Scores

PHYSIOLOGICAL

RTS-Revised Trauma Score

-assigns values of 0-4 to GCS, SBP, & Resp. Rate
-each measure is weighted & summed
-high score = high P (s) -varies from 0 to ~8

(T-RTS-triage version of RTS, values are summed & not weighted)
to produce integers 0-12)

TS-Trauma Score

-assigns values for SBP, RR, Resp. expansion, capillary refill, & GCS
-measures are summed for a value of 1-16
-high score = high Ps

Anatomical

AIS-severity code of 1-6 assigned to each of 7 body regions
(Abbrev. Inj. Scale) 1-minor 6-unsurvivable

ISS-3 highest AIS scored body regions, AIS scores are squared and summed for value of
(Inj. Sev. Score) 1 to 75.

AP-value of A, B, C, or D= the square root of the sum of the squares of the AIS scores
(Anatomic Profile) for injuries in that component.
-4 body regions of injury (A, B & C have AIS of 3 to 5) (D has AIS of 1-2)
A =head/brain/spinal cord B =thorax & non-spinal cord neck C =all other serious
D =all non-serious

A & P

TRISS-combines RTS or (TS), ISS, pt age & type of injury (blunt or penetrating) to calculate Ps. Ps>0.5 for non-survivors & Ps<0.5 for survivors are statistically "unexpected outcomes".

ASCOT-combines AP, RTS variables, type of injury & refined description of pt age to c calculate Ps. (GCS & A have highest wt among each phys. & anat.)
(severity characterization of trauma)

TraumReg/ Training Materials/ Scores.doc

PRE-CHART

RTS/ISS pairs below & to left of Isobar have Ps>0.5
(unexpected deaths below)
RTS/ISS pairs above & to the right of Isobar have
(unexpected survival above) Ps<0.5

W-statistic
Z-statistic – quantitates differences in actual # of deaths (or survivors) and predicted # of deaths (or survivors). \Z\> = 1.96 produces significance of 0.05.

- want neg Z value for mortality (predicted exceeds observed)
- want pos Z value for survival (observed > predicted)

(m-statistic – represents match between study & baseline pt groups, range 0 to 1, closer to 1 better match).

Outcome Evaluation Results

Summary -

The Outcome Evaluation report shows the z & W scores based on ASCOT and TRISS for your institution as well as all institutions. If your hospital had any burn patients, a z & W report will be included for the burn population.

Specifics -

"N" = sample size, the sample size is equal to the number of records included in the Suitability for Extended Trauma Outcome Evaluation found on the first page of the Demographics Report under Tab A.

Expanded Outcome Evaluation Patient Sets:

(1) Have all data required for ASCOT/TRISS:

Use ASCOT/TRISS Model to compute P(s)

TRISS - combines RTS, ISS, patient age and type of injury (blunt or penetrating) to calculate P(s).

ASCOT - combines AP, RTS, type of injury (blunt or penetrating) and patient age to calculate P(s).

(2) Missing RTS, have all other data required for ASCOT/TRISS, and not intubated (no):

The best value of the missing RTS data elements are filled in and the ASCOT/TRISS model is used to calculate P(s).

The elements used to determine RTS are GCS, SBP, and Respiratory rate.

(3) Missing RTS, have all other data required for ASCOT/TRISS, and intubated (yes):

Does not fill in the best value of the missing RTS elements.
Uses the AP (Anatomic Profile) model instead of the ASCOT/TRISS model to calculate P(s).

(4) Missing RTS, have all other data required for ASCOT/TRISS, and intubation unknown:

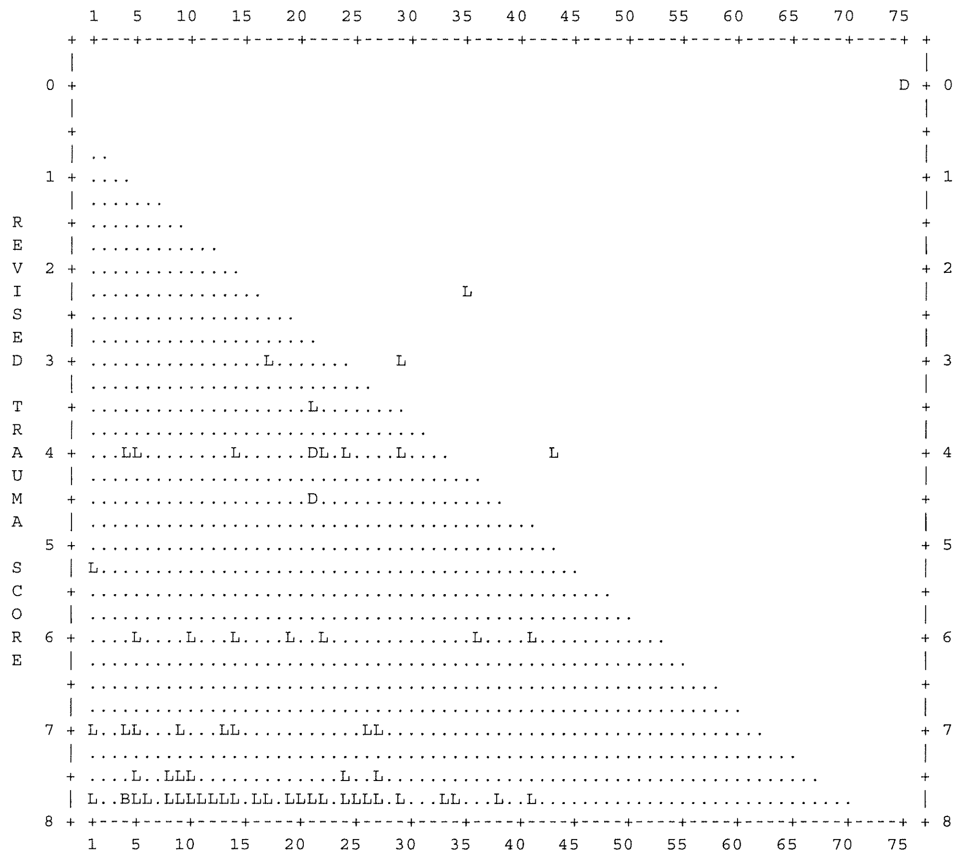
Same method applies as in Set 2.

(5) Missing data, other than RTS, that is required for ASCOT/TRISS:

No P(s) is calculated and these records are not included in the Extended Outcome Evaluation.

2003 PTOS Central Site COLLECTOR
Adult Blunt (15 - 54) AIS 90 Coding

Report generated on 01/10/2004
Institution 5385
Batch Number 69
Trauma Numbers from 00000000 to 99999999
Query is EVERYONE
606 records



L = SURVIVOR(S)
D = DEATH(S)
B = BOTH

SHADED = Ps >= 0.50

Unexpected Deaths: Adult Blunt (15 - 54) AIS 90 Coding

	Inst-Trauma Number	Coded Values G	S	R	RTS	ISS	AGE	TRISS P(s)	Anatomic Profile A	B	C	D	ASCOT P(s)	Set
+	5385-20031718	-	-	-	-	19	46	0.873	0.00	3.00	3.00	2.45	0.873	3
	5385-20031929	4	4	4	7.84	4	42	0.996	0.00	0.00	0.00	2.00	0.999	2
+	5385-20032022	-	-	-	-	29	32	0.635	10.86	0.00	0.00	2.24	0.635	3
+	5385-20032050	-	-	-	-	34	17	0.615	7.07	3.00	0.00	1.00	0.615	3
	5385-20032051	2	2	4	4.50	21	21	0.808	0.00	5.83	0.00	3.74	0.843	1
+	5385-20032176	-	-	-	-	13	21	0.956	0.00	0.00	3.00	3.61	0.956	3
+	5385-20032212	-	-	-	-	21	42	0.810	7.68	0.00	0.00	3.61	0.810	3
+	5385-20032346	-	-	-	-	26	17	0.877	5.83	0.00	0.00	3.46	0.877	3

These are the Expanded Outcome Evaluation Patient SOBs described on the Outcome Evaluation Results Summary page.

APPENDIX 1 - OUTCOME EVALUATION METHODS AND MEASURES

TRISS (AIS-90)

TRISS (Revised Trauma Score, ISS, and Age) is used to estimate patient survival probability by a logistic model of the form:

$$P(s) = \frac{1}{1+e^{-d}}$$

where:

- $P(s)$ = probability of survival,
- e = 2.718282 (base of Napierian logarithms) and
- $d = b_0 + b_1(\text{RTS}) + b_2(\text{ISS}) + b_3(\text{AGE}^*)$ (for blunt-injured patients); **or**
  $d = p_0 + p_1(\text{RTS}) + p_2(\text{ISS}) + p_3(\text{AGE}^*)$ (for penetrating-injured patients)

  where:

  RTS = Revised Trauma Score measured on ED admission
  ISS = Injury Severity Score
  AGE* = 1 if patient age ≥ 55
  AGE* = 0 if patient age < 55

  and b_0, b_1, b_2 and b_3 (or p_0, p_1, p_2 and p_3) are regression coefficients.

TRISS regression coefficients are given in the following table for AIS-90 based norms:

Blunt		Penetrating	
b_0	-0.4499	p_0	-2.5355
b_1 (RTS)	0.8085	p_1 (RTS)	0.9934
b_2 (ISS)	-0.0835	p_2 (ISS)	-0.0651
b_3 (AGE*)	-1.7430	p_3 (AGE*)	-1.1360

The adult blunt-injured norms (AGE* = 0) are used for both blunt and penetrating-injured pediatric patients (<15 years old).

ASCOT (AIS-90)

Values of *G*, *S*, *R*, *A*, *B*, *C* and patient age have been related to *P(s)* in the ASCOT methodology.

G, *S*, and *R* are the coded values of RTS variables (*G* - Glasgow Coma Scale, *S* - Systolic Blood Pressure, *R* - Respiratory Rate).

Glasgow Coma Scale	Systolic Blood Pressure	Respiratory Rate	Coded Value
13-15	>89	10-29	4
9-12	76-89	>29	3
6-8	50-75	6-9	2
4-5	1-49	1-5	1
3	0	0	0

A, *B*, *C* and *D* are summary scores of injuries to the various body regions or systems. A component (*A*, *B*, *C* or *D*) value equals the square root of the sum of the squares of the AIS scores for a patient's injuries in the component. The injury regions, severities and ICD-9 codes associated with each component are defined below:

A (Head: AIS severity 3,4,5; ISS body region 1)
(ICD-9-CM = 800,801,803,850,851,852,853,854,950,LOC)
(Spinal Cord: AIS severity 3,4,5; ISS body region 1,3,4)
(ICD-9-CM = 806,952,953)

B (Thorax: AIS severity 3,4,5; ISS body region 3)
(ICD-9-CM = 807,839.61,839.71,860,861,862,901)
(Front of Neck: AIS severity 3,4,5; ISS body region 1)
(ICD-9-CM = 807.5,807.6,874,900)

C (All others: AIS severity 3,4,5; ISS body region 1,2,3,4,5,6)

D (All AIS severity 1,2; ISS body region 1,2,3,4,5,6)

D was found to be a non-significant contributor to *P(s)*.

AGE* is assigned a value between 0 and 4 according to the age ranges provided in the following table:

AGE*	Age Range (Years)
0	0-54
1	55-64
2	65-74
3	75-84
4	≥85

In ASCOT, patients with extremely poor or good prognoses were divided into three groups. These groups are defined in the following table. The ASCOT *P(s)* assigned to patients in each of these groups is also provided.

Set-Aside	Blunt	Penetrating
GROUP #1		
AIS = 6, RTS <4	0.000	0.048
AIS = 6, RTS≥4	0.500	0.500
GROUP #2		
RTS = 0, Maximum AIS < 6	0.011	0.029
GROUP #3		
RTS > 0, Maximum AIS ≤ 2, AGE* = 0	0.999	1.000
RTS > 0, Maximum AIS ≤ 2, AGE* = 1	0.989	1.000
RTS > 0, Maximum AIS ≤ 2, AGE* = 2	0.964	1.000
RTS > 0, Maximum AIS ≤ 2, AGE* = 3	0.929	1.000
RTS > 0, Maximum AIS ≤ 2, AGE* = 4	0.875	1.000

For the remaining patients (group 4 or non-"set-asides"), *P(s)* is estimated with a logistic function,

$$P(s) = \frac{1}{1 + e^{-K}}$$

where $K = K_0 + K_1 G + K_2 S + K_3 R + K_4 A + K_5 B + K_6 C + K_7(\text{AGE*})$

The next table gives the ASCOT model coefficients for the non-"set-aside" patients:

Term	Blunt	Penetrating
Constant	-1.1570	-1.1350
G	0.7705	1.0626
S	0.6583	0.3638
R	0.2810	0.3332
A	-0.3002	-0.3702
B	-0.1961	-0.2053
C	-0.2086	-0.3188
AGE*	-0.6355	-0.8365

INTUBATED MODEL (AIS-90)

Survival probabilities for patients missing one or more RTS variables and who were intubated on ED arrival were estimated using logistic models whose independent variables are age (as in ASCOT), anatomic injury scores *A*, *B* and *C* and an intubation indicator variable (0 = patient not intubated, 1 = patient intubated on ED arrival). These regressions are based on data from 1993-94 Pennsylvania Trauma Outcome Study patients.

P(s) is estimated for these patients using a logistic function,

$$P(s) = \frac{1}{1+e^{-K}}$$

where $K = K_0 + K_1 A + K_2 B + K_3 C + K_4(\text{AGE}^*) + K_5(\text{Intubation Coded Value})$

AGE* is assigned a value between 0 and 4 according to the age ranges provided in the AGE* table in the ASCOT discussion.

The following table gives the regression model coefficients:

Term	Blunt	Penetrating
Constant	5.7350	4.4618
A	-0.2803	-0.3772
B	-0.3832	-0.4276
C	-0.1730	-0.2779
AGE*	-0.7105	-0.3383
Intubated	-2.1346	-2.7551

In the Intubated Model, patients with extremely poor prognoses (AIS severity = 6) are assigned either a *P(s)* of 0.030 (Blunt) or 0.140 (Penetrating).

z and W

Outcome evaluation results (sample sizes, *z*, and *W* scores) are given for adult patients (15 years or older) with blunt injuries, adult patients with penetrating injuries, and pediatric patients (less than 15 years old) who are suitable for outcome analysis.

z measures the statistical significance of differences between the actual number of survivors among a set of patients (A) and the number expected from outcome norms (E).

z is defined as:

$$z = \frac{(A-E)}{S}$$

where $E = \sum P_i$ and S is a scale factor that accounts for statistical variation:

$$S = \sqrt{\sum P_i(1-P_i)}$$

where P_i is the survival probability for the *i*th patient.

If *z* exceeds or equals 1.96 (is less than or equals -1.96), there are statistically significantly more (fewer) survivors than expected from outcome norms.

W is computed only when *z* is statistically significant ($|z| \geq 1.96$). *W* measures the clinical significance of statistically significant differences between the actual (A) and expected (E) numbers of survivors in a patient group. The ability to detect such differences, called statistical power, increases with sample size. Thus, for larger samples, significant *z* values may indicate slight, but statistically significant differences between A and E . *W* is defined as:

$$W = \frac{(A-E)}{N/100}$$

where A and E are defined as in z and N is the number of patients analyzed. A positive (negative) *W* is the number of survivors more (less) than would be expected from the outcome norms per 100 patients treated. *W* values based upon small patient samples should be considered preliminary.

Outcome Evaluation Measures z and W

z   The z score measures the **statistical significance** of the differences between the actual number of survivors among and institution's patients and the number expected from outcome norms. The scale for z ranges from 1.96 to -1.96. If z is more positive than 1.96 or less than -1.96, then statistically there are significantly more/less survivors than expected from MTOS/TRISS norms.

```
<-----|--------------------|---------------------|------>
-2 -1.96      -1            0            1       1.96 2

<-----|                                          |------>
significant                                      significant
```

W   W is computed **only** when z is statistically significant. W measures the **clinical significance** of the statistically significant differences between the actual and expected numbers of survivors in a patient group.

```
<-----|                                          |------>
    -1.96                                        1.96
```

significant: *calculate W* — **significant:** *calculate W*

A positive/negative W is the **number of survivors** more/less than would be expected from the outcome norms **per 100** patients treated.

Note: **The ability to detect statistically significant differences, called statistical power, increases with sample size. W values based upon small patient samples should be considered preliminary.**

should come prepared with requests for reports to be generated from COLLECTOR. (1 to 2 days)

RDL\CQO Report Writing - Students are taught to write reports using RDL (Report Development Language) and CQO (COLLECTOR Query Language). Topics include writing statistical reports, data tables and queries outside of COLLECTOR, using COLLECTOR's compiling tools, and running stand alone queries and reports. Students need strong skills in report writing. Familiarity with a programming language (e.g., SQL, VisualBASIC, C++, Lisp, etc.) is recommended but not required. (2 to 3 days)

Automation of Reports - Students are taught to use COLLECTOR's batch report utility (CBR) to automate the running of queries and reports. Students should have familiarity with report writing. (1 day)

Customized training is also available. Training costs are $500/day plus travel-related expenses. For more information on Network capability or COLLECTOR Training Workshops please contact Don Dove at Tri-Analytics.

z and W Scores

Several readers of TAI News have requested further explanation of the z and W statistics used in trauma outcome evaluations. W and z compare the actual number of survivors in a patient sample with the number expected, based on TRISS or ASCOT Major Trauma Outcome Study norms. W measures the clinical significance, and z the statistical significance of the comparison. For example, a W value of +2 indicates that for the sample evaluated there were two more survivors per hundred patients treated than would have been expected based on national data. Likewise, a W value of -2 indicates that two fewer patients survived per hundred treated than would have been expected.

W = 0 unless z is statistically significantly different from 0, i.e., z must be greater than +1.96 or less than -1.96. If z is between -1.96 and +1.96 the difference between the actual and expected numbers of survivors is not statistically different from zero, and hence neither is W.

Example: Here are some actual z, W values for institutions across the United States.

	N	z	W
1.	530	6.02	5.2
2.	42	2.33	8.8
3.	234	2.05	2.27
4.	158	2.56	3.81
5.	291	3.62	3.37
6.	2234	10.23	0.58

Comments:

1. The results for institution 5 are better than those for institution 3, as N, z and W are all greater for 5. The results for Institution 1 are even better than those for 5.

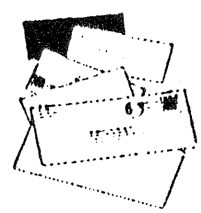
2. Although institution 2 has a striking W value, the small sample size (N) causes one to reserve judgment about its ability to sustain such a large W value.

3. Institution 6 is an example of large z, small W results. The W value of 0.58 indicates slight, but statistically better, clinical outcomes than the norm. The big sample size gives the potential for large z values.

Christmas Cards

We at TAI thank our many friends for their Holiday cards and notes.

Thank You!

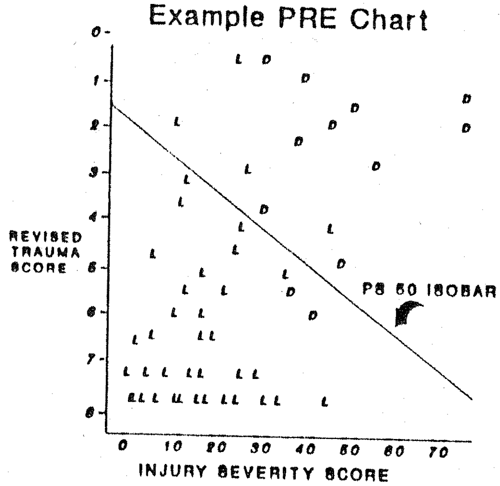


APPENDIX D - PRE

PRE, from "PREliminary", is a methodology that can be used by a trauma care institution for self audit. To implement PRE using TRISS, each patient is characterized by the Revised Trauma Score measured at hospital admission and the Injury Severity Score based on surgery, CT scan, autopsy or definitive diagnosis. Each patient's values are plotted on a graph with ISS and RTS axes (see Figure below). Survivors (L) and non-survivors (D) have different plotting symbols. The sloping line identified as "P_s50" represents the combinations of RTS and ISS which have a 0.50 probability of survival for patients in the baseline population. The equation for this line can be found by noting that $P_s = 0.50$ when $b = 0$ in the logistic model. PRE charts are provided for various patient groups.

Patients whose RTS-ISS coordinates are above the P_s50 line have probabilities of survival less than 0.50. Patients whose coordinates are below the line have survival probabilities which exceed 0.50. Survivors whose coordinates are above the P_s50 line and non-survivors whose coordinates are below the line are considered atypical (unexpected in a statistical sense) and worthy of medical review. Data from such non-survivors may be reviewed for the possibility of predictive index failure, health care system failure, or therapeutic failure. Reviews of exceptional survivors may provide guidelines for future patient management.

Figure
Example PRE Chart



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Evaluating Trauma Care: The TRISS Method

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Evaluation of trauma care must be an integral part of any system designed for care of seriously injured patients. However, outcome review should offer comparability to national standards or norms. The TRISS method offers a standard approach for evaluating outcome of trauma care. Anatomic, physiologic, and age characteristics are used to quantify probability of survival as related to severity of injury. TRISS offers a means of case identification for quality assurance review on a local basis, as well as a means of comparison of outcome for different populations of trauma patients. Methods for calculating statistics associated with TRISS are presented. The *Z* and *M* statistics are explained with the nonstatistician in mind. We feel this article is a source for those interested in developing or upgrading trauma care evaluation.

People involved in trauma care are increasingly confronted with the term "TRISS methodology." Presentations at national meetings, original articles on every aspect of trauma care, and any discussions of the ongoing Major Trauma Outcome Study (MTOS) are sure to include reference to the TRISS methodology (15). Bits and pieces of what the TRISS method is and explanations of how one calculates the various statistics associated with this method can be found in several excellent articles by Flora, Baxt, and Champion (5, 6, 16–19, 25). However, to our knowledge, one clear, concise, and complete source geared to nonstatisticians is lacking. Basic to the understanding of the TRISS method is the Trauma Score and the Injury Severity Score. These two scores and the patient's age are the basis for TRISS.

THE TRAUMA SCORE

The Trauma Score was first described by Champion et al in 1981 (17). Essentially, it is a field scoring system utilizing four physiologic parameters—systolic blood pressure, capillary refill, respiratory rate, and respiratory expansion—combined with the Glasgow Coma Scale. Probability of survival has been shown to be related to Trauma Score (TS) values, thereby indicating severity of injury. Table I shows the Trauma Score and its method of computation (17). Table II depicts the probability of survival (PS) for each value of the Trauma Score, as determined in 1981 (17).

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The Trauma Score is used as a field index of physiologic derangement. Most physicians involved in trauma care would agree that patients with a 10% risk of death should be treated at a level one trauma center. A Trauma Score of 13 corresponds to a mortality rate of approximately 10% (Table II). Therefore a primary use of the Trauma Score has been as a triage instrument in the field (9, 14, 27, 33). The Trauma Score has also been viewed as a mechanism for reviewing prehospital care. For example, one would expect the Trauma Score to improve, or at least not worsen, once field care has been initiated. One preliminary study has even suggested that long-term survival might be favorably influenced by early improvement in the Trauma Score through field use of Advanced Life Support measures (27).

Some of the deficiencies of the Trauma Score are noteworthy (30, 35). Like other physiologic indices, the Trauma Score has a sensitivity rate of approximately 80%. That is to say, 20% of the patients with severe injury will not be identified with this score, usually because they have physiologically adequately compensated for volume deficits, and/or field response is so rapid that the time elapsed has not allowed physiologic compromise to occur. Also, the Trauma Score has a specificity of 75%, in that it will overestimate severity of injury when physiologic changes are related to factors other than the consequences of hypovolemia, cerebral edema, or hypoxia. A specific age limit has not been established for use of the Trauma Score, although it has been demonstrated to reliably reflect injury severity in patients over 12 years of age (13). If this physiologic-based score is combined with an index of injury severity based on known anatomical injury, the predictive value is greatly improved, and the misclassification rate reduced.

TABLE I
Trauma Score

Respiratory rate		10–24	4	
		25–35	3	
		>35	2	
		0–9	1	____
Respiratory effort		Normal	1	
		Shallow, retractive	0	____
Systolic blood pressure		>90	4	
		70–90	3	
		50–69	2	
		<50	1	
		No carotid pulse	0	____
Capillary refill		Normal	2	
		Delayed	1	
		Absent	0	____
Glasgow Coma Scale				
Eye opening				
Spontaneous	4			
To voice	3			
To pain	2			
None	1			
Verbal response				
Oriented	5			
Confused	4			
Inappropriate words	3			
Incomprehensible words	2			
None	1			
Motor Response				
Obeys commands	6			
Localizes	5			
Withdraws	4	Total GCS Points		
Abnormal flexion	3	14–15	5	
Abnormal extension	2	11–13	4	
None	1	8–10	3	
		5–7	2	
Total GCS Points	____	3–4	1	____
		TOTAL TRAUMA SCORE		____

TABLE II
Trauma score and probability of survival

Trauma Score	Probability of Survival (PS)
16	99%
15	98%
14	95%
13	91%
12	83%
11	71%
10	55%
9	37%
8	22%
7	12%
6	7%
5	4%
4	2%
3	1%
2	0%
1	0%

TABLE III
Thoracic section of Abbreviated Injury Scale

AIS	Severity	Injury Description
1	Minor	Rib contusion/fracture*
		Sternal contusion
2	Moderate	2-3 rib fractures, stable chest*
		Multiple fractures of single rib*
		Sternal fracture
3	Severe, not life threatening	Rib fracture open/displaced/ comminuted*
		>3 rib fractures, stable chest*
4	Severe, life threatening	Flail chest (unstable chest wall)
5	Critical, survival uncertain	Severe flail (usually requires ventilatory support)

* Add 1 for presence of hemothorax, pneumothorax, hemomediastinum, or pneumomediastinum.

INJURY SEVERITY SCORE

In 1970 the A.M.A. Committee on Medical Aspects of Automotive Safety coordinated an effort to develop a method for quantitating injuries received in motor vehicle accidents (MVA) (21, 22). The resultant Abbreviated Injury Scale (AIS) assessed injury severity on a scale from 1 (minor) to 6 (fatal) in each of five body systems. The thoracic section of the AIS is found in Table III (26). Although a milestone in severity scoring using anatomic pathology, this system proved to be deficient in several areas, including adequacy in describing multiple injuries and utility of the highest single AIS versus the overall (summed) AIS (2, 4, 11). Using this system as a foundation, Baker et al. designed a method which was capable of expressing the cumulative effect of injury to several body systems (3). Each of six anatomic regions is scored with the highest AIS grade for any injury in that region. The AIS values of the three highest scoring body regions are squared and then summed. A score of 6 in any one body system incurs the maximum overall score of 75, indicating a fatal injury. This Injury Severity Score (ISS) has been found to correlate better with mortality than the AIS, and is generally accepted as the standard for anatomic indices of injury severity (36).

An ISS of 16 is predictive of 10% mortality and defines major trauma based on anatomic injury. Both the AIS and the ISS, designed to quantitate severity of injury due to blunt trauma sustained in MVA's, are deficient in appropriately scoring penetrating injuries, and require further revision to accurately identify major injuries in this population subset (7). The most recent AIS revision, AIS-85, attempts to address this deficiency (1).

AGE

The significance of the cardiovascular compromise associated with increasing age as it relates to probability of survival has been documented in the literature (8, 37). Among the 23,000 patients studied in the Major Trauma Outcome Study, an age greater than 55 years, for comparable levels of physiologic derangement and anatomic injury severity, was shown to be associated with significantly increased mortality (23). For example, Trauma Scores and Injury Severity Scores resulting in a 10% predicted mortality for blunt trauma patients under 55 years of age have a predicted mortality of approximately 40% in patients 55 or more years old.

TRISS

Using the TRISS methodology, the probability of survival for any one patient can be estimated from the following formula

$$Ps = 1/(1 + e^{-b})$$

where $b = b_0 + b_1(TS) + b_2(ISS) + b_3(A)$.

$b_{0...3}$ are coefficients derived from Walker-Duncan regression analysis applied to data from thousands of patients analyzed in the Major Trauma Outcome Study (see Table IV). As improvements in trauma care over time result in decreased mortality, these MTOS coefficients can be expected to change. A is the symbol for age. If the patient's age is 54 years or less, A is equal to 0. A is equal to 1 if the patient is 55 or more years of age. The constant e is equal to 2.718282 (the base of Napierian logarithms).

Example: A 40-year-old patient involved in blunt trauma

$$TS = 11$$

$$ISS = 45$$

$$Ps = 1/(1 + e^{-b}).$$

$$b = b_0 + b_1(TS) + b_2(ISS) + b_3(A)$$

$$b = (-1.6465) + (0.5175)(11)$$

$$+ (-0.0739)(45) + (-1.9261)(0)$$

$$b = -1.6465 + 5.6925 - 3.3255 + 0$$

$$b = 0.7205$$

$$Ps = 1/(1 + 2.718282^{-(0.7205)})$$

$$Ps = 1/(1 + 0.4865)$$

$$Ps = 0.673$$

Therefore this patient's probability of survival is 0.673 or 67%.

REVISED TRAUMA SCORE

More recently a Revised Trauma Score (RTS) has evolved from a critical analysis of patients whose outcome was not statistically predicted by the TRISS methodology. The RTS uses three physiologic parameters to quantitate injury severity—Glasgow Coma Scale, systolic blood pressure, and respiratory rate. Specific ranges of each parameter are assigned coded values as seen in Table V (24). The coded value for each variable is then multiplied by an assigned weight derived from regression analysis of over 25,000 patients in the Major Trauma Outcome Study (24). The sum of these three products is the RTS. The total score is no longer restricted to integers, and ranges from 0 to 8.

Using the previous example, the coded values for each parameter are multiplied by the weights found in Table VI, and the products summed.

Parameter		Coded Value	Weight	Coded Value × Weight
Glasgow Coma Scale	9	3	0.9368	2.8104
Systolic Pressure	90	4	0.7326	2.9304
Respiratory Rate	36	3	0.2908	0.8724
				6.6132

The Revised Trauma Score is 6.6132. Next we solve for b and Ps. When using this modification, it is necessary to use the newer coefficients for TRISS based on the RTS and AIS-85 (Table VII) (24).

$$b = b_0 + b_1(TS) + b_2(ISS) + b_3(AGE)$$

$$b = -1.2470 + (0.9544)(6.6132)$$

$$+ (-0.0768)(45) + (-1.9052)(0)$$

$$b = -1.2470 + 6.3117 - 3.456 + 0$$

$$b = 1.6087$$

$$Ps = 1/(1 + 2.718282^{-(1.6087)})$$

$$Ps = 1/(1 + 0.2014)$$

$$Ps = 0.8332$$

The patient's probability of survival is 0.83 or 83%.

This revision has perhaps resulted in two improvements over the original scale. First, by weighting the Glasgow Coma Scale, severe head injury will be identified

TABLE IV
Values for weighted coefficients

	b_0 (Constant)	b_1 (Trauma Score)	b_2 (ISS)	b_3 (Age)
Blunt	−1.6465	0.5175	−0.0739	−1.9261
Penetrating	−0.8068	0.5442	−0.1159	−2.4782

Pediatric patients are scored using the coefficients for blunt trauma, irrespective of injury mode.

TABLE V
Revised Trauma Score

Glasgow Coma Scale	Systolic Blood Pressure (mm Hg)	Respiratory Rate (min)	Coded Value
13–15	>89	10–29	4
9–12	76–89	>29	3
6–8	50–75	6–9	2
4–5	1–49	1–5	1
3	0	0	0

TABLE VI
Weights for Revised Trauma Score

Glasgow Coma Scale	0.9368
Systolic blood pressure	0.7326
Respiratory rate	0.2908

TABLE VII
Revised coefficients for new outcome norms

	b_0	b_1	b_2	b_3
Blunt	−1.2470	0.9544	−0.0768	−1.9052
Penetrating	−0.6029	1.1430	−0.1516	−2.6676

in the absence of coexisting multisystem injury and/or correspondingly severe physiologic derangement. Second, patient outcomes are more reliably predicted.

It should be emphasized that the application of the RTS as a field triage instrument is a departure from the use of the original Trauma Score in the field. Instead of using a numerical total to define major trauma, it has been suggested that any trauma patient with less than a coded value of 4 in any parameter be taken to a trauma center. This simplification highlights the physiologic pathology which best correlates with significant mortality. At this time calculation of the RTS is reserved for after the fact evaluation of care.

PRE-CHART

As can be seen in Figure 1, the coordinate pair of TS (vertical axis) and ISS (horizontal axis) is plotted for each patient. Survivors are denoted by the symbol L, and deaths the symbol D. Based on Walker-Duncan regression coefficients, a line can be drawn through the coordinate pairs that represent a probability of survival (Ps) of 0.50—the S50 Isobar. TS, ISS pairs below and to the left of the line have a Ps > 0.50, and those above and to the right have a Ps < 0.50. This type of graph is useful in identifying unexpected deaths as well as unexpected survivors. All deaths that fall below the S50 Isobar should be reviewed for trauma care system failure. All survivors that fall above the S50 Isobar were saved, although predicted to die. Remember, the S50 Isobar, when used in this manner, compares each patient's outcome to an expectation based on thousands of patients treated in trauma centers across the country. Because the computation of probability of survival is derived from a unique set of coefficients dependent on mechanism of injury (blunt or penetrating), the S50 Isobar for each mode is different. Figure 2 shows a pre-chart utilizing values for the Revised Trauma Score on the vertical axis: the horizontal axis is unchanged. The pre-chart provides individual institutions with an excellent non-biased mechanism to highlight patients with an unexpected outcome. Although the pre-chart serves as an audit filter for case identification, it does not replace the peer review process.

Z STATISTIC

The *Z* statistic, first described by Flora, is a statistic of outcome comparison between two subsets of a population (25). In other words, the *Z* statistic quantitates the difference in the actual number of deaths (or survivors) in the test (e.g., institution) subset, and the predicted number of deaths (or survivors) based on the baseline (MTOS norm). When considering mortality, the formula for calculating *Z* is:

$$Z = \frac{D - \Sigma Qi}{\sqrt{\Sigma PiQi}}.$$

Where

D = Actual number of deaths
Qi = (1 − Pi) Predicted probability of death for patient i
ΣQi = Predicted number of deaths
Pi = Predicted Ps for patient i (from baseline norm).

Example:

Patient Number	Lived/ Died	Pi	Qi	PiQi
1	L	0.997	0.003	0.00299
2	L	0.994	0.006	0.00596
3	L	0.992	0.008	0.00794
4	D	0.049	0.951	0.04660
5	L	0.938	0.062	0.05816
6	L	0.673	0.327	0.22007
7	L	0.800	0.200	0.16000
8	L	0.134	0.866	0.11604
9	D	0.004	0.996	0.00398
10	D	0.287	0.713	0.20463
	D = 3	5.868	4.132	0.82637

Therefore

D = 3 (Actual number of deaths)
ΣQi = 4.132 (predicted number of deaths)
ΣPiQi = 0.82637.

Applying these values to the formula above, we calculate *Z* for this study subset.

$$Z = \frac{D - \Sigma Qi}{\sqrt{\Sigma PiQi}}$$

$$Z = \frac{(3 - 4.132)}{\sqrt{0.82637}}$$

$$Z = \frac{-1.132}{0.9090}$$

$$Z = -1.24.$$

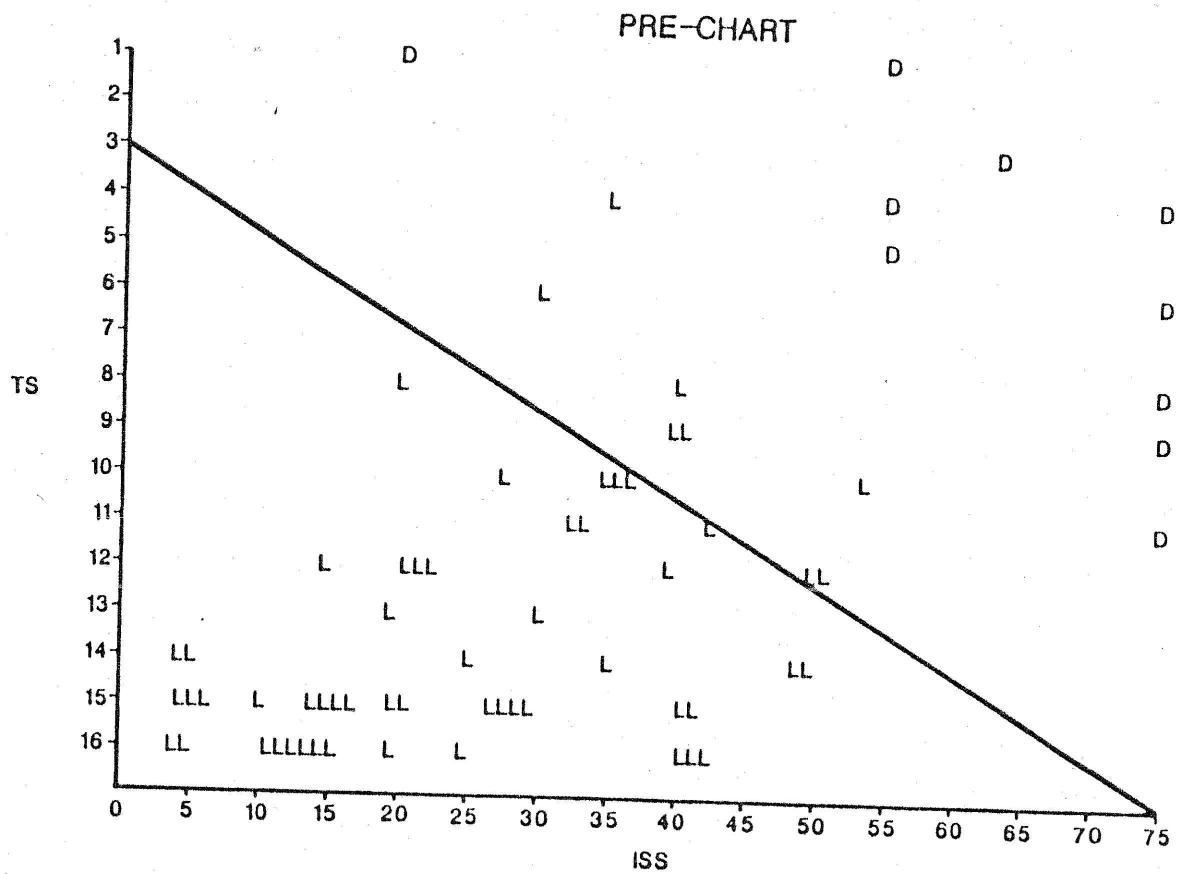

FIG. 1. Survivors (L) and nonsurvivors (D) are plotted on a graph using Trauma Score (TS) and Injury Severity Score (ISS) of each. The S50 Isobar denotes a probability of survival of 0.50.

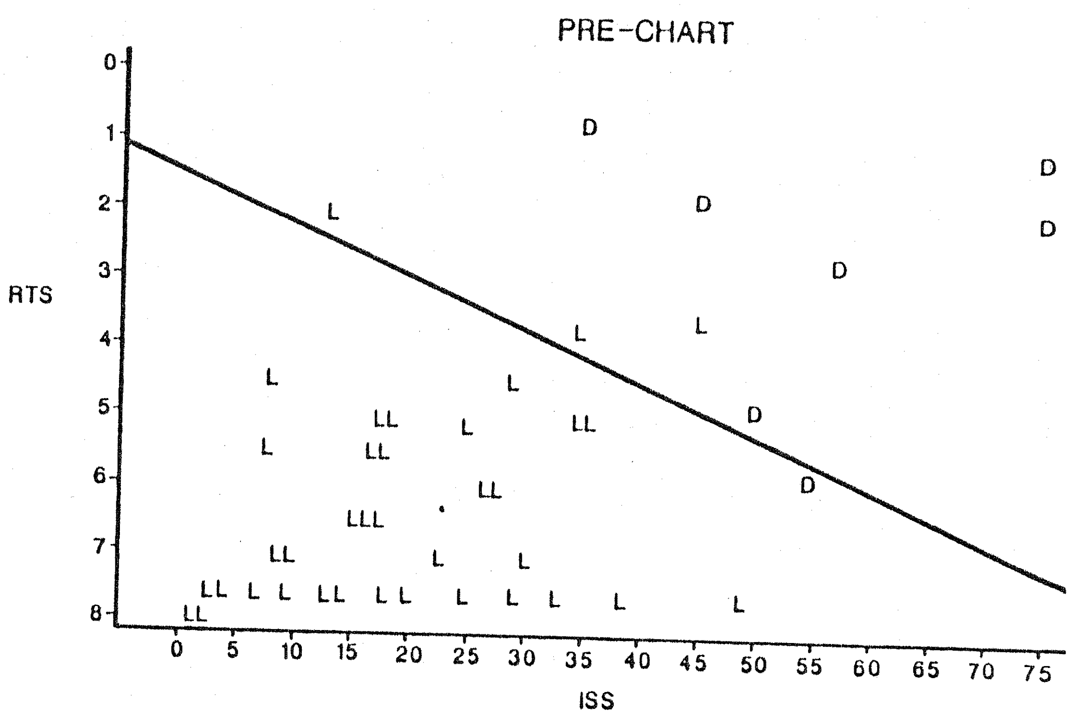

FIG. 2. Sample pre-chart using Revised Trauma Score.

Notice in this example the Z value is negative. When mortality is studied, a negative Z value is the desired esult, since it implies that the number of deaths preicted from the baseline *exceeds* the number observed in he test set. Conversely, when survival is studied, a ositive Z value is desired. The formula for calculating when considering survivors is

$$Z = \frac{S - \Sigma Pi}{\sqrt{\Sigma PiQi}}$$

here

S = Actual number of survivors
Pi = Predicted Ps for patient i (from baseline norm)
ΣPi = Predicted number of survivors (from baseline).

herefore, using the values from the example above

$$Z = \frac{(7 - 5.6868)}{\sqrt{0.82637}}$$

$$Z = \frac{1.132}{0.9090}$$

$$Z = +1.24.$$

Although the formula for calculation and the sign of Z changes, the absolute value does not. An absolute value of Z which exceeds 1.96 is required for a significance level of 0.05. To find the significance level for values of Z, refer to Table VIII (25).

M STATISTIC

Z values can be affected by the injury severity match between the study and baseline patient sets. The heuristic statistic M is a measure of that "match." Values for M range from zero to one, and the closer the value is to one, the better the match of injury severity. The fraction of patients (f1 . . . f6) falling into each of six increments of Ps for the baseline group (MTOS) is compared with the corresponding fraction for the study sample (g1 . . . g6). Let si be the smaller of the two values fi and gi. Then s1 . . . s6 are summed to arrive at M.

TABLE VIII
|Z|: **Critical values from a standard normal distribution**

Significance Level	Critical Value
0.001	3.29
0.005	2.81
0.010	2.58
0.025	2.24
0.050	1.96
0.100	1.65

Example:

Ps Range	Fraction of Patients within Range Study Subset g	Baseline Subset f
0.96–1.00	0.842	0.828
0.91–0.95	0.053	0.045
0.76–0.90	0.052	0.044
0.51–0.75	0.000	0.029
0.26–0.50	0.043	0.017
0.00–0.25	0.010	0.036

$$M = s1 + s2 + s3 + s4 + s5 + s6$$

$$M = 0.828 + 0.045 + 0.044 + 0.000 + 0.017 + 0.010$$

$$M = 0.944.$$

This value for M represents an excellent match between study and baseline patient groups. Lower values for M, in this instance <0.88, indicate a disparity in the severity match between groups. Z values associated with "lower" values of M should be viewed with some skepticism. The low value of M does not explain whether the study group was more or less severely injured than the baseline population.

TRISSCAN

The TRISS method describes a means of determining probability of survival (Ps) utilizing current coefficients from the Major Trauma Outcome Study and Champion's original Trauma Score. Using these predetermined values, we have developed the TRISSCAN chart as a readily available visual reference for close approximation of Ps. This has proven useful not only as a quick and easy method of highlighting unexpected outcomes, but also as an educational tool to emphasize the importance of the interrelationships of the variables representing physiologic derangement (TS), anatomic injury severity (ISS), and age. The TRISSCAN charts for blunt injury in both age groups are presented in Figures 3 and 4. Figure 5 incorporates the more recent coefficients for AIS-85 and the Revised Trauma Score. Blunt and penetrating mechanisms, as well as both age groups, are represented in this graphic reference for estimating probability of survival.

SUMMARY

Indices for quantitating injury severity are integral to understanding the epidemiology of trauma and objectively judging the quality and results of care rendered both prehospital and postadmission (4, 10, 12, 16, 20, 28, 29, 31, 32, 34, 38). The TRISS methodology offers a standard approach for tracking and evaluating outcome of trauma care. Anatomic, physiologic, and age charac-

TRISSCAN

TS \ ISS	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
1	.18	.13	.10	.07	.05	.03	.02	.02	.01	.01	.01	.00	.00	.00	.00
2	.27	.21	.15	.11	.08	.06	.04	.03	.02	.01	.01	.01	.00	.00	.00
3	.39	.30	.23	.17	.13	.09	.06	.05	.03	.02	.02	.01	.01	.01	.00
4	.51	.42	.34	.26	.19	.14	.10	.07	.05	.04	.03	.02	.01	.01	.01
5	.64	.55	.46	.37	.29	.22	.16	.12	.08	.06	.04	.03	.02	.01	.01
6	.75	.67	.59	.50	.40	.32	.25	.18	.13	.10	.07	.05	.03	.02	.02
7	.83	.78	.70	.62	.53	.44	.35	.27	.21	.15	.11	.08	.06	.04	.03
8	.89	.85	.80	.73	.66	.57	.48	.39	.30	.23	.17	.13	.09	.06	.05
9	.93	.91	.87	.82	.76	.69	.61	.51	.42	.34	.26	.19	.14	.10	.01
10	.96	.94	.92	.89	.84	.79	.72	.64	.55	.46	.37	.29	.22	.16	.12
11	.98	.97	.95	.93	.90	.86	.81	.75	.67	.59	.50	.40	.32	.25	.18
12	.99	.98	.97	.96	.94	.91	.88	.83	.78	.70	.62	.53	.44	.35	.27
13	.99	.99	.98	.97	.96	.95	.92	.89	.85	.80	.73	.65	.57	.48	.39
14	.99	.99	.99	.98	.98	.97	.95	.93	.91	.87	.82	.76	.69	.61	.51
15	.99	.99	.99	.99	.99	.98	.97	.96	.94	.92	.89	.84	.79	.72	.64
16	.99	.99	.99	.99	.99	.99	.98	.98	.97	.95	.93	.90	.86	.81	.75

ISS

BLUNT TRAUMA AGE 54 OR LESS

FIG. 3. Probability of survival can be estimated using the TRISSCAN chart. Estimates are for blunt trauma patients 54 years of age or less. Champion's original Trauma Score (TS), AIS-80, and corresponding coefficients are used.

TRISSCAN

TS \ ISS	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
1	.03	.02	.02	.01	.01	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.05	.04	.03	.02	.01	.01	.01	.00	.00	.00	.00	.00	.00	.00	.00
3	.08	.06	.04	.03	.02	.01	.01	.01	.01	.00	.00	.00	.00	.00	.00
4	.13	.10	.07	.05	.03	.02	.02	.01	.01	.01	.00	.00	.00	.00	.00
5	.21	.15	.11	.08	.06	.04	.03	.02	.01	.01	.01	.00	.00	.00	.00
6	.30	.23	.17	.13	.09	.06	.05	.03	.02	.02	.01	.01	.01	.00	.00
7	.42	.33	.26	.19	.14	.10	.07	.05	.04	.03	.02	.01	.01	.01	.00
8	.55	.46	.37	.29	.22	.16	.12	.08	.06	.04	.03	.02	.01	.01	.01
9	.67	.59	.49	.40	.32	.24	.18	.13	.10	.07	.05	.03	.02	.02	.01
10	.77	.70	.62	.53	.44	.35	.27	.21	.15	.11	.05	.06	.04	.08	.02
11	.85	.80	.73	.66	.57	.48	.39	.30	.23	.17	.13	.09	.06	.05	.03
12	.91	.87	.82	.76	.69	.60	.51	.42	.33	.26	.19	.14	.10	.07	.05
13	.94	.92	.89	.84	.79	.72	.64	.55	.46	.37	.29	.22	.16	.12	.08
14	.97	.95	.93	.90	.86	.81	.75	.67	.59	.49	.40	.32	.24	.18	.13
15	.98	.97	.96	.94	.91	.88	.83	.77	.70	.62	.53	.44	.35	.27	.21
16	.99	.98	.97	.96	.95	.92	.89	.85	.80	.73	.66	.57	.48	.39	.30

ISS

BLUNT TRAUMA AGE 55 OR GREATER

FIG. 4. Estimation of probability of survival in blunt trauma patients 55 years of age or greater using TS.

T R I S S C A N

ISS PENETRATING

≤54 RTS	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	>54 RTS
1.0	.33 .45 .07 .05	.25 .27 .05 .03	.19 .15 .03 .01	.14 .08 .02 .01	.10 .04 .02 .00	.07 .02 .01 .00	.05 .01 .01 .00	.03 .00 .01 .00	.02 .00 .00 .00	.02 .00 .00 .00	.01 .00 .00 .00	.01 .00 .00 .00	.01 .00 .00 .00	.00 .00 .00 .00	.00 .00 .00 .00	1.0
1.5	.44 .59 .11 .09	.35 .40 .08 .04	.27 .24 .05 .02	.20 .13 .04 .01	.15 .06 .03 .01	.11 .03 .02 .00	.07 .02 .01 .00	.05 .01 .01 .00	.04 .00 .01 .00	.03 .00 .00 .00	.02 .00 .00 .00	.01 .00 .00 .00	.01 .00 .00 .00	.01 .00 .00 .00	.00 .00 .00 .00	1.5
2.0	.56 .72 .16 .15	.47 .54 .12 .08	.37 .36 .08 .04	.29 .21 .06 .02	.22 .11 .04 .01	.16 .05 .03 .00	.11 .03 .02 .00	.08 .01 .01 .00	.06 .01 .01 .00	.04 .00 .01 .00	.03 .00 .00 .00	.02 .00 .00 .00	.01 .00 .00 .00	.00 .00 .00 .00	.01 .00 .00 .00	2.0
2.5	.67 .82 .24 .24	.59 .68 .17 .13	.49 .50 .13 .06	.40 .32 .09 .03	.30 .18 .06 .02	.23 .09 .04 .01	.17 .05 .03 .00	.12 .02 .02 .00	.09 .01 .01 .00	.06 .01 .01 .00	.04 .00 .01 .00	.03 .00 .00 .00	.02 .00 .00 .00	.01 .00 .00 .00	.01 .00 .00 .00	2.5
3.0	.77 .89 .33 .35	.69 .79 .25 .21	.61 .64 .19 .11	.51 .45 .14 .05	.42 .28 .10 .03	.33 .15 .07 .01	.25 .08 .05 .01	.19 .04 .03 .00	.13 .02 .02 .00	.10 .01 .02 .00	.07 .00 .01 .00	.05 .00 .01 .00	.03 .00 .01 .00	.02 .00 .00 .00	.02 .00 .00 .00	3.0
3.5	.84 .93 .45 .49	.79 .87 .35 .31	.71 .76 .27 .18	.63 .59 .20 .09	.54 .40 .15 .05	.44 .24 .11 .02	.35 .13 .07 .01	.27 .07 .05 .01	.20 .03 .04 .00	.15 .02 .03 .00	.10 .01 .02 .00	.07 .00 .01 .00	.05 .00 .01 .00	.04 .00 .01 .00	.02 .00 .00 .00	3.5
4.0	.90 .96 .56 .63	.86 .92 .47 .45	.80 .85 .37 .27	.73 .72 .29 .15	.65 .55 .22 .08	.56 .36 .16 .04	.46 .21 .11 .02	.37 .11 .08 .01	.29 .06 .06 .00	.22 .03 .04 .00	.16 .01 .03 .00	.11 .01 .02 .00	.08 .00 .01 .00	.06 .00 .01 .00	.04 .00 .01 .00	4.0
4.5	.93 .98 .68 .75	.91 .92 .59 .58	.87 .91 .49 .40	.82 .82 .40 .24	.75 .68 .31 .13	.67 .50 .23 .06	.58 .32 .17 .03	.49 .18 .12 .02	.39 .09 .09 .01	.31 .05 .06 .00	.23 .02 .04 .00	.17 .01 .03 .00	.12 .01 .02 .00	.09 .00 .01 .00	.06 .00 .01 .00	4.5
5.0	.96 .99 .77 .84	.94 .97 .70 .72	.91 .95 .61 .54	.88 .89 .51 .36	.83 .79 .42 .21	.77 .63 .33 .11	.69 .45 .25 .05	.61 .28 .19 .03	.51 .15 .13 .01	.42 .08 .10 .01	.33 .04 .07 .00	.25 .02 .05 .00	.18 .01 .03 .00	.13 .00 .02 .00	.09 .00 .02 .00	5.0
5.5	.97 .99 .34 .91	.96 .99 .79 .82	.94 .97 .72 .68	.92 .93 .63 .50	.89 .87 .54 .32	.84 .76 .44 .18	.78 .59 .35 .09	.71 .41 .27 .05	.63 .24 .20 .02	.53 .13 .15 .01	.44 .07 .10 .01	.35 .03 .07 .00	.27 .02 .05 .00	.20 .01 .04 .00	.14 .00 .02 .00	5.5
6.0	.98 .99 .90 .94	.98 .99 .86 .89	.96 .98 .80 .79	.95 .96 .73 .64	.93 .92 .65 .45	.90 .85 .56 .28	.85 .72 .47 .15	.80 .55 .37 .08	.73 .36 .29 .04	.65 .21 .22 .02	.56 .11 .16 .01	.46 .06 .11 .00	.37 .03 .08 .00	.28 .01 .06 .00	.21 .01 .04 .00	6.0
6.5	.99 .99 .93 .97	.99 .99 .91 .93	.98 .99 .87 .87	.97 .98 .82 .76	.95 .95 .75 .59	.93 .91 .67 .40	.90 .82 .58 .24	.87 .68 .49 .13	.81 .50 .39 .07	.75 .32 .31 .03	.67 .18 .23 .02	.58 .09 .17 .01	.48 .05 .12 .00	.39 .02 .09 .00	.30 .01 .06 .00	6.5
7.0	.99 .99 .96 .98	.99 .99 .94 .96	.99 .99 .91 .92	.98 .99 .88 .85	.97 .97 .83 .72	.96 .95 .77 .55	.94 .89 .69 .36	.91 .79 .61 .21	.88 .65 .51 .11	.83 .46 .42 .06	.77 .28 .33 .03	.69 .16 .25 .01	.60 .08 .18 .01	.51 .04 .13 .00	.41 .02 .10 .00	7.0
7.5	.99 .99 .97 .99	.99 .99 .96 .98	.99 .99 .94 .95	.99 .99 .92 .91	.98 .99 .87 .82	.97 .97 .84 .68	.96 .94 .78 .50	.94 .87 .71 .32	.92 .76 .63 .18	.89 .60 .54 .09	.84 .41 .44 .05	.78 .25 .35 .02	.71 .13 .27 .01	.62 .07 .20 .01	.53 .03 .14 .00	7.5
8.0	.99 .99 .98 .99	.99 .99 .98 .99	.99 .99 .97 .97	.99 .99 .95 .95	.99 .99 .93 .89	.98 .98 .90 .79	.98 .96 .85 .64	.97 .92 .80 .45	.95 .85 .73 .28	.93 .72 .65 .15	.89 .55 .56 .08	.85 .37 .46 .04	.80 .21 .37 .02	.73 .11 .29 .01	.65 .06 .21 .00	8.0
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	

ISS BLUNT

FIGURE 5: FOR PATIENTS LESS THAN 55 YEARS OLD. USE RTS IN LEFT COLUMN. FOR PATIENTS 55 AND ABOVE, USE THE RIGHT COLUMN RTS. FOR BLUNT TRAUMA. USE ISS VALUES FROM BOTTOM SCALE. * PENETRATING ISS VALUES ARE FOUND IN THE TOP SCALE. FOLLOW THE APPROPRIATE COLUMN AND ROW TO ARRIVE AT THE CORRECT SQUARE. THE LEGEND AT THE RIGHT WILL CONFIRM WHICH OF THE FOUR VALUES IS THE CORRECT Ps. EXAMPLE: A 65 YEAR OLD PATIENT INVOLVED IN AN MVA WITH AN RTS OF 6.5 AND AN ISS OF 35 HAS A 58% PROBABILITY OF SURVIVAL.

LEGEND

UPPER LEFT: ≤54YO, BLUNT
UPPER RIGHT: ≤54YO, PENETRATING
LOWER RIGHT: >54YO, PENETRATING
LOWER LEFT: >54YO, BLUNT

THE ABOVE POSITIONS REFER TO THE QUADRANT LOCATION OF THE Ps.

FIGURE 5.

teristics are used to quantify probability of survival as it relates to severity of injury. This method provides an excellent screening tool for case identification in quality assurance review, as well as a means of comparison of outcome for different populations or trauma patients.

In our region of trauma care, medical control utilizes the Trauma Score as a major determinant for triage to the trauma center. ISS is calculated for all trauma admissions and entered in the trauma registry. TRISSCAN charts are utilized by the various groups concerned with quality assurance review, including the trauma service, emergency departments, and the hospital-based Helicopter Emergency Medical Service. Patients with unexpected deaths are promptly brought to review, system failure identified if possible, and recommendations for future management made. The objective standard offered by TRISS tempers the local emotionalism associated with self review.

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