1.13 to 1.29), p<0.001	NR
Raux, 2017	Lactate	Emergency procedure	Multiple logistic regressions to assess the predictive performances of blood lactate and base deficit knowing RTS or MGAP score. Variable performances were reported (odd ratios), and discrimination comparison of models were conducted using paired nonparametric technique.	AOR (95% CI): 1.14 (1.00 to 1.30), p=0.05	NR
Raux, 2017	BD	Emergency procedure	Multiple logistic regressions to assess the predictive performances of blood lactate and base deficit knowing RTS or MGAP score. Variable performances were reported (odd ratios), and discrimination comparison of models were conducted using paired nonparametric technique.	AOR (95% CI): 1.12 (1.04 to 1.20), p=0.003	NR
Raux, 2017	Lactate	ICU LOS >2 days or in-hospital mortality	Multiple logistic regressions to assess the predictive performances of blood lactate and base deficit knowing RTS or MGAP score. Variable performances were reported (odd ratios), and discrimination comparison of models were conducted using paired nonparametric technique.	AOR (95% CI): 1.06 (0.93 to 1.20), p=0.39	NR
Raux, 2017	BD	ICU LOS >2 days or in-hospital mortality	Multiple logistic regressions to assess the predictive performances of blood lactate and base deficit knowing RTS or MGAP score. Variable performances were reported (odd ratios), and discrimination comparison of models were conducted using paired nonparametric technique.	AOR (95% CI): 1.20 (1.12 to 1.27), p<0.001	NR
Raux, 2017	Model 3 (RTS, lactate, BD): normotensive subgroup	Mortality, 30-day in-hospital	Subgroup analysis of normotensive patients - EMS and ED SBP >90 without administration of vasopressors. Multiple logistic regressions to assess the predictive performances of blood lactate and base deficit knowing RTS or MGAP score. Discrimination was quantified by calculating the concordance statistic completed with optimism, the difference of AUC between the entire population and the cross validated population. Reclassification was conducted by calculating the net reclassification index. Blood lactate and base deficit were forced into the models and should be considered as competitors.	NR	0.79 (NR), optimism <0.01

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Raux, 2017	Lactate: model 3 (RTS); normotensive subgroup	Mortality, 30-day in-hospital	Subgroup analysis of normotensive patients - EMS and ED SBP >90 without administration of vasopressors. Multiple logistic regressions to assess the predictive performances of blood lactate and base deficit knowing RTS or MGAP score. Discrimination was quantified by calculating the concordance statistic completed with optimism, the difference of AUC between the entire population and the cross validated population. Reclassification was conducted by calculating the net reclassification index. Blood lactate and base deficit were forced into the models and should be considered as competitors.	AOR (95% CI): 1.36 (1.09 to 1.68), p=0.005; per 1 mmol/L increase	AUC: NR Net reclassification index: 0.425 (SD 0.160), p=0.007
Raux, 2017	BD: model 3 (RTS); normotensive subgroup	Mortality, 30-day in-hospital	Subgroup analysis of normotensive patients - EMS and ED SBP >90 without administration of vasopressors. Multiple logistic regressions to assess the predictive performances of blood lactate and base deficit knowing RTS or MGAP score. Discrimination was quantified by calculating the concordance statistic completed with optimism, the difference of AUC between the entire population and the cross validated population. Reclassification was conducted by calculating the net reclassification index. Blood lactate and base deficit were forced into the models and should be considered as competitors.	AOR (95% CI): 1.05 (0.93 to 1.17), p=0.45; per 1 mmol/L increase	AUC: NR Net reclassification index: 0.231 (SD 0.160), p=0.15
Raux, 2017	RTS: model 3 (RTS); normotensive subgroup	Mortality, 30-day in-hospital	Subgroup analysis of normotensive patients - EMS and ED SBP >90 without administration of vasopressors. Multiple logistic regressions to assess the predictive performances of blood lactate and base deficit knowing RTS or MGAP score. Discrimination was quantified by calculating the concordance statistic completed with optimism, the difference of AUC between the entire population and the cross validated population. Reclassification was conducted by calculating the net reclassification index. Blood lactate and base deficit were forced into the models and should be considered as competitors.	AOR (95% CI): 3.06 (2.36 to 3.96), p<0.001; per 1-point decrease	NR
Raux, 2017	Model 4 (MGAP, lactate, BD): normotensive subgroup	Mortality, 30-day in-hospital	Subgroup analysis of normotensive patients - EMS and ED SBP >90 without administration of vasopressors. Multiple logistic regressions to assess the predictive performances of blood lactate and base deficit knowing RTS or MGAP score. Discrimination was quantified by calculating the concordance statistic completed with optimism, the difference of AUC between the entire population and the cross validated population. Reclassification was conducted by calculating the net reclassification index. Blood lactate and base deficit were forced into the models and should be considered as competitors.	NR	0.81 (NR), optimism <0.01

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Raux, 2017	Lactate: model 4 (MGAP); normotensive subgroup	Mortality, 30-day in-hospital	Subgroup analysis of normotensive patients - EMS and ED SBP >90 without administration of vasopressors. Multiple logistic regressions to assess the predictive performances of blood lactate and base deficit knowing RTS or MGAP score. Discrimination was quantified by calculating the concordance statistic completed with optimism, the difference of AUC between the entire population and the cross validated population. Reclassification was conducted by calculating the net reclassification index. Blood lactate and base deficit were forced into the models and should be considered as competitors.	AOR (95% CI): 1.31 (1.08 to 1.61), p=0.01; per 1 mmol/L increase	AUC: NR Net reclassification index: 0.468 (0.160), p=0.003
Raux, 2017	BD model 4 (MGAP); normotensive subgroup	Mortality, 30-day in-hospital	Subgroup analysis of normotensive patients - EMS and ED SBP >90 without administration of vasopressors. Multiple logistic regressions to assess the predictive performances of blood lactate and base deficit knowing RTS or MGAP score. Discrimination was quantified by calculating the concordance statistic completed with optimism, the difference of AUC between the entire population and the cross validated population. Reclassification was conducted by calculating the net reclassification index. Blood lactate and base deficit were forced into the models and should be considered as competitors.	AOR (95% CI): 1.07 (0.96 to 1.20), p=0.21; per 1 mmol/L increase	AUC: NR Net reclassification index: 0.299 (SD 0.160), p=0.06
Raux, 2017	MGAP: model 4 (MGAP); normotensive subgroup	Mortality, 30-day in-hospital	Subgroup analysis of normotensive patients - EMS and ED SBP >90 without administration of vasopressors. Multiple logistic regressions to assess the predictive performances of blood lactate and base deficit knowing RTS or MGAP score. Discrimination was quantified by calculating the concordance statistic completed with optimism, the difference of AUC between the entire population and the cross validated population. Reclassification was conducted by calculating the net reclassification index. Blood lactate and base deficit were forced into the models and should be considered as competitors.	AOR (95% CI): 1.39 (1.29 to 1.51), p<0.001; per 1-point decrease	NR
Raux, 2017	Model 5 (RTS, lactate, BD): TRISS >0.9 subgroup	Mortality, 30-day in-hospital	Subgroup analysis of patients with a high probability of survival - TRISS score >0.9. Multiple logistic regressions to assess the predictive performances of blood lactate and base deficit knowing RTS or MGAP score. Discrimination was quantified by calculating the concordance statistic completed with optimism, the difference of AUC between the entire population and the cross validated population. Reclassification was conducted by calculating the net reclassification index. Blood lactate and base deficit were forced into the models and should be considered as competitors.	NR	0.73 (NR), optimism <0.01

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Raux, 2017	Lactate: model 5 (RTS); TRISS >0.9 subgroup	Mortality, 30-day in-hospital	Subgroup analysis of patients with a high probability of survival - TRISS score >0.9. Multiple logistic regressions to assess the predictive performances of blood lactate and base deficit knowing RTS or MGAP score. Discrimination was quantified by calculating the concordance statistic completed with optimism, the difference of AUC between the entire population and the cross validated population. Reclassification was conducted by calculating the net reclassification index. Blood lactate and base deficit were forced into the models and should be considered as competitors.	AOR (95% CI): 1.64 (0.99 to 1.64), p=0.06; per 1 mmol/L increase	AUC: NR Net reclassification index: 0.425 (SD 0.160), p=0.007
Raux, 2017	RTS: model 5 (RTS); TRISS >0.9 subgroup	Mortality, 30-day in-hospital	Subgroup analysis of patients with a high probability of survival - TRISS score >0.9. Multiple logistic regressions to assess the predictive performances of blood lactate and base deficit knowing RTS or MGAP score. Discrimination was quantified by calculating the concordance statistic completed with optimism, the difference of AUC between the entire population and the cross validated population. Reclassification was conducted by calculating the net reclassification index. Blood lactate and base deficit were forced into the models and should be considered as competitors.	AOR (95% CI): 3.37 (2.30 to 4.93), p<0.001; per 1-point decrease	NR
Raux, 2017	BD: model 5 (RTS); TRISS >0.9 subgroup	Mortality, 30-day in-hospital	Subgroup analysis of patients with a high probability of survival - TRISS score >0.9. Multiple logistic regressions to assess the predictive performances of blood lactate and base deficit knowing RTS or MGAP score. Discrimination was quantified by calculating the concordance statistic completed with optimism, the difference of AUC between the entire population and the cross validated population. Reclassification was conducted by calculating the net reclassification index. Blood lactate and base deficit were forced into the models and should be considered as competitors.	AOR (95% CI): 1.01 (0.87 to 1.17), p=0.88; per 1 mmol/L increase	AUC: NR Net reclassification index: 0.231 (SD 0.160), p=0.15
Raux, 2017	Model 6 (MGAP, lactate, BD): TRISS >0.9 subgroup	Mortality, 30-day in-hospital	Subgroup analysis of patients with a high probability of survival - TRISS score >0.9. Multiple logistic regressions to assess the predictive performances of blood lactate and base deficit knowing RTS or MGAP score. Discrimination was quantified by calculating the concordance statistic completed with optimism, the difference of AUC between the entire population and the cross validated population. Reclassification was conducted by calculating the net reclassification index. Blood lactate and base deficit were forced into the models and should be considered as competitors.	NR	0.80 (NR), optimism <0.01

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Raux, 2017	MGAP: model 6 (MGAP); TRISS >0.9 subgroup	Mortality, 30-day in-hospital	Subgroup analysis of patients with a high probability of survival - TRISS score >0.9. Multiple logistic regressions to assess the predictive performances of blood lactate and base deficit knowing RTS or MGAP score. Discrimination was quantified by calculating the concordance statistic completed with optimism, the difference of AUC between the entire population and the cross validated population. Reclassification was conducted by calculating the net reclassification index. Blood lactate and base deficit were forced into the models and should be considered as competitors.	AOR (95% CI): 1.39 (1.26 to 1.54), p=0.002; per 1-point decrease	NR
Raux, 2017	Lactate: model 6 (MGAP); TRISS >0.9 subgroup	Mortality, 30-day in-hospital	Subgroup analysis of patients with a high probability of survival - TRISS score >0.9. Multiple logistic regressions to assess the predictive performances of blood lactate and base deficit knowing RTS or MGAP score. Discrimination was quantified by calculating the concordance statistic completed with optimism, the difference of AUC between the entire population and the cross validated population. Reclassification was conducted by calculating the net reclassification index. Blood lactate and base deficit were forced into the models and should be considered as competitors.	AOR (95% CI): 1.23 (0.92 to 1.55), p=0.09; per 1 mmol/L increase	AUC: NR Net reclassification index: 0.468 (SD 0.160), p=0.003
Raux, 2017	BD: model 6 (MGAP); TRISS >0.9 subgroup	Mortality, 30-day in-hospital	Subgroup analysis of patients with a high probability of survival - TRISS score >0.9. Multiple logistic regressions to assess the predictive performances of blood lactate and base deficit knowing RTS or MGAP score. Discrimination was quantified by calculating the concordance statistic completed with optimism, the difference of AUC between the entire population and the cross validated population. Reclassification was conducted by calculating the net reclassification index. Blood lactate and base deficit were forced into the models and should be considered as competitors.	AOR (95% CI): 1.06 (0.97 to 1.21), p=0.43; per 1 mmol/L increase	AUC: NR Net reclassification index: 0.299 (SD 0.160), p=0.06
Regnier, 2012	Lactate: Model 1 (RTS, lactate and lactate clearance)	Mortality, 30-day	Multiple logistic regressions using initial blood lactate, lactate clearance, and either RTS (Model 1) or MGAP (Model 2). Internal validation was performed using 10-fold cross validation. ROC curves averaged 1,000 populations boot-strapped from original study population. Discrimination assessed by AUC and calibration by the Hosmer-Lemeshow statistic. Subgroup analysis of normotensive patients (SBP >90 in field and on ED arrival)	AOR (95% CI) Overall: 1.21 (1.08 to 1.38), p<0.001 Normotensive subgroup: 0.99 (0.77 to 1.26), p=0.93	NR
Regnier, 2012	Lactate: Model 2 (MGAP, lactate and lactate clearance)	Mortality, 30-day	Multiple logistic regressions using initial blood lactate, lactate clearance, and either RTS (Model 1) or MGAP (Model 2). Internal validation was performed using 10-fold cross validation. ROC curves averaged 1,000 populations boot-strapped from original study population. Discrimination assessed by AUC and calibration by the Hosmer-Lemeshow statistic. Subgroup analysis of normotensive patients (SBP >90 in field and on ED arrival)	AOR (95% CI) Overall: 1.29 (1.15 to 1.45), p<0.001 Normotensive subgroup: 1.20 (0.99 to 1.44), p=0.05	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Regnier, 2012	Lactate clearance: Model 1 (RTS, lactate and lactate clearance)	Mortality, 30-day	Multiple logistic regressions using initial blood lactate, lactate clearance, and either RTS (Model 1) or MGAP (Model 2). Internal validation was performed using 10-fold cross validation. ROC curves averaged 1,000 populations boot-strapped from original study population. Discrimination assessed by AUC and calibration by the Hosmer-Lemeshow statistic. Subgroup analysis of normotensive patients (SBP >90 in field and on ED arrival)	AOR (95% CI) Overall: 1.16 (1.01 to 1.31), p=0.02 Normotensive subgroup: 1.13 (0.93 to 1.33), p=0.14	NR
Regnier, 2012	Lactate clearance: Model 2 (MGAP, lactate and lactate clearance)	Mortality, 30-day	Multiple logistic regressions using initial blood lactate, lactate clearance, and either RTS (Model 1) or MGAP (Model 2). Internal validation was performed using 10-fold cross validation. ROC curves averaged 1,000 populations boot-strapped from original study population. Discrimination assessed by AUC and calibration by the Hosmer-Lemeshow statistic. Subgroup analysis of normotensive patients (SBP >90 in field and on ED arrival)	AOR (95% CI) Overall: 1.15 (1.00 to 1.30), p=0.03 Normotensive subgroup: 1.11 (0.93 to 1.29), p=0.17	NR
Regnier, 2012	RTS: Model 1 (RTS, lactate and lactate clearance)	Mortality, 30-day	Multiple logistic regressions using initial blood lactate, lactate clearance, and either RTS (Model 1) or MGAP (Model 2). Internal validation was performed using 10-fold cross validation. ROC curves averaged 1,000 populations boot-strapped from original study population. Discrimination assessed by AUC and calibration by the Hosmer-Lemeshow statistic. Subgroup analysis of normotensive patients (SBP >90 in field and on ED arrival)	AOR (95% CI): Overall: 2.06 (1.64 to 2.55), p<0.001 Normotensive subgroup: 2.50 (1.85 to 3.49), p<0.001	NR
Regnier, 2012	MGAP: Model 2 (MGAP, lactate and lactate clearance)	Mortality, 30-day	Multiple logistic regressions using initial blood lactate, lactate clearance, and either RTS (Model 1) or MGAP (Model 2). Internal validation was performed using 10-fold cross validation. ROC curves averaged 1,000 populations boot-strapped from original study population. Discrimination assessed by AUC and calibration by the Hosmer-Lemeshow statistic. Subgroup analysis of normotensive patients (SBP >90 in field and on ED arrival)	AOR (95% CI) Overall: 1.21 (1.13 to 1.29), p<0.001 Normotensive subgroup: 1.21 (1.10 to 1.32), p<0.001	NR
Regnier, 2012	Model 1: RTS, lactate and lactate clearance	Mortality, 30-day	Multiple logistic regressions using initial blood lactate, lactate clearance, and either RTS (Model 1) or MGAP (Model 2). Internal validation was performed using 10-fold cross validation. ROC curves averaged 1,000 populations boot-strapped from original study population. Discrimination assessed by AUC and calibration by the Hosmer-Lemeshow statistic. Subgroup analysis of normotensive patients (SBP >90 in field and on ED arrival)	NR	AUC (95% CI) Overall: 0.91 (NR) Normotensive subgroup: 0.90 (NR) Net reclassification improvement: Model 1 vs. RTS alone Overall: 0.64 (SD 0.15), p<0.001 Normotensive subgroup: 0.389 (SD

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Regnier, 2012	Model 2: MGAP, lactate and lactate clearance	Mortality, 30-day	Multiple logistic regressions using initial blood lactate, lactate clearance, and either RTS (Model 1) or MGAP (Model 2). Internal validation was performed using 10-fold cross validation. ROC curves averaged 1,000 populations boot-strapped from original study population. Discrimination assessed by AUC and calibration by the Hosmer-Lemeshow statistic. Subgroup analysis of normotensive patients (SBP >90 in field and on ED arrival)	NR	AUC (95% CI) Overall: 0.85 (NR) Normotensive subgroup: 0.83 (NR) Net reclassification improvement: Model 2 vs. MGAP alone Overall: 0.52 (SD 0.15), p<0.001 Normotensive subgroup: 0.304 (SD
Reisner, 2016	Muscle oxygen saturation (SmO_2) plus ED vital signs (HR, SBP, and PP)	Hemorrhagic injury requiring blood transfusion ≥3 units PRBC	Two multivariate logistic regression models: - using only routine vital signs (variables: HR, SBP, PP) - adding muscle oxygen saturation (variables: HR, SBP, PP, and SmO_2) Applied DeLong's test to the ROC AUCs from these models with null hypothesis that SmO_2 did not provide additional diagnostic information compare with using routine vital signs alone.	NR	0.85 (0.75 to 0.91), p<0.05 vs. vital signs only
Reisner, 2016	Muscle oxygen saturation (SmO_2) plus ED vital signs (HR, SBP, and PP)	Hemorrhagic injury requiring blood transfusion ≥9 units PRBC	Two multivariate logistic regression models: - using only routine vital signs (variables: HR, SBP, PP) - adding muscle oxygen saturation (variables: HR, SBP, PP, and SmO_2) Applied DeLong's test to the ROC AUCs from these models with null hypothesis that SmO_2 did not provide additional diagnostic information compare with using routine vital signs alone.	NR	0.89 (0.76 to 0.95), p<0.05 vs. vital signs only
Reisner, 2016	Vital signs (ED HR, SBP, PP)	Hemorrhagic injury requiring blood transfusion ≥3 units PRBC	Two multivariate logistic regression models: - using only routine vital signs (variables: HR, SBP, PP) - adding muscle oxygen saturation (variables: HR, SBP, PP, and SmO_2) Applied DeLong's test to the ROC AUCs from these models with null hypothesis that SmO_2 did not provide additional diagnostic information compare with using routine vital signs alone.	NR	0.77 (0.66 to 0.86)
Reisner, 2016	Vital signs (ED HR, SBP, PP)	Hemorrhagic injury requiring blood transfusion ≥9 units PRBC	Two multivariate logistic regression models: - using only routine vital signs (variables: HR, SBP, PP) - adding muscle oxygen saturation (variables: HR, SBP, PP, and SmO_2) Applied DeLong's test to the ROC AUCs from these models with null hypothesis that SmO_2 did not provide additional diagnostic information compare with using routine vital signs alone.	NR	0.77 (0.61 to 0.87)

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Rickards, 2010	Heart rate variability: fractal dimensions by curve length (FD-L): patients with normal vital signs	Life-saving intervention	Multivariate logistic regression to predict LSI vs. No-LSI from heart period variability metrics. Data were subjected to multivariate outlier analysis (Mahalanobis distances) prior to analysis, and data transformations were used to normalize skewed distributions where appropriate. ROC curves were derived from the logistic prediction equations, as well as other measures of prediction accuracy.	NR	AUC (95% CI): 0.70 (NR) Sensitivity 16% Specificity 99% Overall correct classification rate:
Ryan, 2011b	Mortality Score algorithm: age, VLF, HF (using mean-rank scores for VLF and HF)	Mortality	Multivariate stepwise logistic regression using HRV data (raw and log-transformed) and patient characteristics to predict mortality with maximum sensitivity, specificity and efficiency. The maximum likelihood technique was used to generate the coefficients for each variable. Covariates considered included any variable possibly influencing mortality. Significance was set at the 95% confidence interval. Mortality Score = 49.8505 - 2.0202 x ln(VLF) + 1.5509 x ln(HF) + 0.0516 x age	NR	AUC: 0.845 (SD 0.059) Sensitivity 88.2% Specificity 64.9% Efficiency* 65.6% *Efficiency defined as
Ryan, 2011b	Heart rate variability: VLF (using mean-rank score)	Mortality	Multivariate stepwise logistic regression using HRV data (raw and log-transformed) and patient characteristics to predict mortality with maximum sensitivity, specificity and efficiency. The maximum likelihood technique was used to generate the coefficients for each variable. Covariates considered included any variable possibly influencing mortality. Significance was set at the 95% confidence interval. Mortality Score = 49.8505 - 2.0202 x ln(VLF) + 1.5509 x ln(HF) + 0.0516 x age	AOR (95% CI): 0.133 (0.047 to 0.377), p<0.001	AUC: 0.673 (SD 0.0072) Sensitivity 88.9% Specificity 41.2% Efficiency* 44.4% *Efficiency defined as
Ryan, 2011b	Heart rate variability: HF (using mean-rank score)	Mortality	Multivariate stepwise logistic regression using HRV data (raw and log-transformed) and patient characteristics to predict mortality with maximum sensitivity, specificity and efficiency. The maximum likelihood technique was used to generate the coefficients for each variable. Covariates considered included any variable possibly influencing mortality. Significance was set at the 95% confidence interval. Mortality Score = 49.8505 - 2.0202 x ln(VLF) + 1.5509 x ln(HF) + 0.0516 x age	AOR (95% CI): 4.716 (1.706 to 13.301), p=0.002	NR
Sartorius, 2010 * Sartorius 2010 and Raux 2011 analyze the same study population	SBP: derivation cohort	Mortality: 30-day all cause	Score constructed using multiple forward stepwise logistic regression using prehospital variables and a semiparsimonious approach with the derivation cohort. Colinearity was considered when r >0.8 (Spearman coefficient matrix correlation). Internal validation was performed using 10-fold cross validation. Continuous variables selected in the model were transformed followed by simplification of the weight allocated to each variable (to degree possible), which was derived from logistic regression coefficients. External validation was performed using the validation cohort.	AOR (95% CI) Continuous: 0.98 (0.98-0.99), per 1 mm Hg increase Stratified (>120 reference) - 60-120: 2.7 (2.0-3.6) - <60: 5.4 (4.1-7.3)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Sartorius, 2010 * Sartorius 2010 and Raux 2011 analyze the same study population	MGAP: derivation cohort using continuous variables	Mortality: 30-day all cause	Score constructed using multiple forward stepwise logistic regression using prehospital variables and a semiparsimonious approach with the derivation cohort. Colinearity was considered when r >0.8 (Spearman coefficient matrix correlation). Internal validation was performed using 10-fold cross validation. Continuous variables selected in the model were transformed followed by simplification of the weight allocated to each variable (to degree possible), which was derived from logistic regression coefficients. External validation was performed using the validation cohort.	NR	0.907 (SD 0.011)
Shackelford, 2015 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated. *Mackenzie, 2014 study population included in Shackelford, 2015	Lactate; Decision-assist algorithm (Model 05, cartridge 3)	Blood transfusion (3 hours, rapid, massive)	Stepwise logistic regression models using selected variables/combinations for each decision assist algorithm, among: HR, SBP, pulse oximetry features, 3 sets of laboratory tests (hematocrit, glucose, potassium, chloride, and bicarbonate; prothrombin time and INR; or, Lactate). Forward selection using p=0.05 and backward selection using p=0.1. 10-fold cross-validation repeated 10 times was used to validate the prediction, with models considered not overfitting if they had <10% difference in training and testing AUROC curves.	NR	AUC (95% CI) Transfusion in 3 hours: 0.77 (NR) Rapid transfusion: 0.80 (NR) Massive transfusion: 0.80 (NR)

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Shackelford, 2015 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated. *Mackenzie, 2014 study population included in Shackelford, 2015	Decision-assist algorithm (Model 01): HR and SBP, EMS	Blood transfusion (3 hours, rapid, massive)	Stepwise logistic regression models using selected variables/combinations for each decision assist algorithm, among: HR, SBP, pulse oximetry features, 3 sets of laboratory tests (hematocrit, glucose, potassium, chloride, and bicarbonate; prothrombin time and INR; or, Lactate). Forward selection using p=0.05 and backward selection using p=0.1. 10-fold cross-validation repeated 10 times was used to validate the prediction, with models considered not overfitting if they had <10% difference in training and testing AUROC curves.	NR	AUC (95% CI) Transfusion in 3 hours: 0.59 (NR) Rapid transfusion: 0.71 (NR) Massive transfusion: 0.70 (NR)
Shackelford, 2015 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated. *Mackenzie, 2014 study population included in Shackelford, 2015	Decision-assist algorithm (Model 03, cartridge 1): Laboratory tests: hematocrit, glucose, potassium, chloride, and bicarbonate	Blood transfusion (3 hours, rapid, massive)	Stepwise logistic regression models using selected variables/combinations for each decision assist algorithm, among: HR, SBP, pulse oximetry features, 3 sets of laboratory tests (hematocrit, glucose, potassium, chloride, and bicarbonate; prothrombin time and INR; or, Lactate). Forward selection using p=0.05 and backward selection using p=0.1. 10-fold cross-validation repeated 10 times was used to validate the prediction, with models considered not overfitting if they had <10% difference in training and testing AUROC curves.	NR	AUC (95% CI) Transfusion in 3 hours: 0.83 (NR) Rapid transfusion: 0.85 (NR) Massive transfusion: 0.87 (NR)

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Shackelford, 2015 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated. *Mackenzie, 2014 study population included in Shackelford, 2015	Decision-assist algorithm (Model 04, cartridge 2): Laboratory tests: INR and prothrombin time	Blood transfusion (3 hours, rapid, massive)	Stepwise logistic regression models using selected variables/combinations for each decision assist algorithm, among: HR, SBP, pulse oximetry features, 3 sets of laboratory tests (hematocrit, glucose, potassium, chloride, and bicarbonate; prothrombin time and INR; or, Lactate). Forward selection using p=0.05 and backward selection using p=0.1. 10-fold cross-validation repeated 10 times was used to validate the prediction, with models considered not overfitting if they had <10% difference in training and testing AUROC curves.	NR	AUC (95% CI) Transfusion in 3 hours: 0.75 (NR) Rapid transfusion: 0.81 (NR) Massive transfusion: 0.88 (NR)
Shackelford, 2015 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated. *Mackenzie, 2014 study population included in Shackelford, 2015	Decision-assist algorithm (Model 10): HR, SBP, pulse oximetry features, and all laboratory tests	Blood transfusion (3 hours, rapid, massive)	Stepwise logistic regression models using selected variables/combinations for each decision assist algorithm, among: HR, SBP, pulse oximetry features, 3 sets of laboratory tests (hematocrit, glucose, potassium, chloride, and bicarbonate; prothrombin time and INR; or, Lactate). Forward selection using p=0.05 and backward selection using p=0.1. 10-fold cross-validation repeated 10 times was used to validate the prediction, with models considered not overfitting if they had <10% difference in training and testing AUROC curves.	NR	AUC (95% CI) Transfusion in 3 hours: 0.84 (NR) Rapid transfusion: 0.89 (NR) Massive transfusion: 0.91 (NR)

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Shah, 2013	Lactate, EMS (POC)	Need for critical care	Multivariate logistic regression models using determinants having significant univariate association (p<0.20) with the need for critical care. Interactions between the variables were systematically searched and colinearity was considered when r>0.8 (Spearman coefficient matrix correlation). Calibration of the model was tested using the Hosmer-Lemeshow statistic. Out of hospital lactate was tested for normal distribution by visual inspection of histograms and the Kolmogorov-Smirnov test and was log-transformed for use in logistic regression models.	AOR (95% CI), per 1-unit increase in log-transformed EMS lactate Overall: 1.56 (0.97 to 2.50), p=0.06 Subset with normal EMS vital signs and GCS: 3.4 (1.3 to 8.7), p=0.01	NR
St John, 2016	BD, ED: elderly without TTA	Severe multisystem injury	Poisson regression with robust standard errors. Analysis looked at the strength of association between severe multisystem injury and the variables: gender, ISS, GCS on arrival, and mechanism of injury. ISS was included as a surrogate for overall clinical assessment of severity of injury.	Relative risk (95% CI): 1.07 (0.91 to 1.25), p=0.437	NR
St John, 2016	HR, ED: elderly without TTA	Severe multisystem injury	Poisson regression with robust standard errors. Analysis looked at the strength of association between severe multisystem injury and the variables: gender, ISS, GCS on arrival, and mechanism of injury. ISS was included as a surrogate for overall clinical assessment of severity of injury.	Relative risk (95% CI): 0.83 (0.72 to 0.97), p=0.016; per increase of 10 bpm	NR
St John, 2016	SBP, lowest recorded ED: elderly without TTA	Severe multisystem injury	Poisson regression with robust standard errors. Analysis looked at the strength of association between severe multisystem injury and the variables: gender, ISS, GCS on arrival, and mechanism of injury. ISS was included as a surrogate for overall clinical assessment of severity of injury.	Relative risk (95% CI): 0.76 (0.64 to 0.91), p=0.003; per increase of 10 mm Hg	NR
Stanworth, 2010	SBP, ED	Massive transfusion	Logistic regression to predict massive transfusion with consideration of all candidate predictors potentially available on admission and thought to be associated with transfusion, but excluding center-specific effects. A fractional polynomial was used to relate the odds of death to PRBCs received by logistic regression. Missing data addressed through multiple imputation. Continuous variables underwent normalizing transformations. Backward elimination with p>0.1 was used to select variables. The same model was also fitted using complete data without imputation (excluding Amsterdam dataset), with results consistent with the multiple-imputation analysis.	AOR (95% CI): 0.98 (0.97 to 0.98) Log-odds ratio (SEM): -0.02 (0.003)	NR
Stanworth, 2010	BD, ED	Massive Transfusion	Logistic regression to predict massive transfusion with consideration of all candidate predictors potentially available on admission and thought to be associated with transfusion, but excluding center-specific effects. A fractional polynomial was used to relate the odds of death to PRBCs received by logistic regression. Missing data addressed through multiple imputation. Continuous variables underwent normalizing transformations. Backward elimination with p>0.1 was used to select variables. The same model was also fitted using complete data without imputation (excluding Amsterdam dataset), with results consistent with the multiple-imputation analysis.	AOR (95% CI): 240 (91 to 639), Log-odds ratio (SEM): 5.48 (0.5)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Stanworth, 2010	Prediction model for massive transfusion: uses age, time to ED, penetrating injury, SBP, BD and prothrombin time External validation dataset	Massive transfusion	Model components: √age; ln(time to ED); penetrating injury; SBP; ln(25 + BD); 1/[ln(prothrombin time2)]; intercept. Logistic regression to predict massive transfusion with consideration of all candidate predictors potentially available on admission and thought to be associated with transfusion, but excluding center-specific effects. A fractional polynomial was used to relate the odds of death to PRBCs received by logistic regression. Missing data addressed through multiple imputation. Continuous variables underwent normalizing transformations. Backward elimination with p>0.1 was used to select variables. The same model was also fitted using complete data without imputation (excluding Amsterdam dataset), with results consistent with the multiple-imputation analysis.	NR	AUC (95% CI): 0.81 (NR) Sensitivity 90% Specificity: 50% Correct classification rate: 58%
Stanworth, 2010	Prediction model for massive transfusion: uses age, time to ED, penetrating injury, SBP, BD and prothrombin time. Internal validation datasets	Massive transfusion	Model components: √age; ln(time to ED); penetrating injury; SBP; ln(25 + BD); 1/[ln(prothrombin time2)]; intercept. Logistic regression to predict massive transfusion with consideration of all candidate predictors potentially available on admission and thought to be associated with transfusion, but excluding center-specific effects. A fractional polynomial was used to relate the odds of death to PRBCs received by logistic regression. Missing data addressed through multiple imputation. Continuous variables underwent normalizing transformations. Backward elimination with p>0.1 was used to select variables. The same model was also fitted using complete data without imputation (excluding Amsterdam dataset), with results consistent with the multiple-imputation analysis.	NR	AUC (95% CI): 0.89 (0.87 to 0.92) Sensitivity 90% Specificity: 70%
Vandromme, 2011	SI, ED	Massive Transfusion	Proportional hazards regression assuming an equal time at risk for each patient was used to estimate risk ratios and 95% CIs for the association between SI and massive transfusion using SI >0.5 to 0.7 as the referent category.	Adjusted Risk Ratio (95% CI) SI >0.9 to 1.1: 3.49 (2.34 to 5.20) SI >1.1 to 1.3: 9.67	NR
Vandromme, 2011	SI, EMS	Massive Transfusion	Proportional hazards regression assuming an equal time at risk for each patient was used to estimate risk ratios and 95% CIs for the association between SI and massive transfusion using SI >0.5 to 0.7 as the referent category.	Adjusted Risk Ratio (95% CI) SI >0.9 to 1.1: 1.61 (1.13 to 2.31) SI >1.1 to 1.3: 5.57	NR
Vandromme, 2011b	Lactate ≥ 5: developmental cohort	Massive transfusion	Logistic regression using the developmental cohort. Variables entered into the model based on magnitude of predictive ability identified on univariate analysis (most predictive entered first). The Hosmer-Lemeshow goodness-of-fit test was used to determine the best-fit model. Statistical weighting were applied to account for oversampling of the massive transfusion population. The statistical weight for each patient was the inverse of the probability of selection based on the time period (developmental or validation cohorts) and number of PRBC units. The best-fit model is comprised of these dichotomized variables: lactate ≥5, HR >105, Hb ≤11, INR >1.5, SBP <110.	AOR (95% CI): developmental cohort: 3.13 (1.96 to 5.00) validation cohort: 3.57 (1.89 to 6.67)	NR

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Vandromme, 2011b	SBP < 110: developmental cohort	Massive Transfusion	Logistic regression using the developmental cohort. Variables entered into the model based on magnitude of predictive ability identified on univariate analysis (most predictive entered first). The Hosmer-Lemeshow goodness-of-fit test was used to determine the best-fit model. Statistical weighting were applied to account for oversampling of the massive transfusion population. The statistical weight for each patient was the inverse of the probability of selection based on the time period (developmental or validation cohorts) and number of PRBC units. The best-fit model is comprised of these dichotomized variables: lactate ≥5, HR >105, Hb ≤11, INR >1.5, SBP <110.	AOR (95% CI): Developmental cohort: 2.08 (1.27 to 3.43) Validation cohort: 35.06 (19.06 to 64.47)	NR
Vandromme, 2011b	HR > 105: developmental cohort	Massive Transfusion	Logistic regression using the developmental cohort. Variables entered into the model based on magnitude of predictive ability identified on univariate analysis (most predictive entered first). The Hosmer-Lemeshow goodness-of-fit test was used to determine the best-fit model. Statistical weighting were applied to account for oversampling of the massive transfusion population. The statistical weight for each patient was the inverse of the probability of selection based on the time period (developmental or validation cohorts) and number of PRBC units. The best-fit model is comprised of these dichotomized variables: lactate ≥5, HR >105, Hb ≤11, INR >1.5, SBP <110.	AOR (95% CI): Developmental cohort: 3.55 (2.22 to 5.66) Validation cohort: 3.51 (1.81 to 6.80)	NR
Vandromme, 2011b	Prediction model (best-fit): Lactate ≥5, HR >105, Hb ≤11, INR >1.5, SBP <110 developmental cohort	Massive Transfusion	Logistic regression using the developmental cohort. Variables entered into the model based on magnitude of predictive ability identified on univariate analysis (most predictive entered first). The Hosmer-Lemeshow goodness-of-fit test was used to determine the best-fit model. Statistical weighting were applied to account for oversampling of the massive transfusion population. The statistical weight for each patient was the inverse of the probability of selection based on the time period (developmental or validation cohorts) and number of PRBC units. The best-fit model is comprised of these dichotomized variables: lactate ≥5, HR >105, Hb ≤11, INR >1.5, SBP <110.	NR	0.91 (NR)
Vandromme, 2011b	Prediction model - any 4 of 5 positive predictors (highest AUC) - Lactate ≥5, HR >105, Hb ≤11, INR >1.5, or SBP <110	Massive Transfusion	Logistic regression using the developmental cohort. Variables entered into the model based on magnitude of predictive ability identified on univariate analysis (most predictive entered first). The Hosmer-Lemeshow goodness-of-fit test was used to determine the best-fit model. Statistical weighting were applied to account for oversampling of the massive transfusion population. The statistical weight for each patient was the inverse of the probability of selection based on the time period (developmental or validation cohorts) and number of PRBC units. The best-fit model is comprised of these dichotomized variables: lactate ≥5, HR >105, Hb ≤11, INR >1.5, SBP <110.	NR	AUC (95% CI): 0.90 (NR) Developmental cohort Sensitivity 27.8%, specificity 99.2%, PPV 43.9%, NPV 98.4% Validation cohort Sensitivity 26.9%,

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Vandromme, 2011b	Prediction model - any 3 of 5 positive predictors (best predictive model) - Lactate ≥5, HR >105, Hb ≤11, INR >1.5, or SBP <110	Massive Transfusion	Logistic regression using the developmental cohort. Variables entered into the model based on magnitude of predictive ability identified on univariate analysis (most predictive entered first). The Hosmer-Lemeshow goodness-of-fit test was used to determine the best-fit model. Statistical weighting were applied to account for oversampling of the massive transfusion population. The statistical weight for each patient was the inverse of the probability of selection based on the time period (developmental or validation cohorts) and number of PRBC units. The best-fit model is comprised of these dichotomized variables: lactate ≥5, HR >105, Hb ≤11, INR >1.5, SBP <110.	NR	AUC: NR Developmental cohort: Sensitivity 53.4%, specificity 97.6%, PPV 33.4%, NPV 98.9% Validation cohort: Sensitivity 61.3%, specificity 96.0%,
Williams, 2016	End-tidal CO2 (ETCO2)	Severe injury Composite	Multivariable logistic regression analysis to determine if ETCO2 added predictive ability for primary outcome when combined with age, GCS, SBP or SI. ROC curves were generated and assessed by paired comparison of resulting AUCs.	AOR (95% CI): 1.06 (1.01-1.13)	NR
Williams, 2016	Predictive model using end-tidal CO2 (ETCO2) plus EMS vital	Severe injury Composite	Multivariable logistic regression analysis to determine if ETCO2 added predictive ability for primary outcome when combined with age, GCS, SBP or SI. ROC curves were generated and assessed by paired comparison of resulting AUCs.	NR	0.70 (NR)
Williams, 2016	Predictive model using EMS vital signs only (age,	Severe injury Composite	Multivariable logistic regression analysis to determine if ETCO2 added predictive ability for primary outcome when combined with age, GCS, SBP or SI. ROC curves were generated and assessed by paired comparison of resulting AUCs.	NR	0.68 (NR)
Woodford, 2012	GCS + Oxygen saturation	Mortality	Multivariable logistic regression using relevant indices of injury from the VSDR data and trauma registry to determine possible predictive factors for mortality.	NR	0.88 (NR)
Yang, 2016 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	HR model and lab Hb	Blood transfusion, 1-3 hours after admission	Multivariate logistic regression models using step-wise feature selection. Forward selection included features with Wald $\chi 2$ test ≤0.2, and those with significance level >0.3 removed by backward selection. 10-fold cross-validation was repeated 10 times with stratified sampling to examine prediction using previously unseen data.	NR	AUC (95% CI): 0.72 (0.60 to 0.84) sensitivity: 70% specificity: 73%

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Yang, 2016 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	HR model and lab Hb (HR model: age, sex, EMS HR)	Mortality	Multivariate logistic regression models using step-wise feature selection. Forward selection included features with Wald χ2 test ≤0.2, and those with significance level >0.3 removed by backward selection. 10-fold cross-validation was repeated 10 times with stratified sampling to examine prediction using previously unseen data.	NR	AUC (95% CI): 0.83 (0.73 to 0.93) sensitivity: 83% specificity: 71%
Yang, 2016 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	HR model and non-invasive Hb (SpHb) (HR model: age, sex, EMS HR)	Blood transfusion, 1-3 hours after admission	Multivariate logistic regression models using step-wise feature selection. Forward selection included features with Wald χ2 test ≤0.2, and those with significance level >0.3 removed by backward selection. 10-fold cross-validation was repeated 10 times with stratified sampling to examine prediction using previously unseen data.	NR	AUC (95% CI): 0.65 (0.53 to 0.77) sensitivity: 40% specificity: 86%
Yang, 2016 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	HR model and non-invasive Hb (SpHb) (HR model: age, sex, EMS HR)	Mortality	Multivariate logistic regression models using step-wise feature selection. Forward selection included features with Wald χ2 test ≤0.2, and those with significance level >0.3 removed by backward selection. 10-fold cross-validation was repeated 10 times with stratified sampling to examine prediction using previously unseen data.	NR	AUC (95% CI): 0.85 (0.74 to 0.96) sensitivity: 83% specificity: 74%

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Yang, 2016 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	HR model and other lab tests (HR model: age, sex, EMS HR)	Blood transfusion, 1-3 hours after admission	Multivariate logistic regression models using step-wise feature selection. Forward selection included features with Wald χ2 test ≤0.2, and those with significance level >0.3 removed by backward selection. 10-fold cross-validation was repeated 10 times with stratified sampling to examine prediction using previously unseen data.	NR	AUC (95% CI): 0.88 (0.81 to 0.96) sensitivity: 85% specificity: 84%
Yang, 2016 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	HR model and other lab tests (HR model: age, sex, EMS HR)	Mortality	Multivariate logistic regression models using step-wise feature selection. Forward selection included features with Wald χ2 test ≤0.2, and those with significance level >0.3 removed by backward selection. 10-fold cross-validation was repeated 10 times with stratified sampling to examine prediction using previously unseen data.	NR	AUC (95% CI): 0.86 (0.76 to 0.96) sensitivity: 83% specificity: 75%
Yang, 2016 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	HR model with non-invasive Hb (SpHb) and other lab tests (HR model: age, sex, EMS HR)	Blood transfusion, 1-3 hours after admission	Multivariate logistic regression models using step-wise feature selection. Forward selection included features with Wald χ2 test ≤0.2, and those with significance level >0.3 removed by backward selection. 10-fold cross-validation was repeated 10 times with stratified sampling to examine prediction using previously unseen data.	NR	AUC (95% CI): 0.89 (0.81 to 0.96) sensitivity: 75% specificity: 91%

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Yang, 2016 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	HR model with non-invasive Hb (SpHb) and other lab tests (HR model: age, sex, EMS HR)	Mortality	Multivariate logistic regression models using step-wise feature selection. Forward selection included features with Wald χ2 test ≤0.2, and those with significance level >0.3 removed by backward selection. 10-fold cross-validation was repeated 10 times with stratified sampling to examine prediction using previously unseen data.	NR	AUC (95% CI): 0.92 (0.85 to 0.98) sensitivity: 100% specificity: 67%
Yang, 2016 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	HR model: age, sex, EMS HR	Blood transfusion, 1-3 hours after admission	Multivariate logistic regression models using step-wise feature selection. Forward selection included features with Wald χ2 test ≤0.2, and those with significance level >0.3 removed by backward selection. 10-fold cross-validation was repeated 10 times with stratified sampling to examine prediction using previously unseen data.	NR	AUC (95% CI): 0.64 (0.52 to 0.76) sensitivity: 95% specificity: 29%
Yang, 2016 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	HR model: age, sex, EMS HR	Mortality	Multivariate logistic regression models using step-wise feature selection. Forward selection included features with Wald χ2 test ≤0.2, and those with significance level >0.3 removed by backward selection. 10-fold cross-validation was repeated 10 times with stratified sampling to examine prediction using previously unseen data.	NR	AUC (95% CI): 0.79 (0.67 to 0.91) sensitivity: 67% specificity: 83%

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Yang, 2016 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	SI model and lab Hb (SI model: age, sex, EMS SI)	Blood transfusion, 1-3 hours after admission	Multivariate logistic regression models using step-wise feature selection. Forward selection included features with Wald χ2 test ≤0.2, and those with significance level >0.3 removed by backward selection. 10-fold cross-validation was repeated 10 times with stratified sampling to examine prediction using previously unseen data.	NR	AUC (95% CI): 0.78 (0.65 to 0.92) sensitivity: 75% specificity: 85%
Yang, 2016 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	SI model and lab Hb (SI model: age, sex, EMS SI)	Mortality	Multivariate logistic regression models using step-wise feature selection. Forward selection included features with Wald χ2 test ≤0.2, and those with significance level >0.3 removed by backward selection. 10-fold cross-validation was repeated 10 times with stratified sampling to examine prediction using previously unseen data.	NR	AUC (95% CI): 0.78 (0.63 to 0.93) sensitivity: 75% specificity: 78%
Yang, 2016 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	SI model and non-invasive Hb (SpHb) (SI model: age, sex, EMS SI)	Blood transfusion, 1-3 hours after admission	Multivariate logistic regression models using step-wise feature selection. Forward selection included features with Wald χ2 test ≤0.2, and those with significance level >0.3 removed by backward selection. 10-fold cross-validation was repeated 10 times with stratified sampling to examine prediction using previously unseen data.	NR	AUC (95% CI): 0.80 (0.66 to 0.93) sensitivity: 70% specificity: 91%

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Yang, 2016 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	SI model and non-invasive Hb (SpHb) (SI model: age, sex, EMS SI)	Mortality	Multivariate logistic regression models using step-wise feature selection. Forward selection included features with Wald χ2 test ≤0.2, and those with significance level >0.3 removed by backward selection. 10-fold cross-validation was repeated 10 times with stratified sampling to examine prediction using previously unseen data.	NR	AUC (95% CI): 0.90 (0.82 to 0.98) sensitivity: 92% specificity: 76%
Yang, 2016 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	SI model and other lab tests (SI model: age, sex, EMS SI)	Blood transfusion, 1-3 hours after admission	Multivariate logistic regression models using step-wise feature selection. Forward selection included features with Wald χ2 test ≤0.2, and those with significance level >0.3 removed by backward selection. 10-fold cross-validation was repeated 10 times with stratified sampling to examine prediction using previously unseen data.	NR	AUC (95% CI): 0.91 (0.85 to 0.96) sensitivity: 90% specificity: 77%
Yang, 2016 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	SI model and other lab tests (SI model: age, sex, EMS SI)	Mortality	Multivariate logistic regression models using step-wise feature selection. Forward selection included features with Wald χ2 test ≤0.2, and those with significance level >0.3 removed by backward selection. 10-fold cross-validation was repeated 10 times with stratified sampling to examine prediction using previously unseen data.	NR	AUC (95% CI): 0.81 (0.66 to 0.96) sensitivity: 75% specificity: 82%

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Yang, 2016 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	SI model with non-invasive Hb (SpHb) and other lab tests (SI model: age, sex, EMS SI)	Blood transfusion, 1-3 hours after admission	Multivariate logistic regression models using step-wise feature selection. Forward selection included features with Wald χ2 test ≤0.2, and those with significance level >0.3 removed by backward selection. 10-fold cross-validation was repeated 10 times with stratified sampling to examine prediction using previously unseen data.	NR	AUC (95% CI): 0.91 (0.86 to 0.96) sensitivity: 95% specificity: 73%
Yang, 2016 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	SI model with non-invasive Hb (SpHb) and other lab tests (SI model: age, sex, EMS SI)	Mortality	Multivariate logistic regression models using step-wise feature selection. Forward selection included features with Wald χ2 test ≤0.2, and those with significance level >0.3 removed by backward selection. 10-fold cross-validation was repeated 10 times with stratified sampling to examine prediction using previously unseen data.	NR	AUC (95% CI): 0.91 (0.84 to 0.98) sensitivity: 92% specificity: 79%
Yang, 2016 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	SI model: age, sex, EMS SI	Blood transfusion, 1-3 hours after admission	Multivariate logistic regression models using step-wise feature selection. Forward selection included features with Wald χ2 test ≤0.2, and those with significance level >0.3 removed by backward selection. 10-fold cross-validation was repeated 10 times with stratified sampling to examine prediction using previously unseen data.	NR	AUC (95% CI): 0.78 (0.63 to 0.92) sensitivity: 70% specificity: 89%

Author, Year (See Appendix B for complete reference)	Measure	Indicator of Serious Injury	Method for Constructing Multivariate Model	Risk Estimates Multivariate	AUROC Multivariate AUC (95% CI)
Yang, 2016 *Mackenzie 2015, Shackelford 2015, and Yang 2016 draw from the same population, but differ in eligibility criteria, number analyzed, and measures evaluated.	SI model: age, sex, EMS SI	Mortality	Multivariate logistic regression models using step-wise feature selection. Forward selection included features with Wald χ2 test ≤0.2, and those with significance level >0.3 removed by backward selection. 10-fold cross-validation was repeated 10 times with stratified sampling to examine prediction using previously unseen data.	NR	AUC (95% CI): 0.74 (0.59 to 0.90) sensitivity: 83% specificity: 59%

See Appendix B. Included Studies for full study references.

AOR = adjusted odds ratio; APACHE II = Acute Physiology and Chronic Health Evaluation II; AUROC = area under the receiver operating characteristic curve; BD = base deficit; BP = blood pressure; CI = confidence interval; CT = computed tomography; DBP = diastolic blood pressure; ECG = electrocardiogram; ED = emergency department; EMS = emergency medical services; ETCO2 = end-tidal carbon dioxide; FTS = Field Triage Score; GAP = Glasgow Coma Scale, Age, and Arterial Pressure; GCS = Glasgow Coma Scale; Hb = hemoglobin; HR = heart rate; HRC = heart rate complexity; HRV = heart rate variability; ICU = intensive care unit; INR = international normalized ratio; IQR = interquartile range; ISS = Injury Severity Score; IV = intravenous; LOS = length of stay; LSI = life-saving intervention; MAP = mean arterial pressure; MGAP = Mechanism, Glasgow Coma Scale, Age, and Arterial Pressure; NPV = negative predictive value; NR = not reported; NTTP = National Trauma Triage Protocol; POC = point of care; PPG = photoplethysmography, photoplethysmogram; PPV = positive predictive value; PRBC = packed red blood cell; RBC = red blood cell; REMS = Rapid Emergency Medicine Score; ROC = receiver operating characteristic; RR = respiratory rate; RTS = Revised Trauma Score; SaO2 = oxygen saturation; SBP = systolic blood pressure; SD = standard deviation; SI = shock index; SmO2 = muscle oxygen saturation; Sp = specificity; SpHb = noninvasive continuous hemoglobin concentration; SpO2 = peripheral oxygen saturation; TRISS = Trauma and Injury Severity Score; vs. = versus; VSDR = vital signs data and event recorder; WVSM = wireless vital signs monitor

Appendix E. Risk of Bias Criteria

Table E1. Quality in Prognostic Studies (QUIPS) tool, modified

Domains	Prompting Items for Consideration	QUIPS Tool Ratings (Overall Risk of Bias)	EPC Modifications
Study Participation	a. Adequate participation in the study by eligible persons b. Description of the source population or population of interest c. Description of the baseline study sample d. Adequate description of the sampling frame and recruitment e. Adequate description of the period and place of recruitment f. Adequate description of inclusion and exclusion criteria	**High bias:** The relationship between the PF and outcome is very likely to be different for participants and eligible nonparticipants **Moderate bias**: The relationship between the PF and outcome may be different for participants and eligible nonparticipants **Low bias**: The relationship between the PF and outcome is unlikely to be different for participants and eligible nonparticipants	*** Not Reported can be used for any domain**
Study Attrition	a. Adequate response rate for study participants b. Description of attempts to collect information on participants who dropped out c. Reasons for loss to followup are provided d. Adequate description of participants lost to followup e. There are no important differences between participants who completed the study and those who did not	**High bias**: The relationship between the PF and outcome is very likely to be different for completing and noncompleting participants **Moderate bias**: The relationship between the PF and outcome may be different for completing and noncompleting participants **Low bias**: The relationship between the PF and outcome is unlikely to be different for completing and noncompleting participants	Include assessment of the impact of missing data in this domain, not in others Consider the percent of missing data as well as how the study addressed it (i.e., if there was imputation done)
Prognostic Factor Measurement	a. A clear definition or description of the PF is provided b. Method of PF measurement is adequately valid and reliable c. Continuous variables are reported or appropriate cut points are used d. The method and setting of measurement of PF is the same for all study participants e. Adequate proportion of the study sample has complete data for the PF f. Appropriate methods of imputation are used for missing PF data.	**High bias**: The measurement of the PF is very likely to be different for different levels of the outcome of interest **Moderate bias**: The measurement of the PF may be different for different levels of the outcome of interest **Low bias**: The measurement of the PF is unlikely to be different for different levels of the outcome of interest	Is the measurement of the physiologic measures of circulation/respiration/combinations done well? This included issues with definitions or instrumentation. Is the measurement valid, reliable, reasonable etc.

Domains	Prompting Items for Consideration	QUIPS Tool Ratings (Overall Risk of Bias)	EPC Modifications
Outcome Measurement	a. A clear definition of the outcome is provided b. Method of outcome measurement used is adequately valid and reliable c. The method and setting of outcome measurement is the same for all study participants	**High bias**: The measurement of the outcome is very likely to be different related to the baseline level of the PF **Moderate bias**: The measurement of the outcome may be different related to the baseline level of the PF **Low bias**: The measurement of the outcome is unlikely to be different related to the baseline level of the PF	**Similar to PF measurement, but for us this is about how the indicator of serious injury is measured (the ISS, mortality, major surgery etc.)**
Study Confounding	a. All important confounders are measured b. Clear definitions of the important confounders measured are provided c. Measurement of all important confounders is adequately valid and reliable d. The method and setting of confounding measurement are the same for all study participants e. Appropriate methods are used if imputation is used for missing confounder data f. Important potential confounders are accounted for in the study design g. Important potential confounders are accounted for in the analysis	**High bias:** The observed effect of the PF on the outcome is very likely to be distorted by another factor related to PF and outcome **Moderate bias:** The observed effect of the PF on outcome may be distorted by another factor related to PF and outcome **Low bias:** The observed effect of the PF on outcome is unlikely to be distorted by another factor related to PF and outcome	Code as Not Applicable for Sensitivity/ Specificity -- can't adjust. .
Statistical Analysis and Reporting	a. Sufficient presentation of data to assess the adequacy of the analytic strategy b. Strategy for model building is appropriate and is based on a conceptual framework or model c. The selected statistical model is adequate for the design of the study d. There is no selective reporting of results	**High bias**: The reported results are very likely to be spurious or biased related to analysis or reporting **Moderate bias**: The reported results may be spurious or biased related to analysis or reporting **Low bias**: The reported results are unlikely to be spurious or biased related to analysis or reporting	May be Not Applicable in cases of sensitivity/specificity and no other types of analysis.

Risk Prediction Studies[1]

Criteria:

- The study sample adequately represents the population of interest
- The study data available (i.e., participants not lost to followup) adequately represent the study sample

- The prognostic factor is measured in a similar way for all participants
- The outcome of interest is measured in a similar way for all participants
- Important potential confounding factors are appropriately accounted for
- The observed effect of the prognostic factor on the outcome is very likely to be distorted by another factor related to prognostic factor and outcome.

Definitions of risk of bias based on above criteria:

Low: The least risk of bias, and results are generally considered more valid than studies with the same study design but more flaws. Low risk of bias studies include clear descriptions of the population, setting, interventions, and comparison groups clear reporting of missing data; apply appropriate means to prevent; and appropriately measure outcomes.

Moderate: Susceptible to some bias, though not enough to necessarily invalidate the results. These studies may not meet all the criteria for "low" risk of bias rating, but do not have flaws likely to cause major bias. The study may also be missing information, making it difficult to assess limitations and potential problems.

High: Have significant flaws that may invalidate the results. They may have a serious or "fatal" flaw or set of flaws in design, analysis, or reporting; large amounts of missing information; or discrepancies in reporting. The results of these studies will be least as likely to reflect flaws in the study design as the true difference between the compared interventions.

Definition of risk of bias based on above criteria:

Low: Evaluates relevant available screening test; uses a credible reference standard; interprets reference standard independently of screening test; reliability of test assessed; has few or handles missing data in a reasonable manner; includes a large number (>100), broad-spectrum of patients with and without disease; study attempts to enroll a random or consecutive sample of patients who meet inclusion criteria screening cutoffs pre-stated.

Moderate: Evaluates relevant available screening test; uses reasonable although not best standard; interprets reference standard independent of screening test; moderate sample size (50 to 100 subjects) and a "medium" spectrum of patients (i.e. applicable to most screening settings).

High: Has important limitation such as: uses inappropriate reference standard; screening test improperly administered; biased ascertainment of reference standard; very small sample size of very narrow selected spectrum of patients.

Reference

1. Hayden JA, van der Windt DA, Cartwright JL, et al. Assessing bias in studies of prognostic factors. Ann Intern Med. 2013 Feb 19;158(4):280-6. doi: 10.7326/0003-4819-158-4-201302190-00009. PMID: 23420236.

Appendix F. Risk of Bias Assessment

Table F1. Risk of bias assessment

Author, year (see Appendix B for full reference)	Study Participation	Study Attrition	Prognostic Factor Measurement	Outcome Measurement	Study Confounding	Statistical Analysis and Reporting	Risk of Bias
Ahun, 2014	Moderate	Unknown	Low	Low	NA	Low	Moderate
Allen, 2014	Moderate	Low	Low	Low	Moderate	Low	Moderate
Al-Salamah, 2004	Moderate	Low	Low	Low	Moderate	Moderate	Moderate
Arbabi, 2004	Moderate	Unknown	Low	Low	Moderate	Moderate	Moderate
Aslar, 2004	Low	Low	Low	Low	Moderate	Moderate	Moderate
Baron, 2004	Unclear	Low	Low	Moderate	NA	NA	Moderate
Baron, 2007	Moderate	Moderate	Low	Low	Low	Low	Moderate
Batchinsky, 2007	High	High	Low	Low	Moderate	Low	Moderate
Batchinsky, 2009	Moderate	High	Low	Low	Unclear	Moderate	Moderate
Batchinsky, 2009b	Moderate	Moderate	Low	Low	High	Low	High
Beekley, 2010	Low	Moderate	Moderate	Low	NA	NA	Moderate
Bond, 1997	Low	Low	Low	Low	Moderate	Low	Moderate
Bouzat, 2016	High	Low	Low	Low	High	Low	High
Brown, 2011	Moderate	Low	Low	Low	Low	Low	Moderate
Brown, 2015	Moderate	Moderate	Low	Low	Moderate	Low	Moderate
Brown, 2016	High	Low	Low	Low	Moderate	Low	Moderate
Bruijns, 2013	Low	Moderate	Moderate	Low	NA	Moderate	Moderate
Bruijns, 2014	Moderate	Low	Low	Low	Moderate	Low	Moderate
Callaway, 2009	Low	Low	Low	Low	Moderate	Low	Moderate
Cancio, 2008	High	High	Moderate	Moderate	High	Moderate	High
Cancio, 2008a	Moderate	High	High	Moderate	Moderate	Moderate	High
Cannon, 2009	Low	High	Low	Low	High	Low	Moderate
Caputo, 2012	Low	Low	Low	Low	Moderate	Moderate	Moderate
Caputo, 2015	Low	Low	Low	Low	NA	NA	Low
Chan, 1997	High	High	Low	Low	High	High	High
Chen, 2007	Moderate	Moderate	Low	Low	High	Low	High
Chen, 2008	Low	Unknown	Moderate	Low	Low	Low	Moderate
Chen, 2009	Low	Moderate	Moderate	Low	Moderate	Low	Moderate
Chen, 2010	Low	Moderate	Moderate	Low	Moderate	Low	Moderate
Cherry, 2007	Moderate	Unclear	Low	Low	Low	Low	Moderate
Cooke, 2006a	High	High	Moderate	Moderate	High	Moderate	High
Courville, 2009	Low	Moderate	Low	Low	Low	Low	Low
Cudnik, 2012	Low	Moderate	Low	Low	Low	Low	Moderate
Davis, 1996	High	Low	Low	Low	Moderate and NA	Moderate and NA	Moderate

Author, year (see Appendix B for full reference)	Study Participation	Study Attrition	Prognostic Factor Measurement	Outcome Measurement	Study Confounding	Statistical Analysis and Reporting	Risk of Bias
DeMuro, 2013	Moderate	Low	Moderate	Moderate	NA	Moderate	Moderate
Dinh, 2014	Low	Low	Low	Low	Moderate	Low	Moderate
Dunham, 2017	High	High	Low	Low	High	Low	High
Dunne, 2005	Moderate	Moderate	Low	Low	Low	Low	Moderate
Eastridge, 2007	Moderate	Unknown	Low	Low	NA	Low	Moderate
Edla, 2015b	High	Moderate	Low	Low	NA	Low	Moderate
Engum, 2000	Low	Moderate	Low	Low	Low	Low	Moderate
Franklin, 2000	Moderate	Low	Low	Low	Moderate	Low	Moderate
Folkert, 2015	Moderate	Moderate	Low	Low	High	Low	Moderate
Garner, 2001	Low	Low	Low	Low	Low	Low	Moderate
Gebhart, 2007	Low	Low	Low	Low	NA	NA	Low
Gray, 1997	Moderate	Low	Low	Low	Moderate	Low	Moderate
Grimme, 2005	Moderate	Unclear	Low	Low	Moderate	Moderate	Moderate
Guyette, 2011	Low	Moderate	Low	Low	Low and NA	Low and NA	Moderate
Guyette, 2012	Moderate	Low	Low	Low	High	Low	Moderate
Guyette, 2015	Moderate	Moderate	Low	Low	Low	Low	Moderate
Haider, 2016	Moderate	Unclear	Low	Low	Low	Moderate	Moderate
Hamada, 2014	Moderate	Low	Low	Low	Low	Low	Moderate
Henry, 1996	Low	Low	Low	Low	Low	Low	Low
Holcomb, 2005	High	High	Moderate	Low	High	Moderate	High
Holcomb, 2005b	Moderate	Moderate	Low	Low	Low	Moderate	Moderate
Horne, 2013	High	High	Moderate	Low	High	High	High
Ichwan, 2015	Moderate	Low	Moderate	Low	Low	Low	Moderate
Imhoff, 2014	Moderate	Moderate	Moderate	Low	Low	Moderate	Moderate
Jo, 2014	Moderate	Low	Moderate	Low	NA	NA	Moderate
Jones, 2014	Moderate	Low	Moderate	Low	Moderate	Moderate	Moderate
Joosse, 2014	Moderate	Low	Low	Low	Low	Low	Low
Khasawneh, 2014	Moderate	Low	Low	Low	NA	NA	Moderate
Kim, 2016	High	High	Low	Low	High	Low	High
King, 1996	High	Low	Low	Low	Low	Low	Moderate
King, 2009	High	Moderate	Low	Low	Low	Low	Moderate
Kondo, 2011	Low	Moderate	Low	Low	Low	Low	Moderate
Kuo, 2016	Low	Low	Low	Low	Moderate	Moderate	Moderate
Lai, 2016	Low	Low	Low	Low	Moderate	Low	Moderate
Lalezarzadeh, 2009	Moderate	Moderate	Low	Low	High	Low	High
Lee, 2014	Low	Low	Low	Low	NA	NA	Low
Lehmann, 2007	Moderate	Moderate	Moderate	Low	Moderate	Moderate	Moderate
Lerner, 2017	Moderate	Low	Low	Low	Low	Low	Low

Author, year (see Appendix B for full reference)	Study Participation	Study Attrition	Prognostic Factor Measurement	Outcome Measurement	Study Confounding	Statistical Analysis and Reporting	Risk of Bias
Lin, 2011	Low	Low	Low	Low	High and NA	High and NA	High
Lipsky, 2006	Moderate	Low	Low	Low	High	Low	High
Liu, 2014	High	High	Moderate	Low	Moderate	Moderate	High
Liu, 2014b	High	Unclear	Moderate	Low	NA and Moderate	NA and Moderate	High
Liu, 2014c	Moderate	Moderate	Low	Low	High	Moderate	High
Liu, 2015a	High	Unknown	Low	Low	Low	Moderate	Moderate
Liu, 2015b	High	Unclear	Moderate	Low	NA and Moderate	NA and Moderate	High
Mackenzie, 2014	Moderate	Low	Low	Low	Moderate	Low	Moderate
Mackenzie, 2015	Moderate	High	Low	Low	Low	Low	Moderate
Matsushima, 2016	Moderate	Unknown	Low	Low	Low	Low	Moderate
McManus, 2005	Moderate	Unknown	Low	Low	High	Low	High
McNab, 2013	Low	Unknown	Low	Low	Moderate	Low	Moderate
Miller, 2017	Moderate	Low	Low	Low	Moderate	Low	Moderate
Mizushima, 2011	Moderate	Unclear	Moderate	Moderate	Moderate	Moderate	Moderate
Montoya, 2015	High	Low	Moderate	Low	Moderate	Low	High
Moore, 2006	Moderate	Low	Low	Low	Low	Low	Low
Moront, 1996	Moderate	Unknown	Low	Low	High	Moderate	Moderate
Mutschler, 2013	Low	Low	Low	Low	Low	Moderate	Moderate
Nabaweesi, 2014	Low	Low	Low	Low	Moderate	Moderate	Moderate
Newgard, 2009	Low	Moderate	Low	Low	Low	Low	Moderate
Newgard, 2014	Low	Unclear	Low	Low	Moderate	Low	Moderate
Newgard, 2016	Low	Unclear	Low	Low	NA	Low	Moderate
Ocak, 2009	Moderate	Low	Low	Low	Low	Low	Moderate
Pal, 2006	Low	Moderate	Moderate	Low	Low	Low	Moderate
Paladino, 2008	Moderate	Low	Low	Low	NA	NA	Moderate
Paladino, 2010a	Moderate	Low	Low	Low	NA	NA	Moderate
Paladino, 2010b	Moderate	Low	Low	Low	NA	NA	Moderate
Paladino, 2011	Moderate	Unknown	Low	Low	NA	Low	Moderate
Pandit, 2014	Moderate	Unknown	Low	Low	Low	Low	Moderate
Parimi, 2016	Moderate	High	Low	Low	NA	Low	Moderate
Parsikia, 2014	High	Moderate	Low	Low	Moderate	Moderate	Moderate
Perel, 2012 and Perel, 2013*	Low	Unclear	Low	Low	Low	Low	Moderate
Potoka, 2001	Low	Unclear	Low	Low	Low	Low	Moderate
Pottecher, 2016	Moderate	Low	Low	Low	Moderate	Low	Moderate
Rahmani, 2017	Moderate	Low	Low	Low	Moderate	Low	Moderate
Rainer, 2011	High	Low	Low	Low	Low	Moderate	Moderate
Ramanathan, 2015	Low	Low	Low	Low	NA	NA	Low
Raux, 2006	Moderate	Moderate	Low	Low	Moderate	Moderate	Moderate

Author, year (see Appendix B for full reference)	Study Participation	Study Attrition	Prognostic Factor Measurement	Outcome Measurement	Study Confounding	Statistical Analysis and Reporting	Risk of Bias
Raux, 2011	Low	Unclear	Low	Low	NA	Low	Moderate
Raux, 2017	Moderate	High	Low	Low	Moderate	Low	Moderate
Regnier, 2012	Moderate	Low	Low	Low	NA	NA	Moderate
Reisner, 2016	Moderate	Low	Low	Low	Moderate	Moderate	Moderate
Rickards, 2010	Low	Moderate	Low	Low	Moderate	Low	Moderate
Ryan, 2011	Low	Moderate	Low	Low	Moderate	Low	Moderate
Sammour, 2009	High	High	Low	Low	Moderate	Moderate	High
Sartorius, 2010	Low	Unclear	Low	Low	Low	Low	Moderate
Schenarts, 2008	Moderate	Moderate	Low	Low	High	Low	High
Shackelford, 2015	Low	Moderate	Low	Low	Low	Moderate	Moderate
Shah, 2013	Moderate	Low	Low	Low	Low	Low	Moderate
Shoemaker, 2005	Low	Low	Low	Low	NA	Low	Low
St. John, 2016	Moderate	Low	Low	Low	Low	Low	Moderate
Stanworth, 2010	Low	Moderate	Moderate	Low	Moderate	Moderate	Moderate
Tamim, 2002	Moderate	Moderate	Low	Low	Low	Low	Moderate
Van Haren, 2014	Unclear	Unclear	Low	Low	NA	Low	Moderate
Vandromme, 2010	High	Moderate	Low	Low	Low	Low	Moderate
Vandromme, 2011	Low	High	Low	Low	High	Low	High
Vandromme, 2011b	Moderate	Moderate	Low	Low	Low	Low	Moderate
Vassallo, 2015	Low	Moderate	Low	Low	NA	Moderate	Moderate
Vassallo, 2017	High	High	Low	Low	High	Low	High
Vettorello, 2013	High	Low	Low	Low	NA	Low	High
Williams, 2016	Moderate	Unclear	Low	Moderate	NA	NA	Moderate
Woodford, 2012	Unclear	Moderate	Low	Low	NA	Low	Moderate
Yang, 2016	Moderate	Moderate	Low	Low	Low	Low	Moderate
Yuen, 2016	Unclear	Unclear	Low	Low	Low	Low	Moderate
Zarzaur, 2008	Low	High	Low	Low	NA	Moderate	Moderate

See Appendix B. Included Studies for full study references.

NA=not applicable, as sensitivity and specificity are not adjusted for confounders

Appendix G. Multivariate Results Summaries

Table G1. Measures of circulatory compromise

	Author, Year (see Appendix B for full reference)	Number Analyzed Age Mean (SD)	Measure (cutpoint) *Subgroup*	Serious Injury Indicator Type: Indicator	Multivariate Results Adjusted Odds Ratio (95% CI)	Variables Included in Model
Heart Rate: OH	Barmparas, 2014	135,694 NR	HR (<70) *ED GCS score ≤8*	I: Severe head injury	1.83 (1.58 to 2.12)	Age, gender, HR and SBP
Heart Rate: OH	Barmparas, 2014	135,694 NR	HR (<70) *ED GCS score 9-13*	I: Severe head injury	1.68 (1.39 to 2.04)	Age, gender, HR and SBP
Heart Rate: OH	Barmparas, 2014	135,694 NR	HR (<70) *ED GCS score 14-15*	I: Severe head injury	1.18 (1.12 to 1.25	Age, gender, HR and SBP
Heart rate variability or complexity: OH	Batchinsky, 2009	31	Heart rate variability (800 beats)	M: Mortality: not specified	0.00007 (0 to 0.124)	Data set lengths of 100, and 200 beats.
Heart rate variability or complexity: OH	Batchinsky, 2009	31	Heart rate variability (200 beats)	M: Mortality: not specified	0.00045 (0 to 0.159)	Data set lengths of 100, and 800 beats.
Heart rate variability or complexity: OH	Batchinsky, 2009	31	Heart rate variability (100 beats)	M: Mortality: not specified	0.024 (0.001 to 0.494)	Data set lengths of 200, and 800 beats.

	Author, Year (see Appendix B for full reference)	Number Analyzed Age Mean (SD)	Measure (cutpoint) *Subgroup*	Serious Injury Indicator Type: Indicator	Multivariate Results Adjusted Odds Ratio (95% CI)	Variables Included in Model
Heart rate variability or complexity: OH	Cooke, 2006a	30 43 (2) died 35 (3) survives	Heart rate variability	M: Mortality: not specified	Likelihood ratio (χ2HF/LF) HF/LF, no covariate: 9.96, p=0.0016 HF/LF, covariate age: 5.19, p=0.0227 HF/LF, covariate RRI: 7.06, p=0.007 HF/LF, covariate GCS: 1.96, p=0.1619 HF/LF, covariates age, RRI, and GCS: 0.43, p=0.487 *HF = R-R interval spectral power at the high frequency (0.15-0.4 Hz) *LF = R-R interval spectral power at the low frequency (0.05-0.15 Hz) *RRI = interbeat R-R interval	Age, GCS score, and RRI (interbeat R-R interval)
Heart Rate: OH	Garner, 2001	1,144 (median) 33 (IQR 21-53)	HR (>120)	I: Critical Injury	2.53 (1.15–5.60) Model 1 2.45 (1.10–5.48) Model 2	RR, GCS-motor, SBP, capillary refill, and HR. Models: differ in RR cut offs: Model1: between 10 and 29. (normal) Model 2: s <10 or >29
Heart Rate: OH	Guyette, 2011	1,168 Median 44 IQR 27 to 58)	HR	M: Mortality`	0.97 (0.96–0.98)	Age, sex, initial SBP, HR, RR, and GCS
Heart rate variability or complexity: OH	King, 2009	75 47 (20)	Heart rate variability (SDNN ≤24 msec)	R: Life-saving intervention	11.7 (2.1 to 65.4)	HR, SBP, GCS, and high suspicion of injury
Heart rate variability or complexity: OH	King, 2009	75 47 (20)	Heart rate variability (SDNN ≤39 msec)	I: Serious Injury	5.8 (1.9 to 17.1)	HR, SBP, GCS, and high suspicion of injury

	Author, Year (see Appendix B for full reference)	Number Analyzed Age Mean (SD)	Measure (cutpoint) *Subgroup*	Serious Injury Indicator Type: Indicator	Multivariate Results Adjusted Odds Ratio (95% CI)	Variables Included in Model
Heart Rate: OH	Liu, 2014a	305 39 (16)	HR using standard monitor	R: Life-saving intervention	1.02 (1.01-1.04), p=0.01 per 1 unit increase	Independent variables of age, height, race, and weight and with dependent variables of in-hospital initial vital sign measurements and GCS scores
Heart Rate: OH	Liu, 2014a	305 39 (16)	HR using wireless monitor	R: Life-saving intervention	1.02 (0.99-1.06), p=0.21 per 1 unit increase	Independent variables of age, height, race, and weight and with dependent variables of in-hospital initial vital sign measurements and GCS scores
Heart Rate: OH	Matsushima, 2016	3,988 Children (≤ 18): 12.3% Adults (19-64): 80.5% Elderly ≥ 65): 7.2%	HR (>100)	R: Need for trauma center care	1.37 (1.13-1.66)	"Clinically significant variables" logistic regression
Heart Rate: OH **Children**	Nabaweesi, 2014	1,991 Median Age: 6	HR (abnormal)	R: ED disposition to ICU, OR morgue	2.6 (1.04-6.27), p=0.039	SBP, respiratory distress, HR, GCS, chest injury, abdominal injury, spine injury, air vs. ground, health insurance, race, age
Heart Rate: ED **Elderly**	Pandit, 2014	217,190 77.7 (7.1)	HR	M: Mortality	1.1 (0.9 to 1.3), p=0.2	Age, male sex, ED SBP, ED HR, SI, GCS score, blunt mechanism of trauma, and ISS
Heart Rate: ED **Elderly**	Pandit, 2014	217,190 77.7 (7.1)	HR *Age 65-74*	M: Mortality	1.1 (0.9 to 1.9), p=0.6	Age, male sex, ED SBP, ED HR, SI, GCS score, blunt mechanism of trauma, and ISS
Heart Rate: ED **Elderly**	Pandit, 2014	217,190 77.7 (7.1)	HR *Age 75-84*	M: Mortality	1.1 (0.8 to 2.1), p-0.5	Age, male sex, ED SBP, ED HR, SI, GCS score, blunt mechanism of trauma, and ISS
Heart Rate: ED **Elderly**	Pandit, 2014	217,190 77.7 (7.1)	HR *Age >85*	M: Mortality	1.4 (0.8 to 3.2), p=0.2	Age, male sex, ED SBP, ED HR, SI, GCS score, blunt mechanism of trauma, and ISS
Heart Rate: OH	Raux, 2011	1,360 (national cohort) 38 (17)	HR (≥100)	R: Emergency Procedure	1.42 (1.12 to 1.79), p=0.004	Penetrating trauma, intravenous colloid administration 750 mL, systolic arterial blood pressure 100 mmHg, and HR 100 bpm

See Appendix B. Included Studies for full study references.

ED = emergency department; GCS = Glasgow Coma Scale; HF = high frequency; HR = heart rate; IQR = interquartile range; LF = low frequency; NR = not reported; OH = out of hospital; OR = operating room; RR = respiratory rate; SBP = systolic blood pressure; SI = shock index

Table G2. Measures of respiratory compromise

	Author, Year (see Appendix B for full reference)	Measure	Serious Injury Indicator Type: Specific Indicator	Number Analyzed Age Mean (SD)	Adjusted Odds Ratio	Variables Included in Model
Base Deficit: ED	Aslar, 2004	Lactate	Mortality	64 35.7 (18.6)	Adjusted odds ratio (95% CI): 10.58 (1.88 to 59.24)	Apache II
Base Deficit: ED	Beekley, 2010	BD	LSI	147 27 (11)	AOR BD change of (-2 mEq/L) 1.54 (1.1-2.2)	Retained: DBP, INR, HCT, BD Not Retained: SBP, Hgb, THI Not retained in any model: StO2, radial pulse character, HR, platelets, and pH
Base Deficit: ED	Dunne, 2005	BD> -6 mmol/L	M: Mortality	15,179 37(19)	Not controlling for alcohol and drugs 2.12 (1.50-3.010,p=0.0001	NA
Base Deficit: ED	Dunne, 2005	BD> -6 mmol/L	M: Mortality	15,179 37(19)	Controlling for alcohol and drugs 2.51 (1.75-3.60), p=0.0001	Alcohol and drug use
Base Deficit: ED	Dunne, 2005	Decreasing BD	R: ICU Admission	15,179 37(19)	Not controlling for alcohol and drugs 1.00(0.98-1.02), p=0.64	NA
Base Deficit: ED	Dunne, 2005	BD> -6 mmol/L	R: ICU Admission	15,179 37(19)	Controlling for alcohol and drugs 1.00(0.98-1.05), p0.85	Alcohol and drug use
Base Deficit: ED	Herbert, 2011	BD	I: Serious Injury	5934 34.5 (14.0)	BD: odds ratio 0.769 95% CI 0.680 0.858 p=0.0002	Lactate, age, ISS
Base Deficit: ED	**St John, 2016** **Elderly**	BD	I: severe multisystem injury	3224 Elderly (≥65): 22.4% (721/3,224)	RR (95% CI) BD: 1.07 (0.91 to 1.25), p=0.43	Gender, ISS, GCS on arrival, and mechanism of injury. ISS was included as a surrogate for overall clinical assessment of severity of injury.

	Author, Year (see Appendix B for full reference)	Measure	Serious Injury Indicator Type: Specific Indicator	Number Analyzed Age Mean (SD)	Adjusted Odds Ratio	Variables Included in Model
ETCO2: ED	Williams, 2016	End-tidal CO2 ($ETCO_2$) ≤30	Severe injury composite	170 43 (NR)	Odds ratio 1.06 (95% CI 1.01-1.13), p=0.0423	Triage vital signs
Oxygen saturation ED	Imjoff, 2014	O2 saturation	Mortality, in-hospital	3680 36.5 (17.0) Alive 43.7 (21.0) Dead	Adjusted odds ratio (95% CI), per 1 unit increase: 0.961 (0.940-0.982), p=0.0004	All parameters in REMS. Odds ratios used to estimate relative strength of parameters in score.
Oxygen saturation ED	Khasawneh,2014	StO2 <65%	R: Massive Transfusion	325 46 (NR)	Adjusted odds ratio (95% CI): -2.65 (-10.2 to -1.4), p=0.01	Age, sex, relative probability of survival, injury severity score, mechanism of trauma, traumatic brain injury, use of anticoagulants and beta blockers, transfer time, out-of-hospital blood transfusion, SBP, HR, RR, oxygen saturation, GCS, hemoglobin, pH, base deficit, lactate level, and the Focused Assessment with Sonography for Trauma (FAST).
Oxygen saturation OH	Sagraves, 2009	Minimum STo2	Mortality	41 NR	Odds ratio 2.28 (95% CI NR), p=0.0423	Routine vital signs (variables: HR, SBP, PP) and STO2
Respiratory effort: OH	Lehmann, 2007	Respiratory effort	R: Emergent Intervention	1495 41(22)	Adjusted odds ratio (95% CI): 4.6 (1.9 to 11), p<0.01	Age, sex, mechanism of injury, HR,GCS, SBP

	Author, Year (see Appendix B for full reference)	Measure	Serious Injury Indicator Type: Specific Indicator	Number Analyzed Age Mean (SD)	Adjusted Odds Ratio	Variables Included in Model
RR: ED	Imhoff, 2014	RR	Mortality in-hospital	3680 36.5 (17.0) survived 43.7 (21.0) died	Adjusted odds ratio (95% CI), per 1 unit increase: 1.001 (0.978-1.025), p=0.9023	All parameters in REMS. Odds ratios used to estimate relative strength of parameters in score.
RR: ED	Parsikia, 2014	RR	Mortality	1941 Median 47 (IQR 28-67)	Odds ratop 1.05 (1.04 to 1.07)	Age, gender, initial SBP, HR, respiratory rate, GCS, packed red blood cells, and serum lactate
RR: OH	Garner, 2001	RR >29	Critical Injury	1144 Median 33 IQR 21 to 53)	Jackknife adjusted odds ratio (95% CI): 2.35 (0.99–5.61)	RR, GCS-motor, SBP, capillary refill, and HR. Models: differ in RR cut offs: Model1: between 10 and 29. (normal) Model 2: s <10 or >29
RR: OH	Garner, 2001	RR <10 or >29	Critical Injury	1144 Median 33 IQR 21 to 53)	Jackknife adjusted odds ratio (95% CI): 2.64 (1.21–5.76)	RR, GCS-motor, SBP, capillary refill, and HR. Models: differ in RR cut offs: Model1: between 10 and 29. (normal) Model 2: s <10 or >29
RR: OH	Henry, 1996	RR <10 or >29	Major nonorthopedic interventions or death	1545 Median 30 (range 0 to 93)	Adjusted odds ratio (95% CI): 5.0 (0.8-29.9), not significant	ll ACS trauma triage criteria without regard to statistical significance. Includes SBP, GCS, RR, 3 anatomic criteria, age, known cardiac or respiratory disease and 8 mechanism criteria.
RR: OH	Henry, 1996	RR <10 or >29	ISS ≥16	1545 Median 30 (range 0 to 93)	Adjusted odds ratio (95% CI): 2.5 (0.6-9.8), not significant	ll ACS trauma triage criteria

	Author, Year (see Appendix B for full reference)	Measure	Serious Injury Indicator Type: Specific Indicator	Number Analyzed Age Mean (SD)	Adjusted Odds Ratio	Variables Included in Model
RR: OH	Liu, 2014a	RR: standard monitor	LSI in ED	305 39(16)	Adjusted odds ratio (95% CI), per unit increase: 1.02 (0.99-1.04), p=0.16	Independent variables of age, height, race, and weight and with dependent variables of in-hospital initial vital sign measurements and GCS scores
RR: OH	Liu, 2014a	RR: wireless monitor	LSI in ED	305 39(16)	Adjusted odds ratio (95% CI), per unit increase: 1.10 (1.01-1.21), p=0.02	Independent variables of age, height, race, and weight and with dependent variables of in-hospital initial vital sign measurements and GCS scores
RR: OH may be both	Nabaweesi, 2014	Respiratory distress	ICU, OR use, or mortality	1991 Median Age: 6	Odds ratio: 2.9 (95% CI 0.72-11.8), p=0.133	SBP, respiratory distress, HR, GCS, chest injury, abdominal injury, spine injury, air vs. ground, health insurance, race, age

See Appendix B. Included Studies for full study references.

AOR = adjusted odds ratio BD = base deficit; CI = confidence interval; DBP = diastolic blood pressure; ED = emergency department; GCS = Glasgow Coma Scale; HR = heart rate; ICU = intensive care unit; INR = international normalized ratio; ISS = Injury Severity Score; LSI = life-saving intervention; NA = not applicable; OH = out of hospital; PP = pulse pressure; REMS = Rapid Emergency Medicine Score; RR = respiratory rate; SBP = systolic blood pressure; SD = standard deviation; StO2 = tissue oxygen saturation

Appendix H. Strength of Evidence

Table H1. Strength of evidence: out-of-hospital

Key Question	Measure	Number of Studies (N)	Study Limitations (Low, Medium, High)	Directness (Direct, Indirect)	Consistency Consistent, Inconsistent, Unknown	Precision (Precise, Imprecise)	Reporting Bias (Not detected, Suspected)	Main Findings	Strength of Evidence Grade (Insufficient, Low, Moderate, High)
KQ 1. Predictive utility of measures of circulatory compromise	*SBP	9	Medium	Direct	Consistent	Precise	Not detected	AUROC: 0.67 (95% CI, 0.58-0.75, I^2=90.1%)	Moderate
	*SBP <90	17	High	Direct	Inconsistent	Imprecise	Not detected	Sen: 19% (12-29%, 98.8)	Low
	*SBP <90	17	High	Direct	Consistent	Precise	Not detected	Sp: 95% (91-97%, 99.2)	Moderate
	*SBP <100+	6	Medium	Direct	Inconsistent	Imprecise	Not detected	Sen: 35% (19-54%, 99.7)	Low
	*SBP <100+	6	Medium	Direct	Inconsistent	Imprecise	Not detected	Sp: 88% (73-95%, 99.8)	Low
	*HR	5	Medium	Direct	Inconsistent	Imprecise	Not detected	AUROCs: 0.67 (95% CI 0.56 to 0.79, I^2=84.5%)	Low
	*HR >110 or 120	4	Medium	Direct	Inconsistent	Imprecise	Not detected	Sen: 28% (20-37% 41.3)	Low
	*HR >110 or 120	4	Medium	Direct	Inconsistent	Imprecise	Not detected	Sp: 85% (74-91%, 88.0)	Low
	*SI	7	Medium	Direct	Inconsistent	Imprecise	Not detected	AUROC: 0.72 (95% CI 0.66 to 0.77, I^2=54.6%)	Low
	*SI >1	5	Medium	Direct	Inconsistent	Imprecise	Not detected	Sen: 37% (22-56% 94.5)	Low
	*SI >1	5	Medium	Direct	Inconsistent	Precise	Not detected	Sp: 85% (72-92%, 99.6)	Low
	BD	0	–	–	–	–	–		Insufficient
	*Lactate	2	Low	Direct	Inconsistent	Precise	Not detected	AUROC: 0.77 (95% CI 0.67 to 082, I^2=10.2)	Low
	*Lactate >2	3	Medium	Direct	Inconsistent	Imprecise	Not detected	Sen: 74%(48-90%, 98.5)	Low
	*Lactate >2	3	Medium	Direct	Consistent	Precise	Not detected	Sp: 62% (51-72%, 98.6)	Moderate
	*Lactate >4	1	–	–	–	–	–	Sen:23% (21-25%, NA)	Insufficient
	*Lactate >4	1	–	–	–	–	–	Sp: 93% (92-94%, NA)	Insufficient
	HRV/HRC	7	High	Direct	Consistent	Imprecise	Not detected	AUROCs: 0.60 to 0.95	Low
	HRV/HRC	2	High	Direct	Consistent	Precise	Not detected	Sen: 80 to 90%	Low
	HRV/HRC	2	High	Direct	Consistent	Imprecise	Not detected	Sp: 67 to 100%	Low

Key Question	Measure	Number of Studies (N)	**Study Limitations** (Low, Medium, High)	**Directness** (Direct, Indirect)	**Consistency** Consistent, Inconsistent, Unknown	**Precision** (Precise, Imprecise)	**Reporting Bias** (Not detected, Suspected)	Main Findings	**Strength of Evidence Grade** (Insufficient, Low, Moderate, High)
KQ 2. Predictive utility of measures of respiratory compromise	*RR	3	Low	Direct	Consistent	Imprecise	Not detected	0.70 (95% CI 0.66 to 0.79, I^2=16.6%)	Low
	*RR	6	Low	Direct	Inconsistent	Imprecise	Not detected	Sen: 13% (5-29% 97.8)	Low
	*RR	6	Low	Direct	Inconsistent	Imprecise	Not detected	Sp: 96% (83-99%, 99.6)	Low
	O2 Sat	3	Medium	Direct	Inconsistent	Imprecise	Not detected	AUROCs: 0.530 to 0.747	Low
	O2 Sat	3	Medium	Direct	Inconsistent	Imprecise	Not detected	Sen: 13% to 63%	Low
	O2 Sat	3	Medium	Direct	Consistent	Imprecise	Not detected	Sp:85% to 99%	Low
	Airway Support	4	High	Direct	Inconsistent	Imprecise	Not detected	Sen: 8% to 53%	Low
	Airway Support	4	High	Direct	Inconsistent	Imprecise	Not detected	Sp: 61% to 100%	Low
KQ 3. Predictive utility for combinations of measures	RTS	3	Medium	Direct	Inconsistent	Precise	–	AUROC: 0.570 (95% CI 0.423 to 0.720, I^2=16.6%)	Low
	RTS	1	–	–	–	–	–	Sen 95%	Insufficient
	RTS	1	–	–	–	–	–	Sp: 38%	Insufficient
	GAP	0	–	–	–	–	–		Insufficient

AUROC = area under the receiver operating characteristic curve; HR = heart rate; HRC = heart rate complexity; HRV = heart rate variability; KQ = Key Question; O2 sat = oxygen saturation; RR = respiratory rate; GAP=GSC, airway, pressure; RTS = Revised Trauma Scale; SBP = systolic blood pressure; Sen = sensitivity; SI = shock index; Sp = specificity

*Assessment is of pooled studies for the measures analyzed using meta-analysis.

Table H2. Strength of evidence: emergency department

Key Question	Measure	Number of Studies (N)	Study Limitations (Low, Medium, High)	Directness (Direct, Indirect)	Consistency Consistent, Inconsistent, Unknown	Precision (Precise, Imprecise)	Reporting Bias (Not detected, Suspected)	Main Findings	Strength of Evidence Grade (Insufficient, Low, Moderate, High)
KQ 1. Predictive utility of measures of circulatory compromise	*SBP	12	Medium	Direct	Consistent	Precise	Not detected	AUROC: 0.64 (95% CI 0.60 to 0.68, I^2=97.5%)	Moderate
	*SBP <90	9	Medium	Direct	Inconsistent	Imprecise	Not detected	Sen: 18% (11-28%, 99.1)	Low
	*SBP <90	9	Medium	Direct	Consistent	Precise	Not detected	Sp: 97% (97-98%, 93.5)	Moderate
	*SBP <100+	4	Medium	Direct	Inconsistent	Imprecise	Not detected	Sen: 35% (14-63%, 98.7)	Low
	*SBP <100+	4	Medium	Direct	Consistent	Imprecise	Not detected	Sp: 89% (75-95%, 99.5)	Moderate
	*HR	9	Medium	Direct	Consistent	Precise	Not detected	AUROC: 0.66 (95% CI 0.62 to 0.70, I^2=83.9%)	Moderate
	*HR	5	Medium	Direct	Consistent	Precise	Not detected	Sen: 29% (26-32%, 26.7)	Moderate
	*HR	5	Medium	Direct	Consistent	Precise	Not detected	Sp: 93% (90-95%, 94.5)	Moderate
	*SI	11	Medium	Direct	Consistent	Precise	Not detected	AUROC: 0.71 (95% CI 0.66 to 0.76, I^2=94.7%)	Moderate

Key Question	Measure	Number of Studies (N)	Study Limitations (Low, Medium, High)	Directness (Direct, Indirect)	Consistency Consistent, Inconsistent, Unknown	Precision (Precise, Imprecise)	Reporting Bias (Not detected, Suspected)	Main Findings	Strength of Evidence Grade (Insufficient, Low, Moderate, High)
	*SI >1	11	Medium	Direct	Inconsistent	Precise	Not detected	Sen: 40% (24-57%, 99.7)	Low
	*SI >1	11	Medium	Direct	Consistent	Precise	Not detected	Sp: 93% (85-96%, 99.6)	Moderate
	Lactate	14	Medium	Direct	Consistent	Precise	Not detected	AUROC: 0.68 (95% CI 0.65 to 0.71, I^2= 66.6	Moderate
	Lactate >2	9	Medium	Direct	Inconsistent	Imprecise	Not detected	Sen: 74% (66-81%, 89.6)	Low
	Lactate >2	9	Medium	Direct	Inconsistent	Imprecise	Not detected	Sp: 62% (51-72%, 98.6)	Low
	Lactate >4	9	Medium	Direct	Inconsistent	Imprecise	Not detected	Sen: 50% (37-63%, 973.5)	Low
	Lactate >4	9	Medium	Direct	Inconsistent	Imprecise	Not detected	Sp: 86% (78-91%, 92.1)	Moderate
	BD	12	Medium	Direct	Consistent	Precise	Not detected	AUROCs: 0.67 to 0.90	Moderate
	BD	9	Medium	Direct	Inconsistent	Imprecise	Not detected	Sen: 19% to 59%	Low
	BD	9	Medium	Direct	Inconsistent	Imprecise	Not detected	Sp: Range 59% to 98%	Low
	HRV low to high frequency index ratio	1	–	–	–	–	–	AUROC: 0.68 (NR)	Insufficient

Key Question	Measure	Number of Studies (N)	**Study Limitations** (Low, Medium, High)	**Directness** (Direct, Indirect)	**Consistency** Consistent, Inconsistent, Unknown	**Precision** (Precise, Imprecise)	**Reporting Bias** (Not detected, Suspected)	Main Findings	**Strength of Evidence Grade** (Insufficient, Low, Moderate, High)
	HRV/HRC spectral power at very low frequency	1	–	–	–	–	–	AUROC: 0.67 (NR)	Insufficient
KQ 2. Predictive utility of measures of respiratory compromise	RR	3	Medium	Direct	Consistent	Precise	Not detected	AUROC: 0.61 (95% CI 0.48 to 0.74, I^2=90.5%)	Moderate
	RR	4	Medium	Direct	Inconsistent	Precise	Not detected	Sen: 27% (21-35%, 95.2)	Moderate
	RR	4	Medium	Direct	Consistent	Precise	Not detected	Sp: 95% (94-96%, 93.5)	Moderate
	O2 Sat	2	Medium	Direct	Consistent	Precise	Not detected	AUROCs: 0.61 to 0.76	Low
	O2 Sat	2	Medium	Direct	Inconsistent	Imprecise	Not detected	Sen: 25% to 100%	Low
	O2 Sat	2	Medium	Direct	Inconsistent	Imprecise	Not detected	Sp: 39% to 99%	Low
	Airway Support	3	Medium	Direct	Inconsistent	Imprecise	Not detected	Sen: 32% to 57%	Low
	Airway Support	3	Medium	Direct	Inconsistent	Imprecise	Not detected	Sp: 85% to 96%	Low

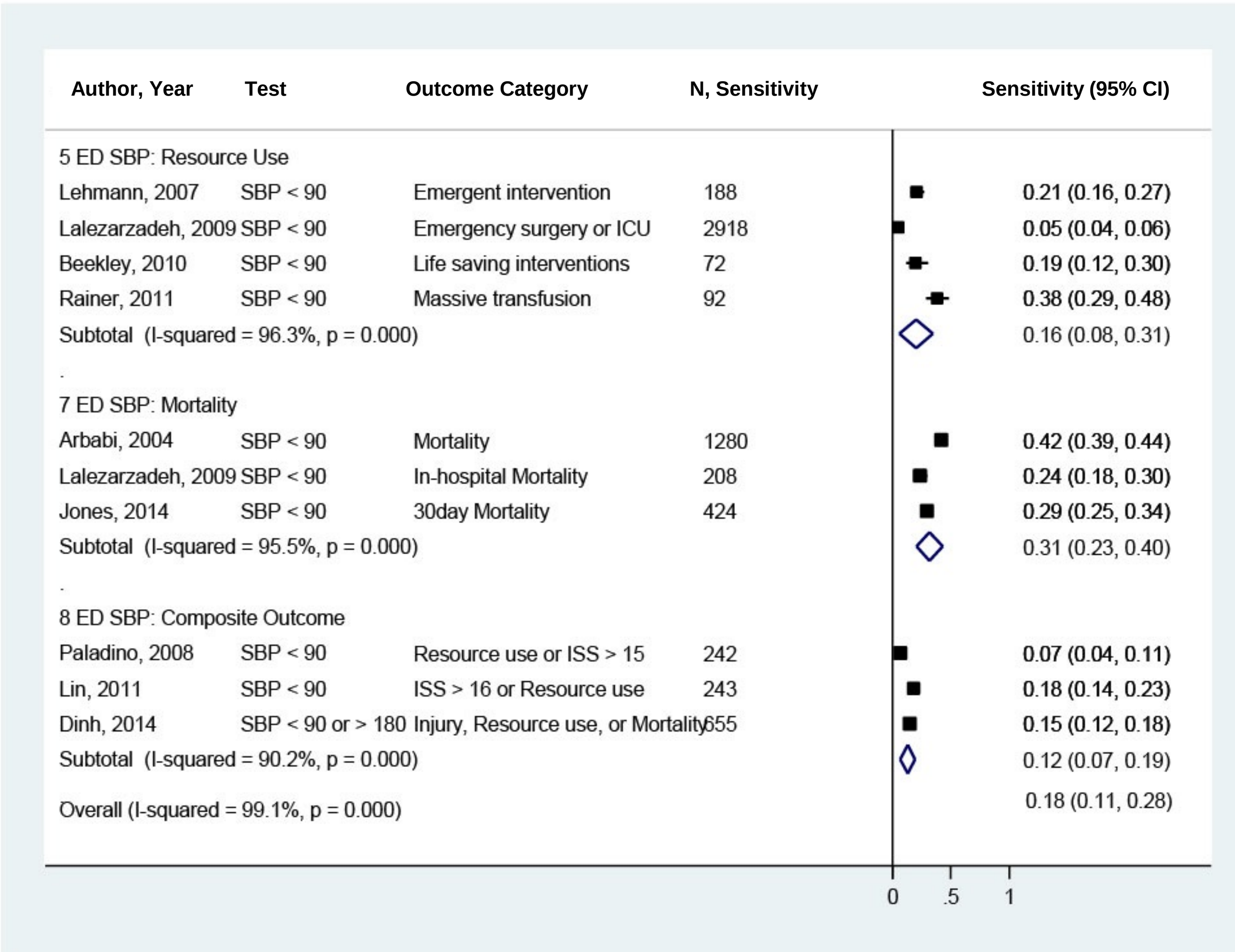
Key Question	Measure	Number of Studies (N)	Study Limitations (Low, Medium, High)	Directness (Direct, Indirect)	Consistency Consistent, Inconsistent, Unknown	Precision (Precise, Imprecise)	Reporting Bias (Not detected, Suspected)	Main Findings	Strength of Evidence Grade (Insufficient, Low, Moderate, High)
KQ 3. Predictive utility for combinations of measures	RTS	7	Medium	Direct	Inconsistent	Precise	Not detected	AUROC 0.88 (95% CI 0.82 to 0.92, I^2=94.9%)	Low
	RTS	6	Medium	Direct	Inconsistent	Imprecise	Not detected	Sen:19% to 84%	Low
	RTS	6	Medium	Direct	Inconsistent	Imprecise	Not detected	Sp: 64 % to 100%	Low
	GAP	3	Medium	Direct	Consistent	Precise	Not detected	AUROC: 0.96 (95% CI 0.90 to 1.00, I^2=94.2% for Mortality)	Moderate
	GAP	2	Medium	Direct	Inconsistent	Imprecise	Not detected	Sen: 75% to 98%	Low
	GAP	2	Medium	Direct	Inconsistent	Imprecise	Not detected	Sp: 57% to 91%	Low

AUROC = area under the receiver operating characteristic curve; BD = base deficit; ETCO2 = end-tidal carbon dioxide; GAP = Glasgow Coma Scale, age, and arterial pressure; HR = heart rate; HRC = heart rate complexity; HRV = heart rate variability; KQ = Key Question; O2 sat = oxygen saturation; RR = respiratory rate; RTS = Revised Trauma Scale; SBP = systolic blood pressure; Sen = sensitivity; SI = shock index; SLCO2 = sublingual capnometry; Sp = specificity

*Assessment is of pooled studies for the measures analyzed using meta-analysis.

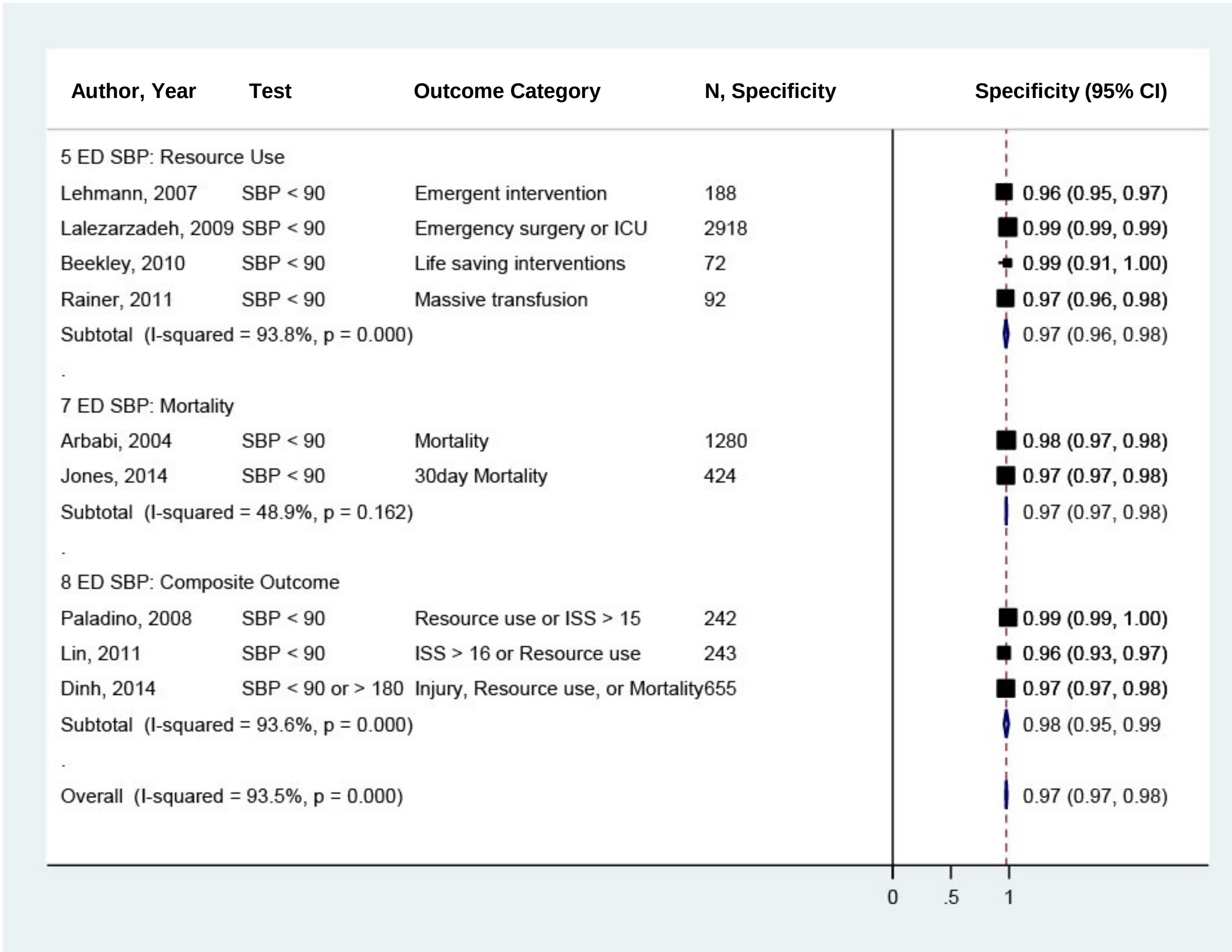
Appendix I. Meta-Analysis Results for Studies of Predictive Utility in the Emergency Department Setting

Figure I1. Pooled sensitivity of emergency department SBP <90 mmHg



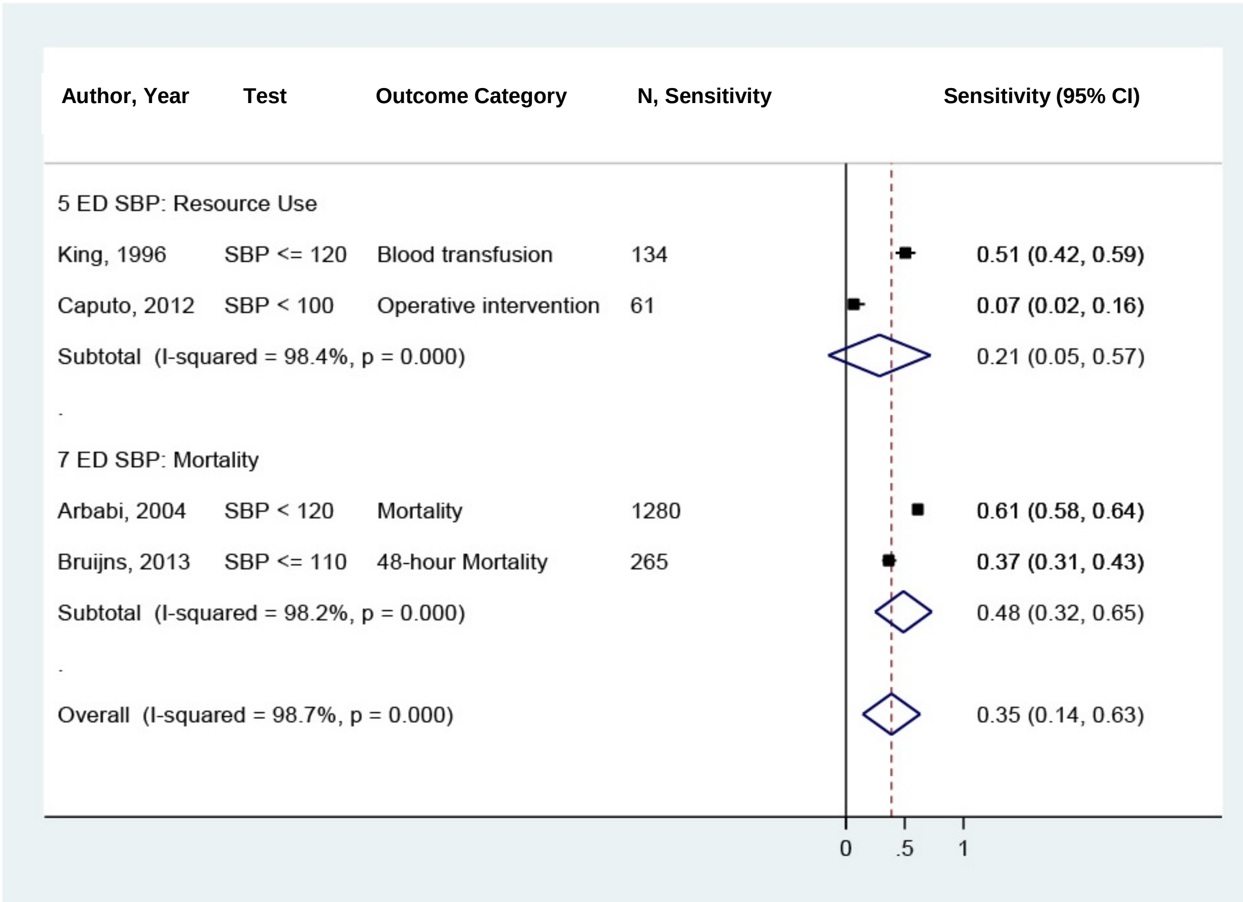
Overall results are from the bivariate logistic mixed effects model analysis.

Figure I2. Pooled specificity of emergency department SBP <90 mmHg



Overall results are from the bivariate logistic mixed effects model analysis.

Figure I3. Pooled sensitivity of emergency department SBP <100 mmHg

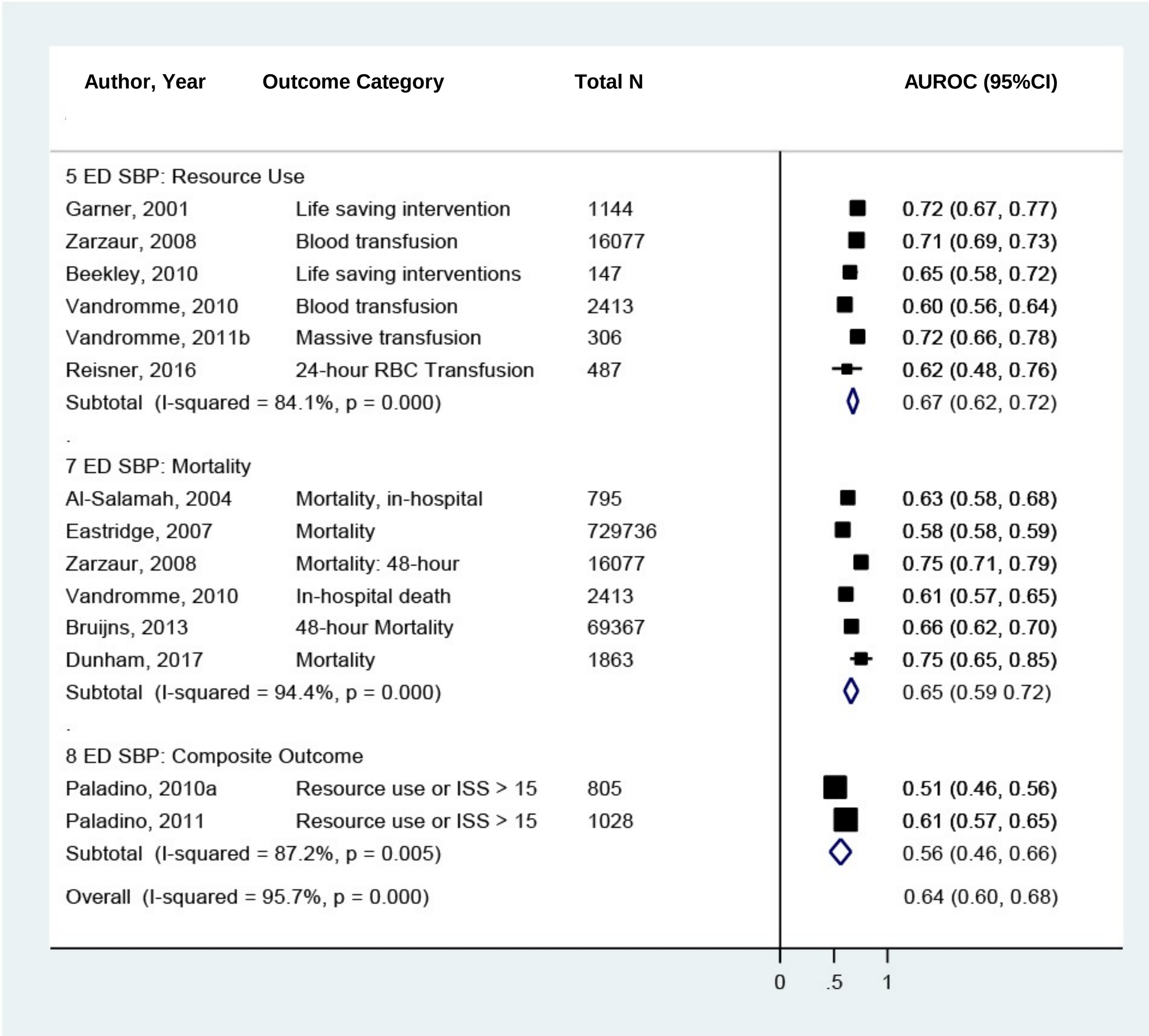


Overall results are from the bivariate logistic mixed effects model analysis.

Figure I4. Pooled specificity of emergency department SBP <100 mmHg

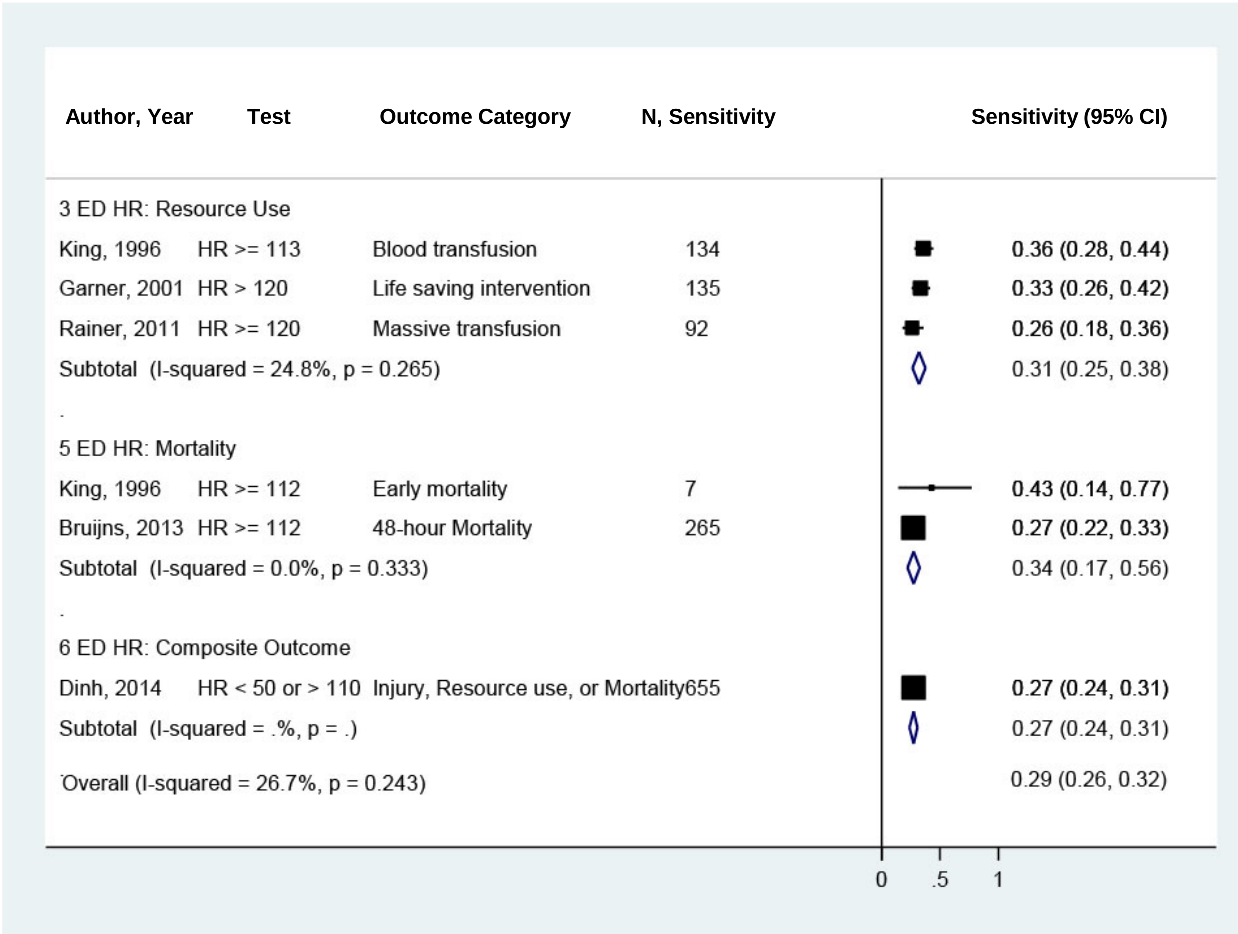
Overall results are from the bivariate logistic mixed effects model analysis.

Figure I5. Pooled AUROC of emergency department systolic blood pressure



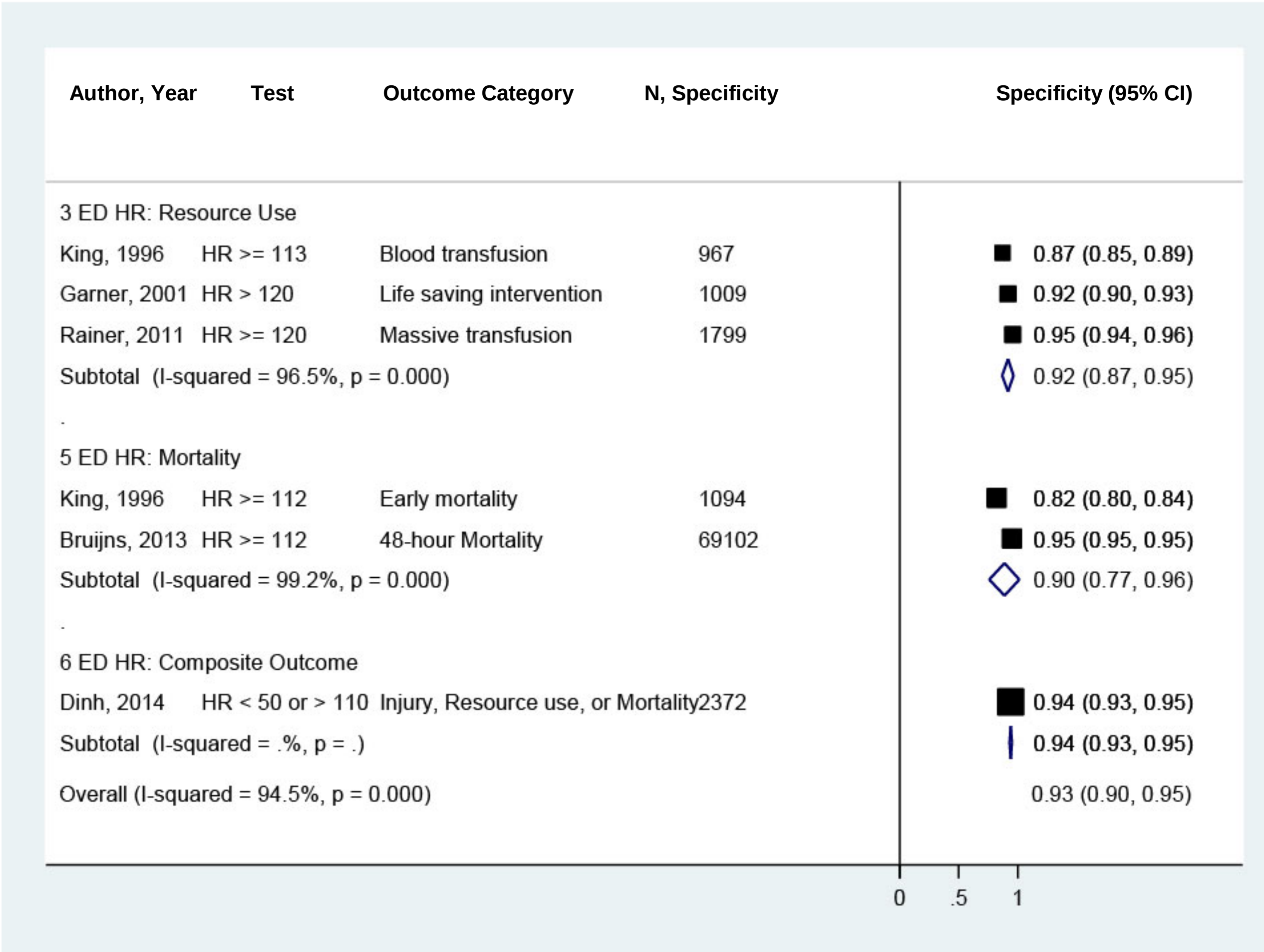
Paladino, 2010a = Reference no. 98; Vandromme, 2011b = Reference no. 129.
Overall results are from the bivariate logistic mixed effects model analysis.

Figure I6. Pooled sensitivity of emergency department heart rate ≥110



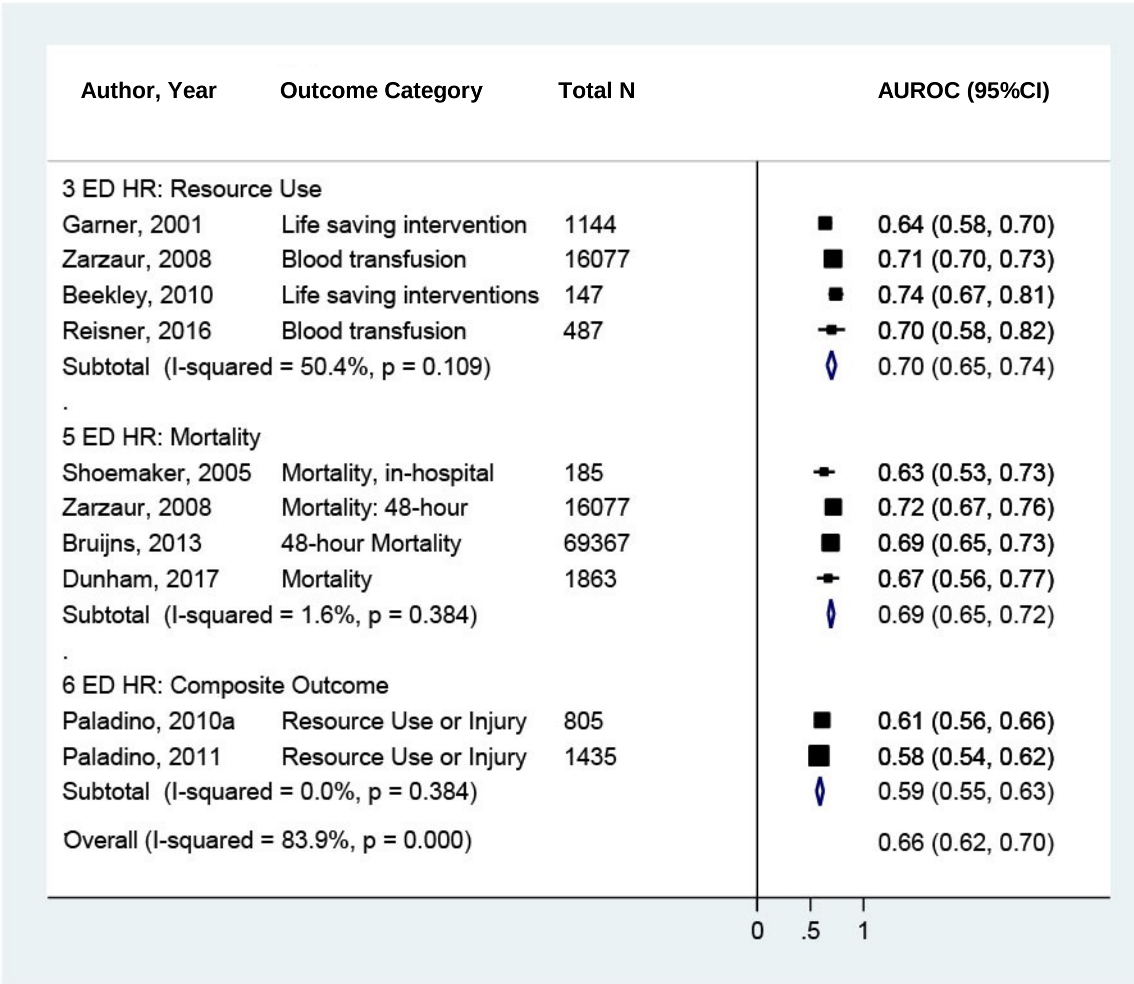
Overall results are from the bivariate logistic mixed effects model analysis.

Figure I7. Pooled specificity of emergency department heart rate ≥110



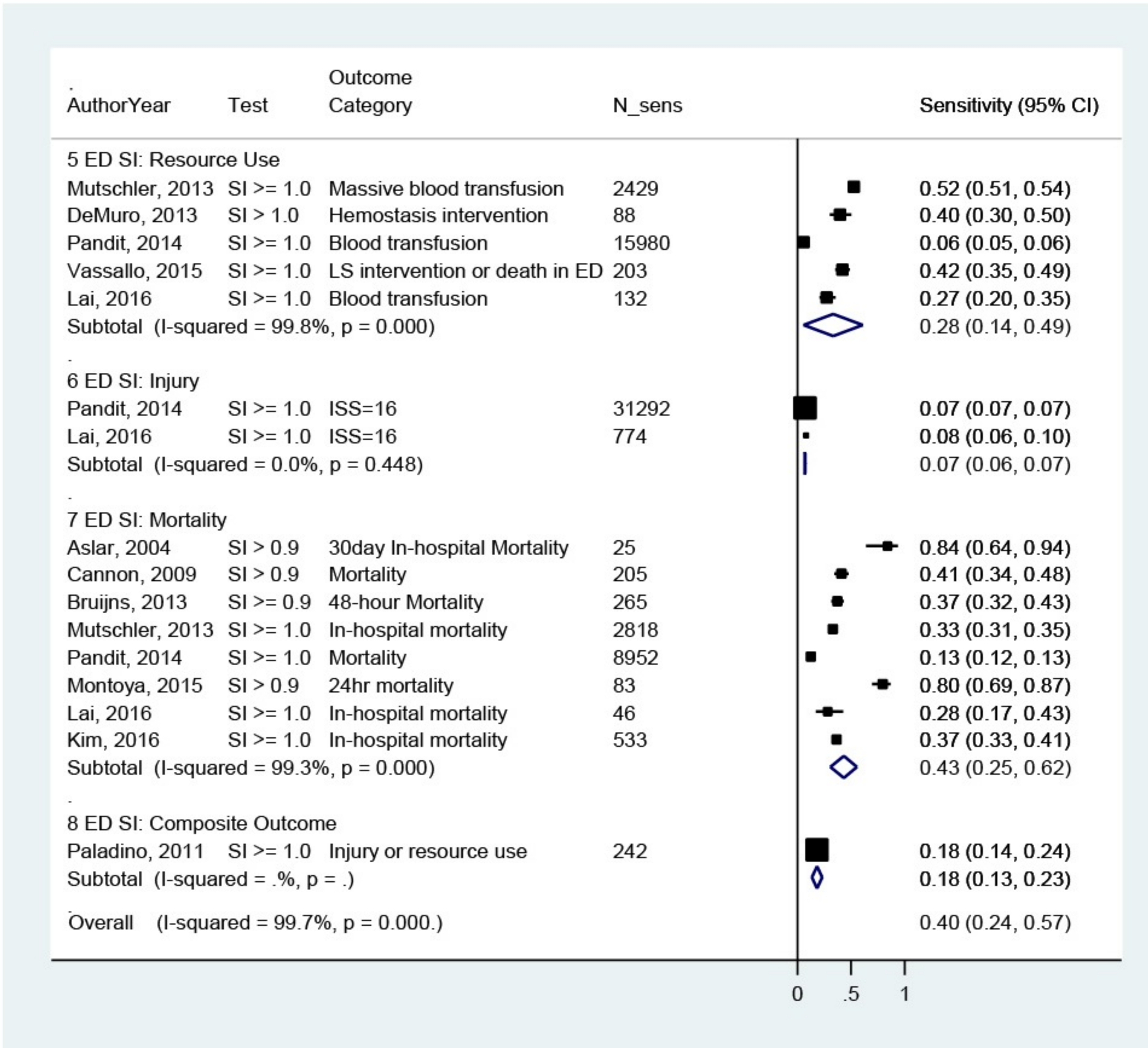
Overall results are from the bivariate logistic mixed effects model analysis.

Figure I8. Pooled AUROC of emergency department heart rate ≥110



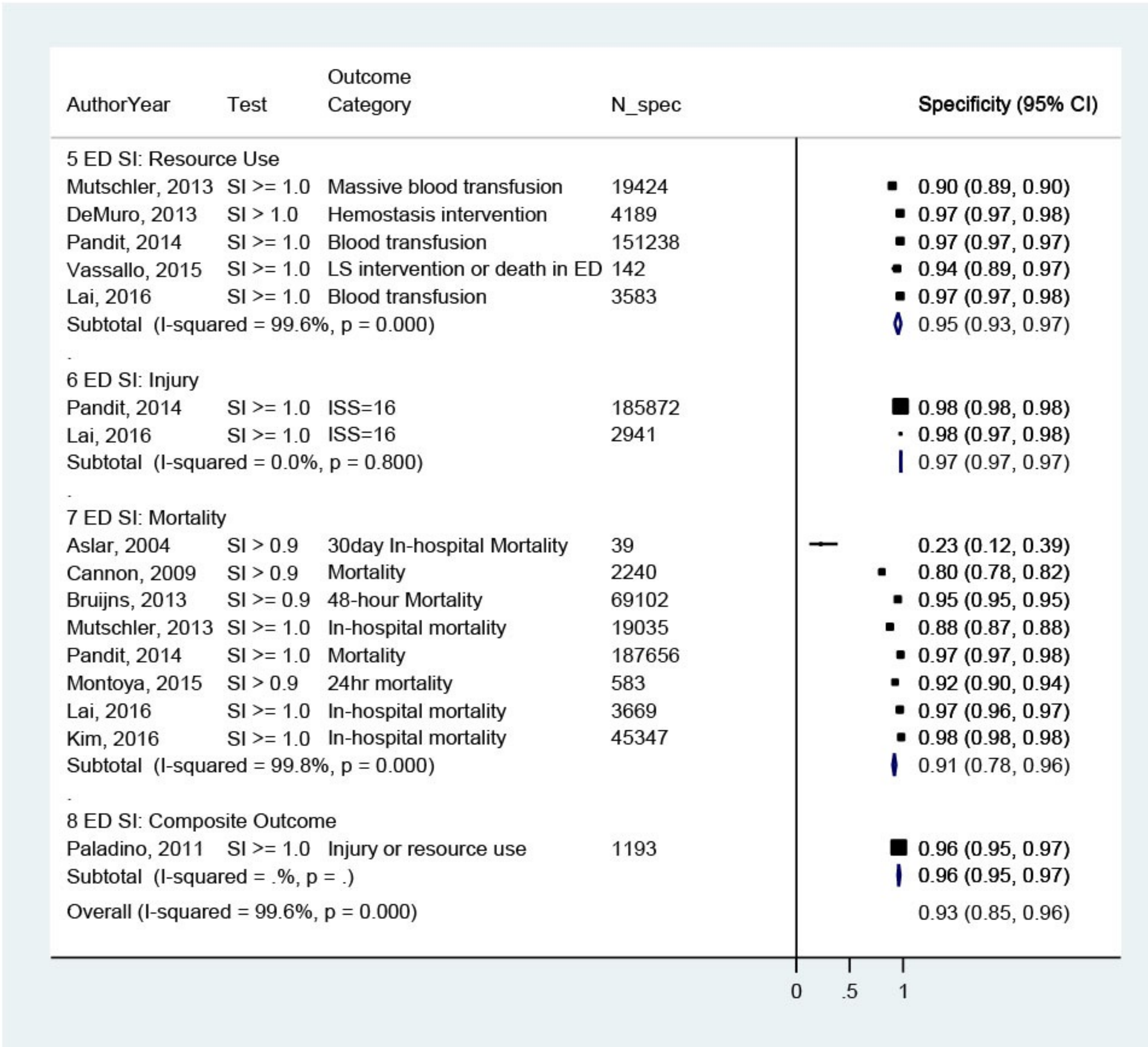
Paladino, 2010a = Reference no. 98.
Overall results are from the bivariate logistic mixed effects model analysis.

Figure I9. Pooled sensitivity of emergency department shock index



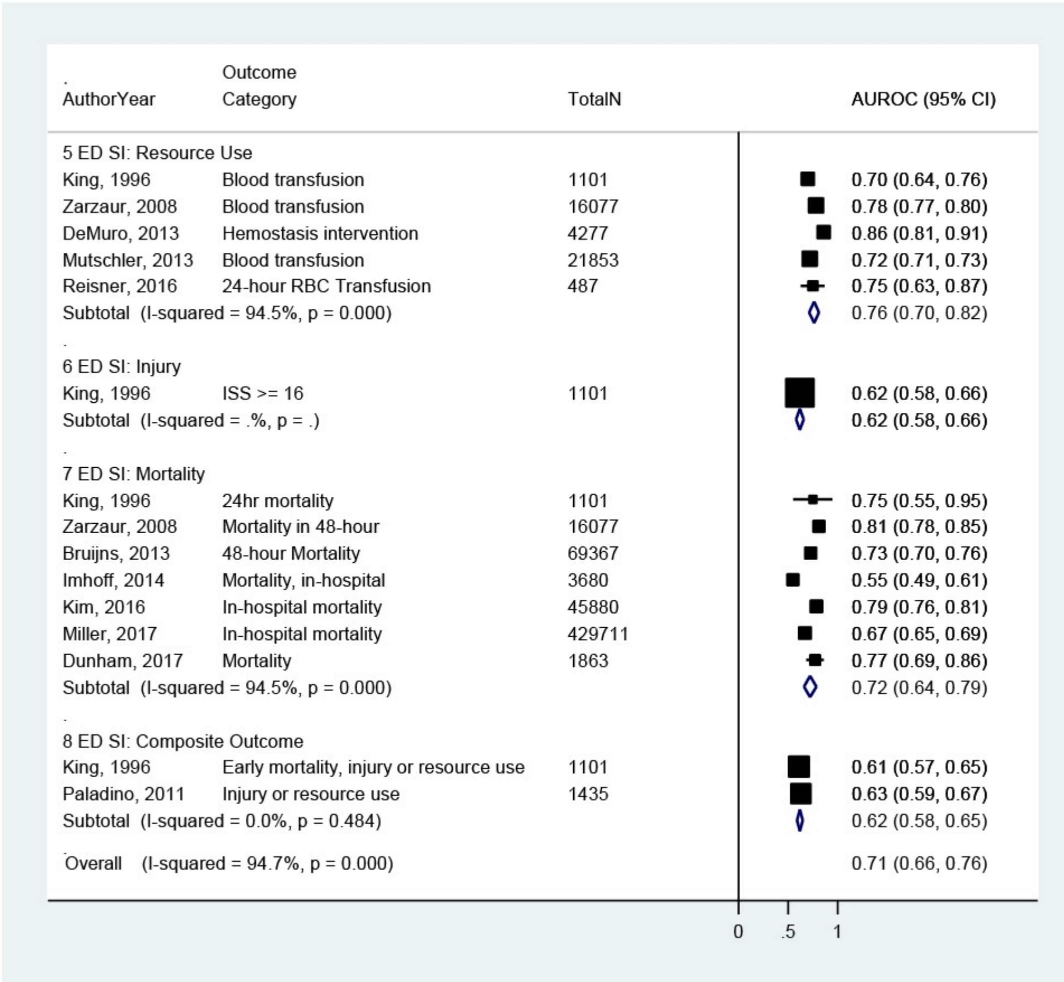
Overall results are from the bivariate logistic mixed effects model analysis.

Figure I10. Pooled specificity of emergency department shock index, stratified by outcome



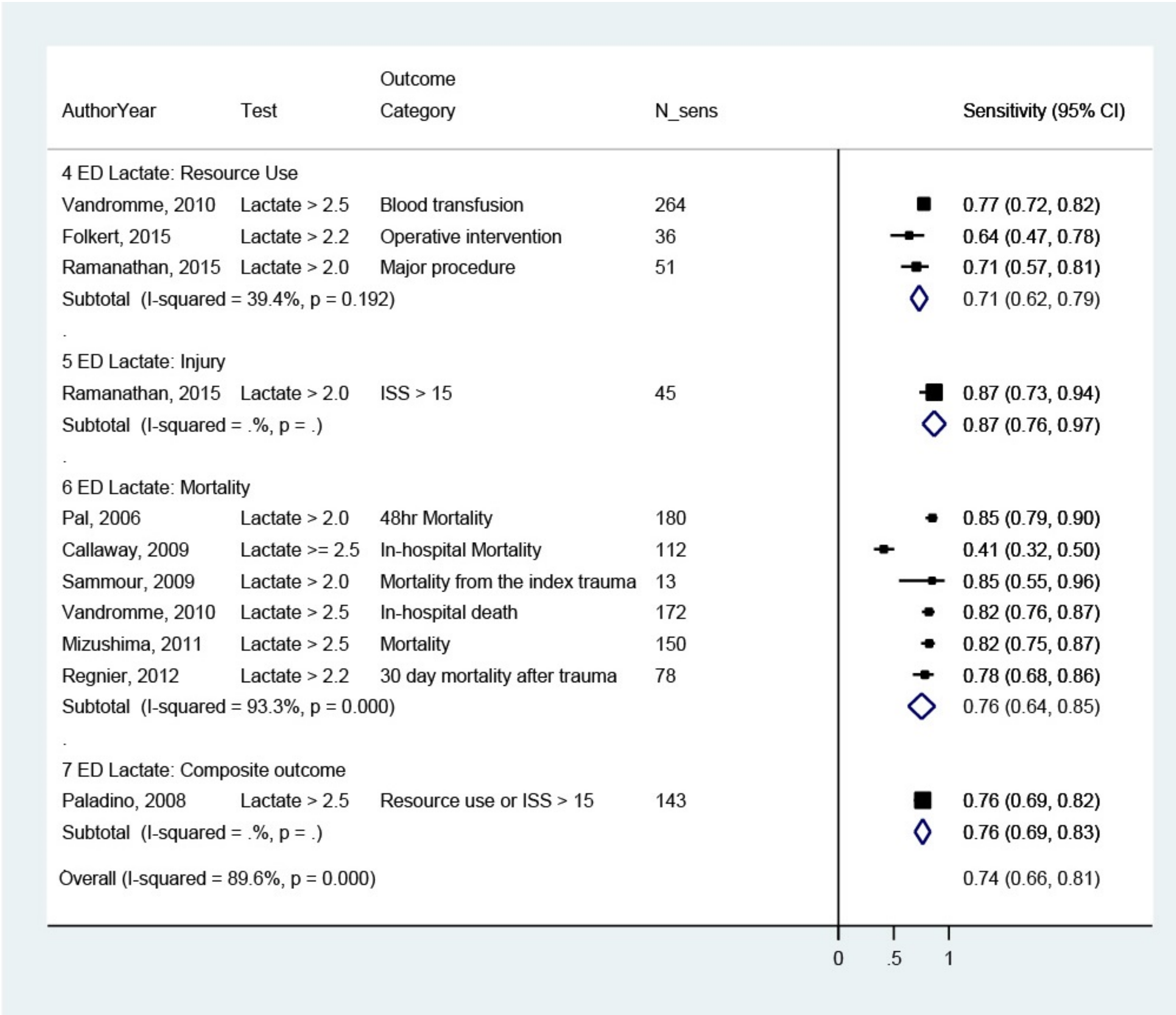
Overall results are from the bivariate logistic mixed effects model analysis.

Figure I11. Pooled AUROC of emergency department shock index



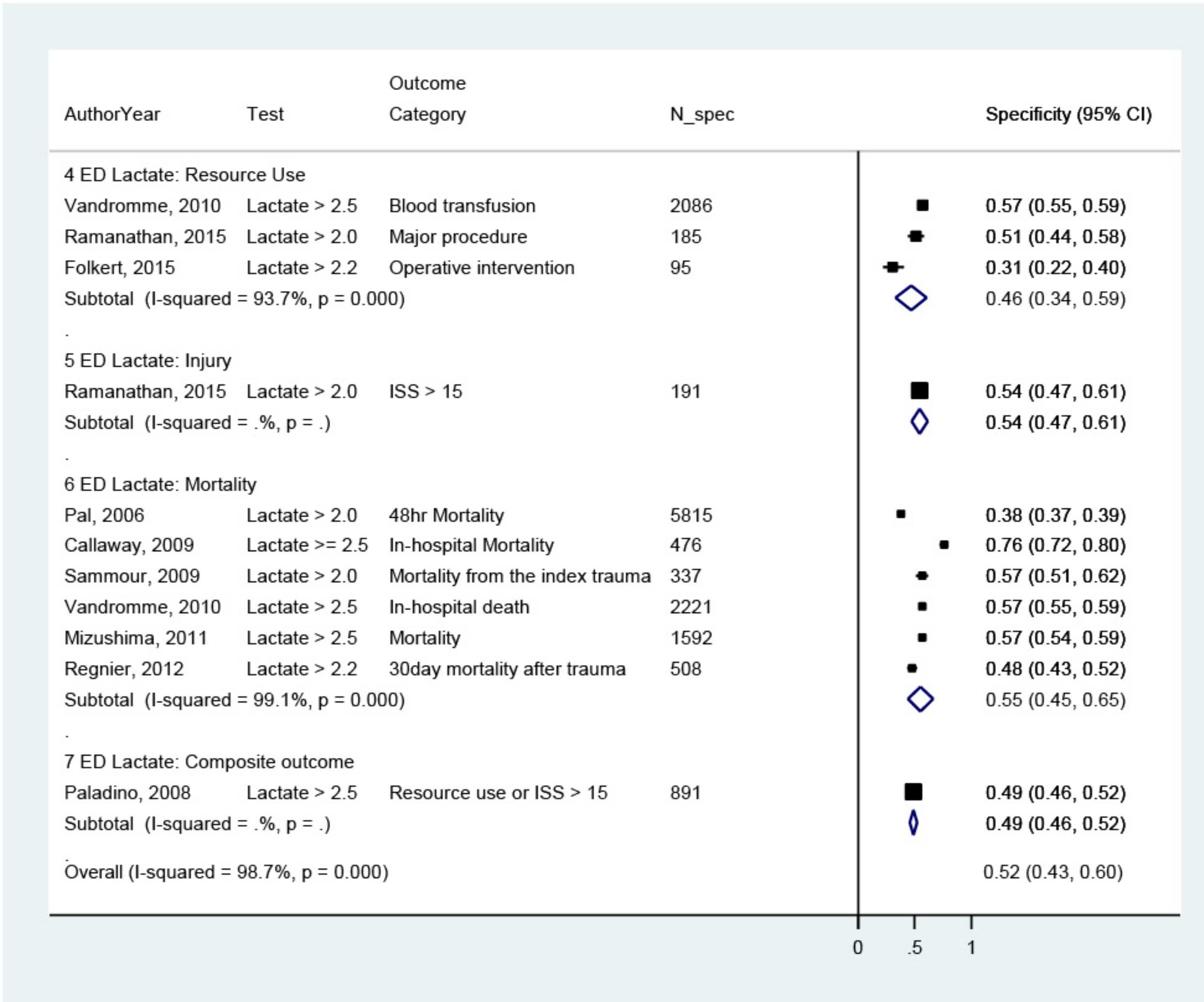
Overall results are from the bivariate logistic mixed effects model analysis.

Figure I12. Pooled sensitivity of emergency department lactate >2



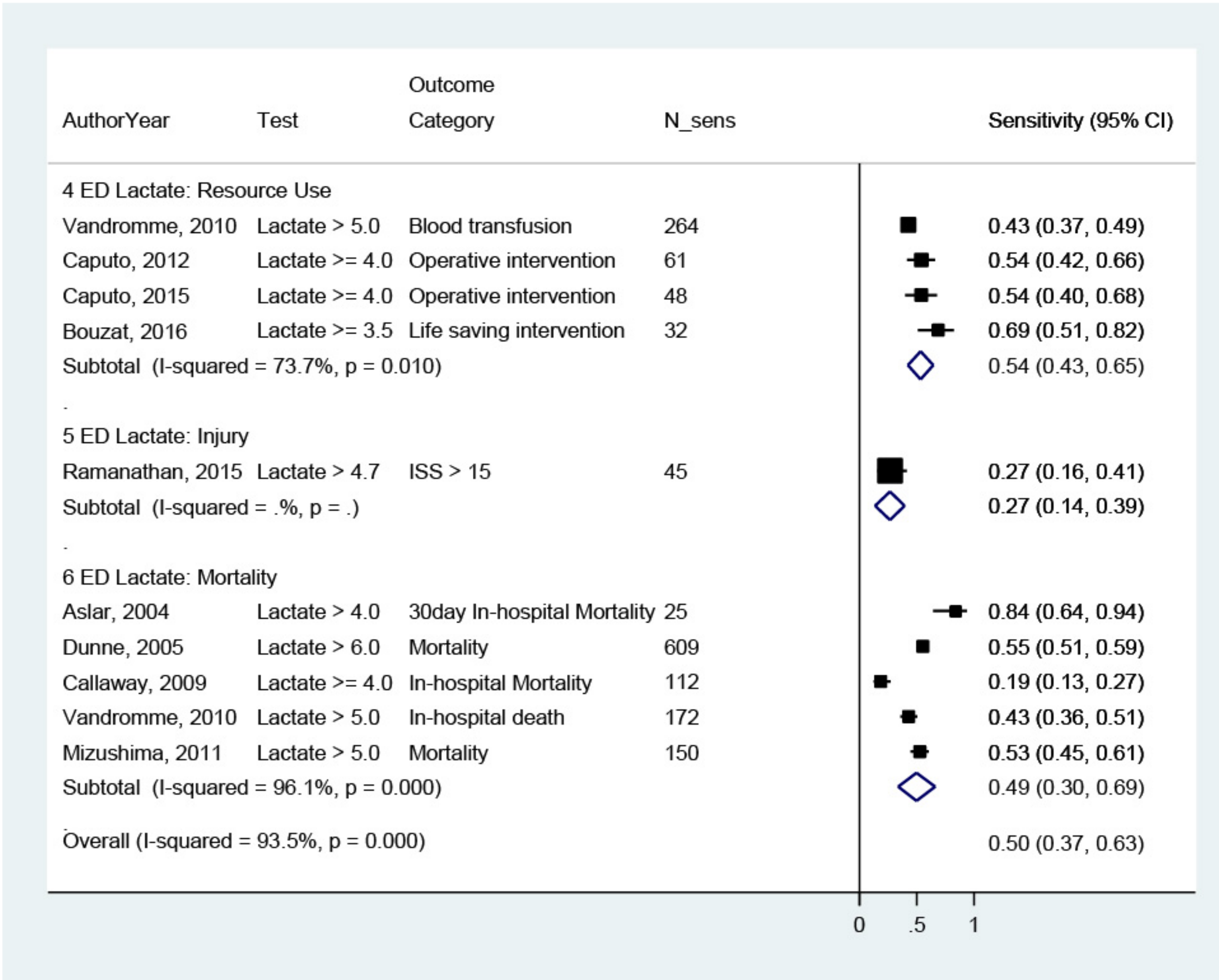
Overall results are from the bivariate logistic mixed effects model analysis.

Figure I13. Pooled specificity of emergency department lactate >2



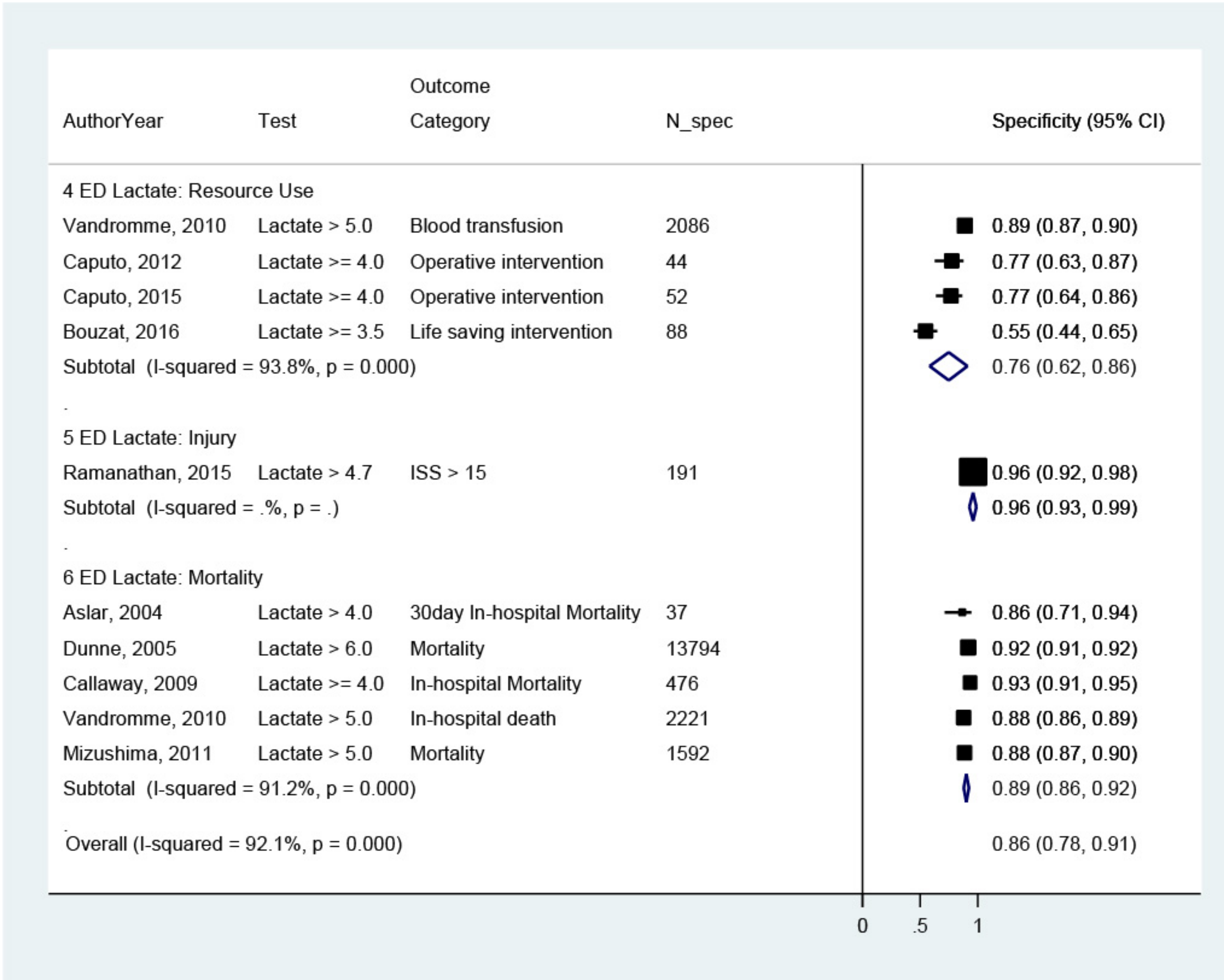
Overall results are from the bivariate logistic mixed effects model analysis.

Figure I14. Pooled sensitivity of emergency department lactate >4



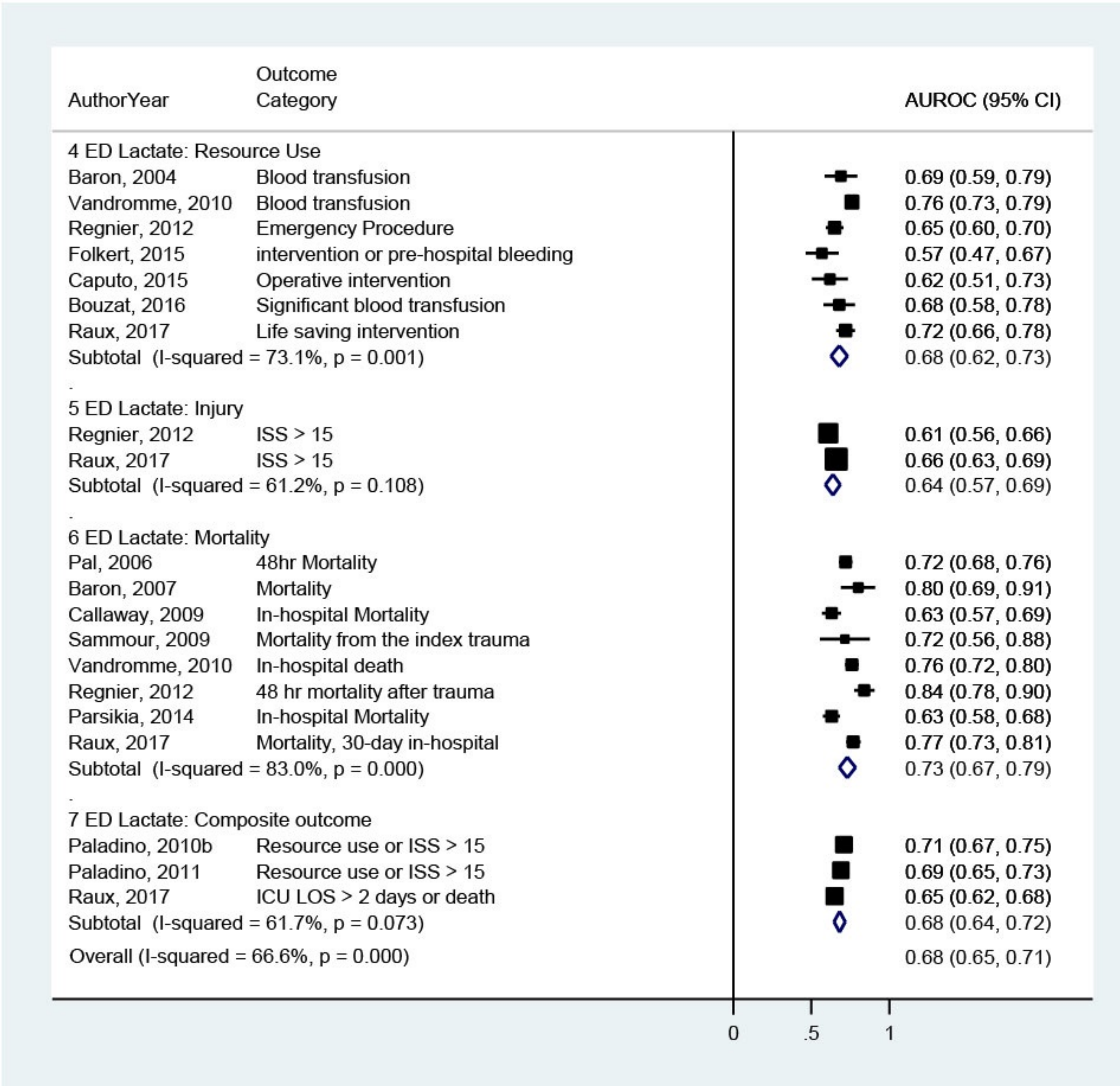
Overall results are from the bivariate logistic mixed effects model analysis.

Figure I15. Pooled specificity of emergency department lactate >4



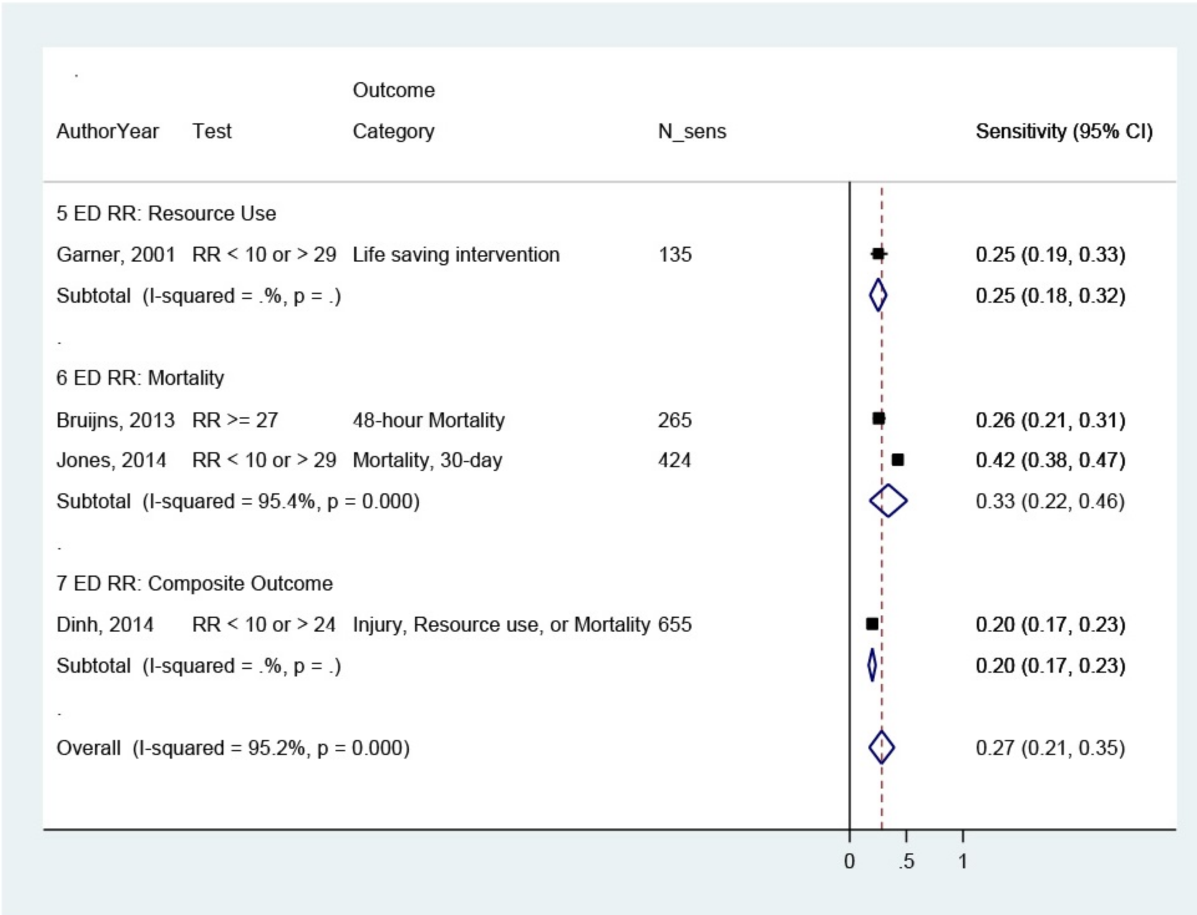
Overall results are from the bivariate logistic mixed effects model analysis.

Figure I16. Emergency department lactate, stratified by outcome



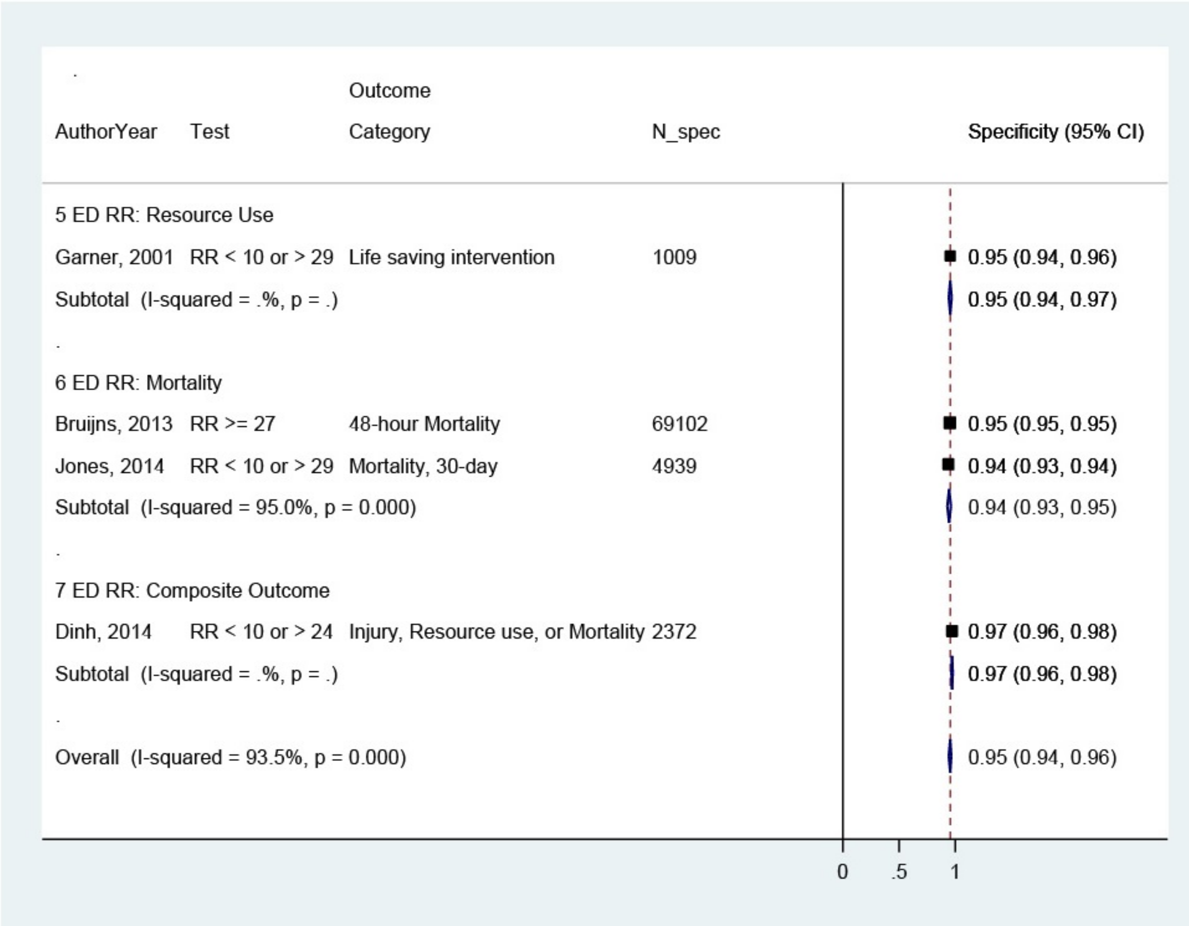
Paladino, 2010b = Reference no. 99.
Overall results are from the bivariate logistic mixed effects model analysis.

Figure I17. Pooled sensitivity of emergency department respiratory rate



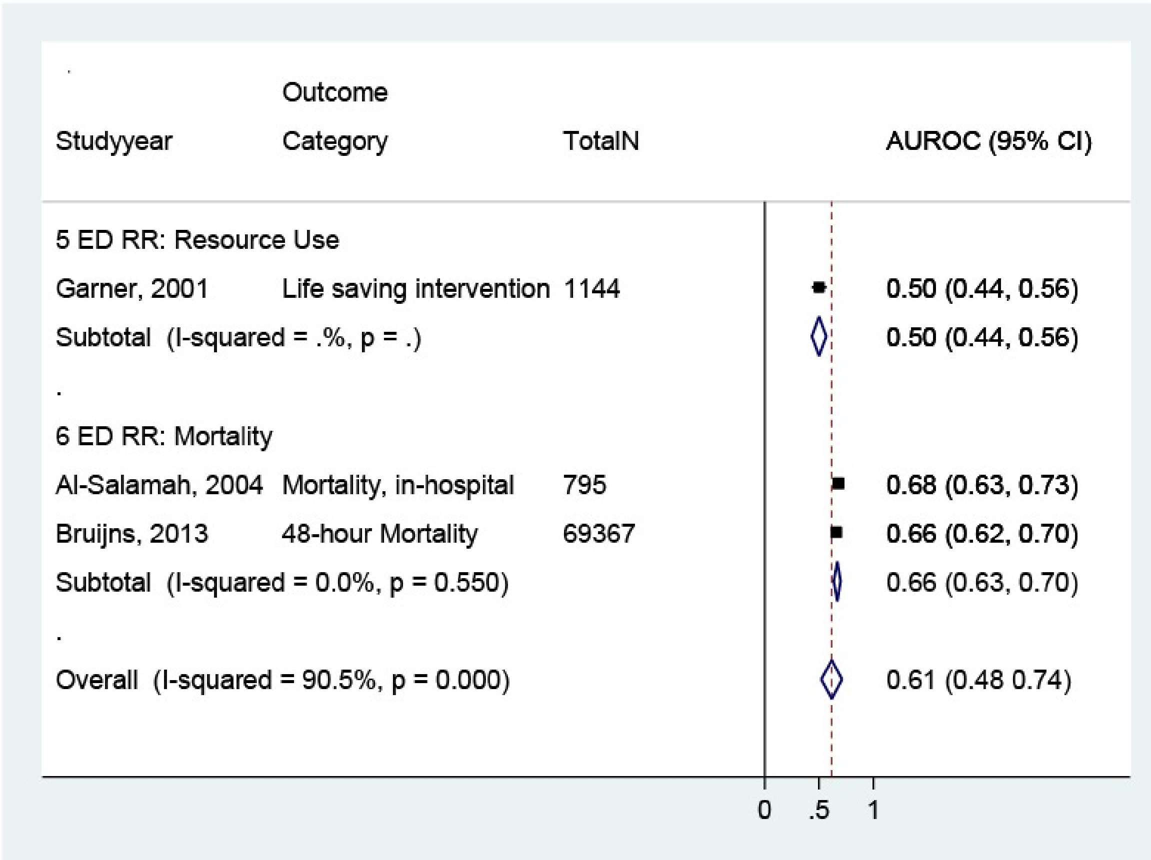
Overall results are from the bivariate logistic mixed effects model analysis.

Figure I18. Pooled specificity of emergency department respiratory rate



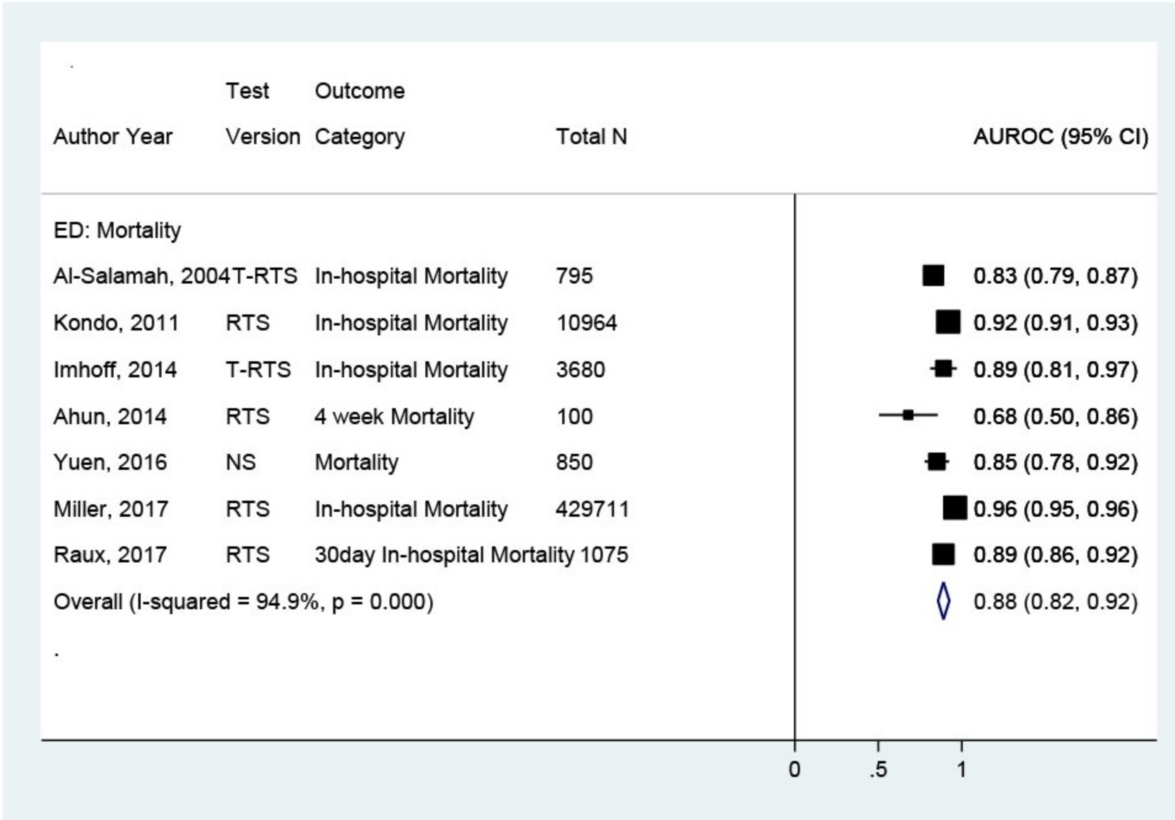
Overall results are from the bivariate logistic mixed effects model analysis.

Figure I19. Pooled AUROC of emergency department respiratory rate



Overall results are from the bivariate logistic mixed effects model analysis.

Figure I20. AUROC of the Revised Trauma Score



Overall results are from the bivariate logistic mixed effects model analysis.