A Systematic Review and Meta-Analysis Comparing Outcome of Severely Injured Patients Treated in Trauma Centers Following the Establishment of Trauma Systems

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Background: **The establishment of trauma systems was anticipated to improve overall survival for the severely injured patient. We systematically reviewed the published literature to assess if outcome from severe traumatic injury is improved for patients following the establishment of a trauma system.**

Methods: **A systematic literature review of all population-based studies that evaluated trauma system performance was conducted. A qualitative analysis of each study's design and methodology and a meta-analysis was performed to evaluate the evidence to date of trauma system effectiveness.**

Results: **A search of the literature yielded 14 published articles. Trauma systems demonstrated improved odds of survival in 8 of the 14 reports. The overall quality-weighted odds ratio was 0.85 lower mortality following trauma system implementation.**

Conclusions: **The results of the meta-analysis showed a 15% reduction in mortality in favor of the presence of a trauma system. Evaluation of trauma system effectiveness must remain an uncompromising commitment to optimal outcome for the injured patient.**

Key Words: **Meta-analysis, Trauma system, Performance outcome.**

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Injury is the leading cause of lost years of life,[1] and is estimated to result in 500 years of lost productivity annually per 100,000 population.[2] Morbidity and mortality from serious injury or trauma can be reduced through improved patient assessment and management systems. Components of contemporary systems include injury prevention, prehospital care, services at trauma centers and other acute care facilities, and posthospital care. The American College of Surgeons recognized the need for a systematic approach to trauma in 1922 and formed the Committee on Treatment of Fractures, which became the Committee on Trauma. The Committee on Trauma has provided leadership in conceptualizing and advocating for trauma systems.

National attention to trauma system development did not begin until 1966. It was stimulated by the 1966 National Research Council report, *Accidental Death and Disability—The Neglected Disease of Modern Society*.[3] A sequence of subsequent national and state legislative decisions led to the development of emergency medical systems which provided resources to supply communities with modern ambulances and trained prehospital care personnel. Systems were based on a military approach to trauma care that had been developed and tested in military conflicts.[4]

In 1966, the Highway Safety Act and National Traffic and Motor Vehicle Safety Act were passed in a national effort to reduce traffic crash injuries and fatalities. The Emergency Medical Services (EMS) program was established in the Department of Transportation to provide leadership and standards for regional EMS systems and training. In 1973, the EMS Systems Act identified trauma systems as one of 15 essential components of an EMS system, and appropriated federal funds to support the development of regional EMS systems.

In 1981, federal EMS funds were shifted to state preventive health block grants with the Omnibus Budget Reconciliation Act. This gave states discretion on the use of funds. As a consequence, many EMS systems lost funding. In 1990, the Trauma Care Systems Planning and Development Act was passed to improve trauma care and EMS services. It established a Division of Trauma and EMS in the Department of Health and Human Services. Funding was discontinued in fiscal year 1995 and then reestablished for the 2001 and 2002 years.[5]

Regional trauma systems and centers are designed to reduce morbidity and mortality from injury. They also improve preparedness for potential mass casualty situations, both natural and manmade. However, trauma systems and centers "have not been universally implemented because of questions of need, efficacy, cost and possibly political enthusiasm."[6] We systematically reviewed the published literature for population-based studies to assess if outcome from severe traumatic injury was improved for patients following the establishment of a trauma system.

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OUTCOMES EVALUATION

The evaluation of trauma system performance began with expert panel studies. Their purpose was to determine whether trauma centers reduced preventable deaths of severely injured patients. The development of trauma registries has since allowed for comparison of outcomes among trauma systems. One of the first models is the Trauma and Injury Severity Score (TRISS).[7] TRISS uses a national injury registry to compare observed deaths at a trauma center with estimated survival probabilities for blunt and penetrating injuries. The probabilities are derived from the Major Trauma Outcome Study (MTOS).[8] A statistically different survival rate probability is calculated with Flora's Z-statistic. TRISS has been often used as the national standard that allows trauma centers to compare their outcomes.[9]

One alternative method to assess trauma system performance from national injury registries is the *International Classification of Diseases, 9th Edition* Injury Severity Score (ICISS). A survival risk ratio (SRR) is calculated for every trauma ICD-9 code by dividing the number of patients who survived by the total number of patients with the same injury in the database. The SRRs were hypothesized to predict survival better than empirically derived injury severity scores such as Injury Severity Score or the Abbreviated Injury Scale. Osler et al. showed that ICISS has the best ability to discriminate survivors from nonsurvivors.[10] For evaluating resource utilization, ICISS outperformed the diagnostic-related groups predicting hospital length of stay and costs.[11]

The TRISS methodology has received its fair share of criticism.[12,13] In particular, the basis for TRISS, MTOS, collected data on hospitalized patients in the 1980s. Hospital participation was voluntary and included a variety of trauma and nontrauma hospitals. Thus, the MTOS database may not provide a nationally representative survival norm to use for current trauma center comparisons.[14] There have been attempts to improve TRISS, such as the addition of anatomic region to the computation of survival probabilities.[15] Despite these modifications, the TRISS methodology continues to demonstrate poor performance as a predictor of survival. The application of TRISS for datasets with significantly different survival distributions tends to misclassify patients and thus overpredict unexpected survivors.[16,17]

The ICISS methodology has its own limitations as well. ICISS has performed inconsistently when compared with anatomic-derived measures.[18,19] The SRRs are database-dependent and can vary substantially contingent upon the source of the dataset. Another weakness is that patients with more than one minor injury are assigned a low survival probability due to the multiplicative nature of the SRRs. Thus, observed survival probabilities tend to be compressed that lead to an overestimation of injury severity. ICISS shows improved reliability and predictive validity of survival over the combined risk ratios with utilization of a national injury registry to normalize SRRs[20] or from independently derived SRRs.[21]

Hypothesis

The published literature will demonstrate that outcome from severe injury was better for patients treated at trauma centers following the establishment of a trauma system.

MATERIALS AND METHODS

A literature review of all population-based studies that evaluated trauma system performance was conducted. The electronic databases MEDLINE, PUBMED, and CINAHL were searched from 1966 through August 2004. Keyword terms used to identify published articles included "trauma center," "trauma system," "trauma outcome," and "logistic regression." The literature search was limited to English language population studies from North America. A further review of citations among identified articles was also performed. The search included pre- to posttrauma center designation, concurrent trauma center to nontrauma hospital, and regional or state trauma system to a nontrauma system comparisons. Logistic regression was the most common statistical method used across studies. Studies with methodologies based on expert panels, or national injury registries (e.g., TRISS) were excluded.

A meta-analysis was performed to evaluate the evidence to date of trauma system effectiveness. Table 1 lists the inclusion criteria for consideration in the meta-analysis. The articles must have published sufficient data to calculate odds ratios and effect sizes. First, a heterogeneity test was computed to determine identical characteristics and effects of the included studies.[22] The Mantel-Haenszel method to calculate the weighted summary odds ratio under the fixed effects model was followed by incorporation of the heterogeneity statistic to compute the summary odds ratio under the random effects model.

A qualitative analysis of each study's design and methodology was also performed to obtain a qualitative score.[23,24] The scoring criteria were provided in Table 2. The total possible qualitative score was 40. The odds ratios from the meta-analysis were then multiplied by the qualitative score to calculate the quality-adjusted odds ratio for each study. Next, the sum of all quality-adjusted odds ratios was divided by the sum of the scores of all studies to determine the overall quality-adjusted odds ratio. Medcalc statistical software was used to compare odds of individual reports and the effect size of all compared trauma systems.

Table 1 Meta-analysis Criteria

Published in a peer reviewed journal
A population-based study
Statistical analysis by logistic regression
Sufficient data provided to calculate odds ratio

RESULTS

A search of the literature yielded 14 published articles. Summaries of the 14 studies are presented in an evidentiary table (Table 3).[25–38] The summary table details the methods, type of comparison, risk adjustments, and results of the studies. The population-based studies included in outcome analysis were considered to represent strong Class III evidence.[39] Trauma systems demonstrated improved odds of survival in 8 of the 14 reports. Three comparative studies showed worse odds of mortality for trauma systems, whereas three did not demonstrate any significant difference.

Trauma System Effectiveness

One of the first published population-based studies examined the Los Angeles County Trauma System. Kane showed the odds of survival for the severely injured improved after implementation of the system. The minor injury patients treated at trauma centers most likely did not require trauma services, whereas the most severely injured were unlikely to survive regardless of which treatment facility was utilized. In a similar study, Hedges examined Oregon's trauma system. Although overall mortality was not statistically different from before the existence of a trauma system, the number of more severely injured patients admitted to trauma centers had increased during the postdesignation period.

Three studies compared the performance of the Oregon trauma system with nontrauma hospitals. Mullins also found an increase in the number of more seriously injured patients being sent to a trauma center postdesignation, as well as a significant risk reduction of mortality following implementation of the trauma system. When reexamined, the reduced mortality seen throughout the Oregon trauma system was partially attributed to improved training of EMS personnel and advancements in technology. When the Oregon trauma system was compared with the adjacent state of Washington, which did not have a formal trauma system in place, the Oregon trauma system showed reduced mortality. The authors suggested that many tertiary hospitals may be functioning as trauma centers without the benefit of the designation.

Sampalis investigated the effect of trauma center designation on mortality in a study of the Canadian trauma system. Odds of mortality were higher before trauma center designation. The study again showed a steady increase in severely injured patients being transferred to trauma centers postdesignation. It seems that overall level of care improved because of more timely intervention and better access to resources provided to the trauma centers. Okeefe studied survival of patients treated in the state of Washington. Mortality was shown to decline significantly over a 10-year period. Increased experience seemed to explain the reduced mortality while acknowledging advancements in trauma care and the authors recommended limiting the number of trauma centers to maintain a sufficient volume that optimized experience.

Nathens evaluated the mortality rates among the 22 states with an existing trauma system. When compared with states without a formal trauma system using a national vital statistics database, a 9% mortality reduction was demonstrated for states with a trauma system. The authors cautioned that the use of mortality data tends to underestimate trauma center effectiveness, while geographic and legislative differences between states may overestimate the mortality benefit of a trauma system. Barquist examined the trauma system in upstate New York. Compared with the early developmental period, there was a significant reduction in the mortality rate for the region during the time following implementation of the system. It was also suggested that functional outcome measures were necessary to support public policy changes.

Rogers studied a single Vermont trauma center compared with 13 community hospitals. Although mortality was shown to be lower at the nontrauma centers than the trauma center, of the more severely injured patients who were expected to die, patients treated at a trauma center had a higher survival rate. Again, the authors discussed the possibility of a higher mortality bias at trauma centers because more seriously injured patients are transferred there. Mann investigated survival among trauma patients over 65 years old during the early development of Washington State's trauma system. No difference was shown in the survival of elderly patients both before and after implementation of the trauma system. However, a 5.1% increase in survival was found for worse injuries among geriatric patients during the later time period. The increased number of comorbidities common among elderly patients likely raised their risk of death.

Abernathy examined Alabama's voluntary regional trauma system. A significant reduction in mortality was shown following implementation of the trauma system. In addition, with the existence of a trauma system there was a reduction in cost of treating the more injured trauma patients. In another Alabama study, Melton examined mortality and the resources available to care for seriously injured patients. The mortality risk was reduced over 3 years that was associated with resource availability. Finally, Reilly examined a regional trauma system in New York City. The odds of mortality were higher for the trauma centers there and the authors discussed how coding inaccuracies and limited resource allocation may have negatively affected outcomes.

Table 2 Qualitative Analysis

Qualitative Scoring Criteria	Points*
Were the objectives of the study defined?	5
Were the outcome measures defined clearly?	5
Was there a clear description of the inclusion and exclusion criteria?	5
All trauma patients included?	5
Comparability of groups (n within 20%)?	5
Comparability of injury (e.g., Injury Severity Score, Abbreviated Trauma Score) within 20%?	5
Any method to attempt comparability?	5
Were the methods of statistical analysis described?	5

*Total: poor, 8–23; average, 24–27; good, 28–30; excellent, 31–40.

Table 3 Trauma Center versus Nontrauma Center Meta-Analysis Studies

Authors	Year of Publication	Study Population	Sample Size (Year)	Data Source	Study Design	Analysis	Adjustments	Injuries	Findings
Kane[25]	1992	California TS 36 NTC 21 L1–3 TC	 505 (1982) 575 (1984)	MR, PRE, AU	Regional Pre vs. Post	Risk-adjusted log odds	Age, HI, UVS, MI, Hypotension	ISS > 15	Survival OR (post) 1.35 (95 % CI, 0.91–1.98)
Hedges[26]	1994	Oregon TS 29 NTC 45 L1–4 TC	 116,995 (1983–87) 32229 (1990–91)	Discharge data	State comparison Pre vs. Post	Risk-adjusted log odds	Age, ISS, HI	All trauma	Mortality OR (post) 0.99 (95% CI, 0.92–1.08)
Mullins[27]	1994	Oregon TS 13 NTC 2 L1 TC	14094 (1984–85) 7238 (1990–91)	Discharge data	Regional Pre vs. Post	Risk-adjusted log odds	Age, age,[2] Gender PC, AIS,	All trauma ISS ≥ 16	Mortality OR (post) 0.94 (95% CI, 0.82–1.07) OR (post) 0.83 (95% CI, 0.70–0.99)
Sampalis[28]	1995	Quebec 3 L1 TC	158 (1987) 288 (1993)	MR	3 Level 1 TC Pre vs. Post	Risk-adjusted log odds	Age, ISS, MI, BR, PT	All trauma ISS > 15	Mortality (Pre) Crude OR 2.10 (95% CI, 1.22–3.62) Adjust OR 3.25 (95% CI, 1.62–6.52)
Mullins[29]	1996	Oregon TS 29 L3–4, NTC 45 L1–2 TC	14694 (1985–87) 13694 (1991–93)	Discharge data	State comparison Pre vs. Post	Risk-adjusted log odds	Age, MI, AIS, PC	HI, CH, SL, PF, FT	Mortality (Post) OR 0.82 (95% CI, 0.73–0.92)
Mullins[30]	1998	Washington NTS Oregon TS	17369 (1990–93) 11879 (1990–93)	Claims data	State comparison TS vs. NTS	Risk-adjusted log odds	Age, Gender, PC, AIS, ISS	HI, CH, SL, PF, B, FT	Mortality (TS) OR 0.80 (95% CI, 0.70–0.91)
O'Keefe[31]	1999	Washington 1 L1 TC	2023 (1986) 3221 (1995)	Trauma registry	Level 1 TC Pre vs. Post	Risk-adjusted log odds	Age, MI, AIS, Year, Transfer	All trauma	Mortality (Post) OR 0.70 (95% CI, 0.52–0.91)
Nathens[32]	2000	28 NTS states 22 TS states & DC	67429 (1995)	NCHS FARS	National TS vs. NTS	Incident rate ratios	None	All injuries	Mortality (presence TS) IRR=0.91 (CI, 0.89–0.92)
Barquist[33]	2000	New York 15 NTC 3 TC	 1676 (1993–1996) 3793 (1993–1996)	Trauma registry	Regional TS vs. NTS	Risk-adjusted log odds	Hospital type, RTS	Blunt Trauma ISS ≥ 9	Mortality (NTS) Early OR 0.50 (95% CI, 0.42–0.61) Late OR 0.30 (955 CI, 0.21–0.42)
Rogers[34]	2001	Vermont TS 13 NTC 1 L1 TC	 10390 (1995–99) 5764 (1995–99)	Discharge data	State comparison TS vs. NTC	Risk-adjusted log odds	Age, ICISS	All trauma	Mortality (TC) OR 1.69 (95% CI, 1.31–2.18)
Mann[35]	2001	Washington TS 73 L1-V TC Age > 65	46424 (1988–92) 30712 (1993–95)	Discharge data	State comparison Pre vs. Post	Adjusted relative risks	Age, Gender, ISS, PC, AIS, Geographic Region	All injuries ISS > 15	Survival (60 days) RR (not reported, ns.) 5.1% increase survival, p=0.03
Abernathy[36]	2002	Alabama 1 L1 TC	1306 (1995–96) 1718 (1997–98)	Trauma registry	Level 1 TC Pre vs. Post	Risk-adjusted log odds	Age, Race, Gender, ISS, B/P, Transfer, Injury Type	HI, CH, SL, PF, FT	Mortality (Post) Crude OR 0.64 (95% CI, 0.46–0.89) Adjust OR 0.48 (95% CI, 0.32–0.71)
Melton[37]	2003	Alabama 7 L1–2 61 L 3–4 26 NTC	not reported (1997–99)	ADPS	State comparison TC counties vs. NTC counties	Adjusted relative risks	Sociodemographic, Prehospital	MVC	Mortality (TC) both signif. Crude RR 0.36 (CI not reported) Adjust RR 0.75 (CI not reported)

Table 3 Continued

Authors	Year of Publication	Study Population	Sample Size (Year)	Data Source	Study Design	Analysis	Adjustments	Injuries	Findings
Reilly[38]	2004	New York 55 NTC 15 L1 TC	53704 (1998–00) 50021 (1998–00)	Discharge data	Regional TS vs. NTS	Risk adjusted log odds	Age, Gender, Severity, TC discharge	All trauma	Mortality (TC) OR 1.84 (95% CI, 1.68–2.01)

For study population: TC, trauma center; TS, trauma system; NTC, nontrauma center; NTS, nontrauma system; [21]excluded ED admissions less than 48 hrs, drowning, smothering, strangulation, choking, hanging, electric shock, asphyxiation, spontaneous pathologic fracture; [22]excluded late effects or foreign bodies; [23]excluded late effects, foreign bodies, and trauma complications; [24]excluded rehabilitation patients; [25]excluded younger than 16 or older than 79, rehabilitation patients, and severe HI discharged within 3 days of admit; [27]excluded ED deaths; [28]excluded suicides, burns, submersion, poisoning, inhalation of toxins; [30]excluded age $>$ 60 isolated hip fractures; [31]excluded late effects, foreign bodies, trauma complications, and rehabilitation patients; [32]excluded late effects, foreign bodies, and trauma complications; [33]excluded burns.

For data source: MR, medical record; PRE, paramedic run sheet; AU, autopsy record; NCHS, National Center for Health Statistics; FARS, Fatality Analysis Reporting System; ADPS, Alabama Department of Public Safety; AHCA, Agency for Health Care Administration.

For study design: Pre, predesignation TC/TS; Post, postdesignation TC/TS.

For adjustments: HI, head injury; UVS, unresponsive to verbal stimuli, MI, mechanism of injury; ISS, injury severity score; PC, preexisting conditions; AIS, abbreviated injury score; BR, body region; PT, penetrating trauma; RTS, revised trauma score; ICISS, international classification of diseases injury severity score; B/P, blunt/penetrating trauma.

For injuries: CH, chest injury; SL, spleen/liver injury; PF, pelvic fracture; FT, femur/tibia fracture; B, burn; MVC, motor vehicle crash; SF, skull fracture; VASC, vascular injury; SCI, spinal cord injury.

For findings: OR, odds ratio; IRR, incident rate ratio; RR, relative risk ratio; CI, confidence interval.

Meta-analysis

Six of these reports met all the criteria for inclusion in the meta-analysis to evaluate trauma system performance. Table 4 shows the odds ratios and confidence intervals of the six studies as well as the fixed and random effects. Odds ratios <1 favor postdesignation trauma systems. Two of the studies were statistically significant, showing lower odds postdesignation, whereas four studies showed lower—albeit nonsignificant—odds of mortality.

For the estimate of the overall effect, first the test for heterogeneity revealed that the studies come from different populations. The test was significant ($p = 0.03$). The studies' population characteristics were statistically different among the different studies. Therefore, a fixed effects model to compute the effect size may be invalid. A random effects model that allows the studies to have different characteristics and effects was used to calculate the random effects statistic. Overall crude odds ratio without adjustment was 0.881 (95% CI, 0.778–0.998). The effect size was statistically significant.

The qualitative analysis produced a range of scores between 18 and 33. One study design was rated poor, two were rated as average, two were rated good, and one was excellent. Figure 1 shows the six studies in the meta-analysis plotted by qualitative score verses crude odds ratio for mortality. The overall quality-weighted odds ratio was 0.85 lower mortality following trauma system implementation versus beforehand.

DISCUSSION

The results of the meta-analysis showed a 15% reduction in mortality in favor of the presence of a trauma system. Large, population-based studies confirm that regionalized trauma systems ultimately save lives. This finding was consistent with the 1999 Skamania Conference on trauma system efficiency that concluded there was a 15% to 20% reduction in mortality risk where trauma systems outperformed nontrauma hospitals.[40] Thus, there should be a concerted effort to direct the severely injured to trauma centers. Although prediction of individual survival remains the focus of trauma center effectiveness, greater emphasis on systems assessment should not be overlooked.[41]

The success of a trauma system requires the commitment of hospital resources dedicated to the mission of trauma.[42] Many trauma centers that were created are no longer in existence due to financial and other reasons. Those that remained viable have witnessed improvement in the care of the severely injured. Emphasis on field triage and shortened arrival times has lead to better patient outcomes over time.[43] Patient survival also improved with greater efficiency in the process of managing trauma patients once at the hospital.[44] Reduced intensive care unit and hospital lengths of stay were achieved with more experience. Mann et al.[35] suggested that a trauma system goes through a transitional period that may take up to 10 years to truly stabilize.

Evaluation methods of trauma system performance needed to evolve along with trauma system maturation. Early

Table 4 Meta-analysis

Study	Postdesignation	Predesignation	Odds	95%	CI
Kane[26]	207/766	191/658	0.905	0.718	1.142
Mullins[27]	284/7236	182/4230	0.909	0.751	1.099
Sampalis[28]	30/288	31/158	0.476	0.276	0.822
Mullins[29]	611/10803	568/9893	0.984	0.875	1.107
Mullins[30]	666/11879	766/13129	0.959	0.861	1.067
Abernathy[36]	65/1718	77/1306	0.628	0.447	0.880
Total (fixed effects)	1863/32690	1815/29374	0.930	0.869	0.995
Total (random effects)	1863/32690	1815/29374	0.881	0.778	0.998

Test for heterogeneity: $Q = 12.2856$, $DF = 5$, $p = 0.0311$.

published population-based reports relied primarily on mortality rates that did not account for demographic information or injury severity. The evaluation of a trauma system based on an event that rarely occurs presents as a significant challenge. In large population studies, the use of mortality as an indicator of efficacy can dilute the true measure of performance in the process of caring for severely injured patients. A further limitation of the population-based studies is that few accounted for physiologic effects on the outcome of severely injured patients. With multivariate statistics that allow for better control of patient and injury differences, population-based studies can offer the best evidence of trauma system effectiveness.

Beyond mortality are process issues, functional return, and cost savings that may provide better benchmarks of trauma system performance. Process issues such as complication rates, delays in treatment, or management of comorbidity are important areas for investigation.[45] Functional return may be used as a measure of the impact of severe injury. Although the majority of trauma patients have physical limitations that lasted less than 1 year,[46] 44% of full-time employees had not returned to work 1 year after their injury.[47] Still, even temporary impairment can negatively effect a person's present quality of life.[48] Finally, although the higher cost of caring for the average trauma patient in a trauma center was higher than a nontrauma hospital, the marginal cost per life saved was recovered over the expected remaining years of survival for an individual.[49]

CONCLUSIONS

A systematic review of the trauma literature over the last 40 years documenting the establishment and maturation of trauma systems across North America has revealed a 15% lowered mortality compared to pretrauma system existence. As outcome research continues into the new century, this should be considered a benchmark for all trauma centers to achieve. The next logical step in the process of trauma system evaluation is to establish measures that consistently capture true outcome performance. Evaluation of trauma system effectiveness will require ongoing

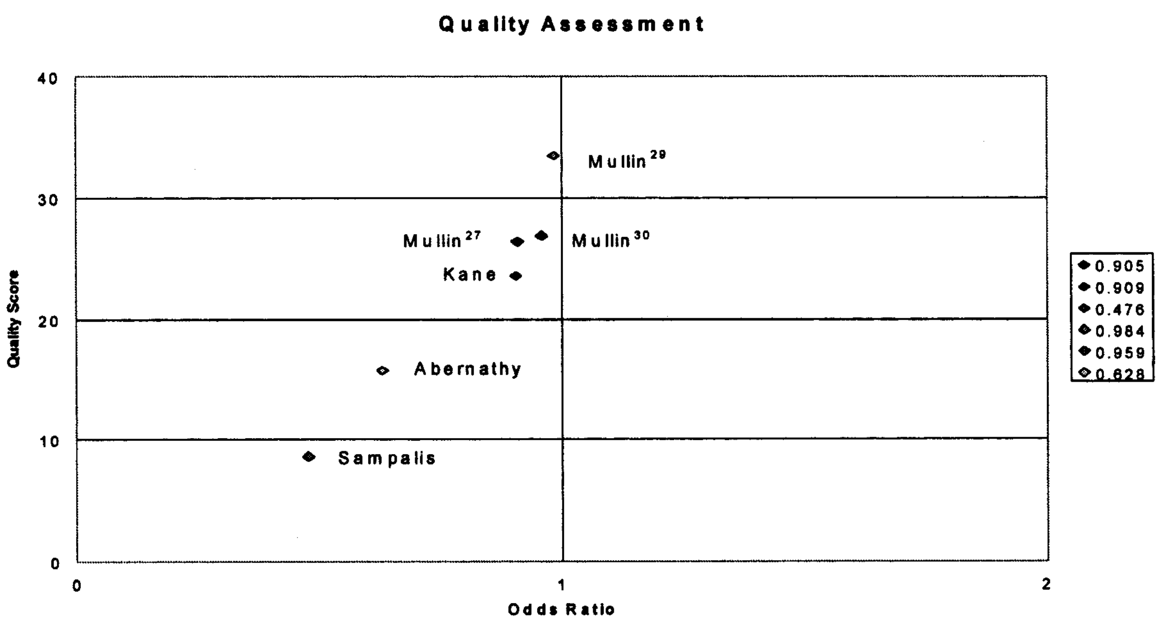

Fig. 1. *Qualitative assessment versus crude odds ratio. Odds ratios >1 indicate that posttrauma center existence increases the chance of mortality.*

outcome analysis in what must remain an uncompromising commitment to optimal outcome for the injured patient.

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EDITORIAL COMMENT

Dr. Celso and his group from Florida present a rigorously performed and important meta-analysis examining the effect of establishment of a trauma system on outcome for severely injured patients. They also present a thorough review of the history of trauma system implementation and its scientific evaluation. This study demonstrates a 15% reduction in mortality following establishment of trauma systems using all available North American population-based studies. This analysis adds further strength to the growing body of knowledge regarding trauma system effectiveness in reducing mortality after injury.

Regionalized trauma systems save lives. We should now turn our efforts to examining outcomes other than death when evaluating trauma systems. Outcomes that should be assessed in the future include: quality of life, functional outcome, and other morbidity outcome measures. Surviving initial injury is only the first step in a successful outcome following trauma. Regionalized trauma systems have been shown to not only positively impact on the survival of injured patients, but also on their quality of life.[1]

The global care of the injured patient consists of the management of the patient from the time of injury, until the return to normal activities of daily living.[2] Injury significantly impacts on both the functional status and quality of life of patients and their families. These effects occur not only in the short-term, but also for months, years, or possibly life, following the initial event.[3]

The authors conclude that the next logical step in the process of trauma system evaluation is to establish measures that consistently capture true outcome performance. Although we agree that this is important in the continuous re-evaluation of the quality of care in established trauma systems, we believe that the positive impact on regionalized trauma systems has been definitely established. The goal should now turn to examining ways in which to improve, not only the outcomes of established systems, but also their efficiency. It is also vital to identify ways in which to decrease costs within these systems. The manner in which we and others have chosen to try and improve efficiency of the system is to examine the components that go into running a system and their effect on outcome.[4–7] This will hopefully enable the design of cost-efficient, regionally-based, tailor-made trauma systems for the future.

Trauma care has come a long way since the first and landmark study critically evaluating civilian regionalized trauma care published by West, Trunkey, and Lim in 1979.[8,9] This remarkable and original study was responsible for a new field of healthcare and health services research. Over the past 30 years, many authors, including Celso et al., have refined and reconfirmed the findings of this original and pivotal paper. They provide the foundation for further study and innovation over the next 30 years.

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