

Effects of a Rural Trauma System on Traumatic Brain Injuries

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ABSTRACT

The response of trauma systems in rural areas is uncertain since distances between injury scenes and trauma care are considerable. Timely arrival at definitive care is critical for persons with traumatic brain injury (TBI) since secondary damage can occur during the hours following injury. We evaluated how the implementation of a trauma system in a predominately rural state affected the triage of TBI patients and their risk for mortality. The Iowa System Trauma Registry Dataset was analyzed, and included patients evaluated before trauma system implementation, 1997–1998, and after implementation, 2002–2003. Patients were identified using ICD9-CM codes or AIS codes, and included 710 pre-system patients and 886 post-system patients. Multivariate logistic regression assessed the effect of the trauma system on survival while controlling for confounders. Following implementation of the trauma system, patients treated in Level I or II facilities were older ($p = 0.019$), more often had multiple injuries ($p = 0.0002$), and had more severe TBI ($p = 0.008$). After controlling for confounders, transferred patients and those directly admitted were less likely to die in 72 h in the post-system than the pre-system (odds ratio [OR] = 0.56, 95% confidence interval (CI) = 0.36, 0.88; OR = 0.50, 95% CI = 0.32, 0.79). Implementation of the Iowa trauma system seems to have led to more appropriate triage and transport for TBI patients, and this likely contributed to reduced in-hospital mortality.

Key words: brain injuries; emergency medical services; rural hospitals

INTRODUCTION

THE DEVELOPMENT of U.S. trauma systems originated from the American military experience in both the Korean and Vietnam wars, and has grown to include over 1,000 designated trauma centers nationwide (Nathens et al., 2004). U.S. trauma systems were designed to transport the injured to medical facilities where appropriate care is available; therefore, trauma systems are most successful in large metropolitan cities where the number and

quality of acute care facilities is plentiful (Mullins et al., 1994). Their success in rural areas is highly debated (Rogers et al., 1999a,b; Mullins et al., 2002; Clay et al., 2001; Mullins and Mann, 1999).

Rural areas present challenges to the development and success of trauma systems. There are normally long distances and times between specialized care facilities and the injury scene. Also, the number and distribution of these facilities are not advantageous to the injured patient, especially to those patients with a traumatic brain

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injury (TBI) (Young et al., 2003). Timely arrival at definitive care is critical for persons with TBI since secondary damage can occur during the hours following an injury event (Marion, 1999).

In 1995, the Iowa Trauma System Development Act implemented a state-wide inclusive trauma system (Iowa Department of Public Health, www.idph.state.ia.us/ems/trauma.asp). On January 1, 2001, the system was fully implemented state-wide with the overall goals of reducing injury deaths, improving patient outcomes, and reducing medical care costs for injuries (Young et al., 2003). Features of the system included categorization and verification of each hospital, minimal ATLS training, definition of triage protocol, and uniform data definition and collection. Included in the state-wide system were two Level I facilities, i.e., Iowa Resource Level, seven Level II facilities, i.e., Iowa Regional Level, and over 100 area and community hospitals spread throughout the 99 counties of the state of Iowa. These Level I and II hospitals were required to have specialty coverage, including neurosurgery for traumatic injuries.

The main objective of this study is to examine how the implementation of the trauma system affected the triage and in-hospital mortality of TBI patients. While a more serious injury profile in the post-system years would indicate trauma system success in delivering sicker patients to the appropriate facilities, the effect on mortality is unclear. Additionally, we hypothesize a stronger effect of the trauma system on patients transferred from one facility to another versus non-transferred patients due to the triage and transfer protocols defined by the trauma system.

METHODS

Study Design and Participating Hospitals

A retrospective analysis of an injured cohort was used to assess TBI survival before and after the implementation of the trauma system. Two years of data prior to implementation of the trauma system, 1997–1998, were compared to 2 years after full implementation, 2002–2003. Overall, a total of 14,768 patients were included in the registry in the pre-system years, and 13,995 were seen in the post-system years (Fig. 1).

All data was obtained from the State Trauma Registry (STR) (Bureau of Emergency Medical Services, Iowa Department of Public Health, 2005). This data was compiled by the trauma system coordinator from the Iowa Department of Public Health (IDPH) using aggregated data from each trauma registry hospital. Patient demographics, injury characteristics, and outcomes were collected using pre-specified definitions by trained trauma nurse coordinators at each site using Trauma! software in 1997 and 1998, and COLLECTOR software in 2002 and 2003 (COLLECTOR, 2001; System Trauma Registry, 1986). All data was converted so that it was compatible with COLLECTOR software; therefore, data definitions did not change over time. Changes in the data collection software meant incomplete data was collected between 1999 and 2001, so these years were excluded.

Included in the STR dataset are all those patients who died in the emergency department (ED), all transfers to a trauma registry hospital, all readmissions to the ED at 72 h after the initial discharge, and all patients admitted to the hospital for at least 24 h through the ED (Iowa Depart-

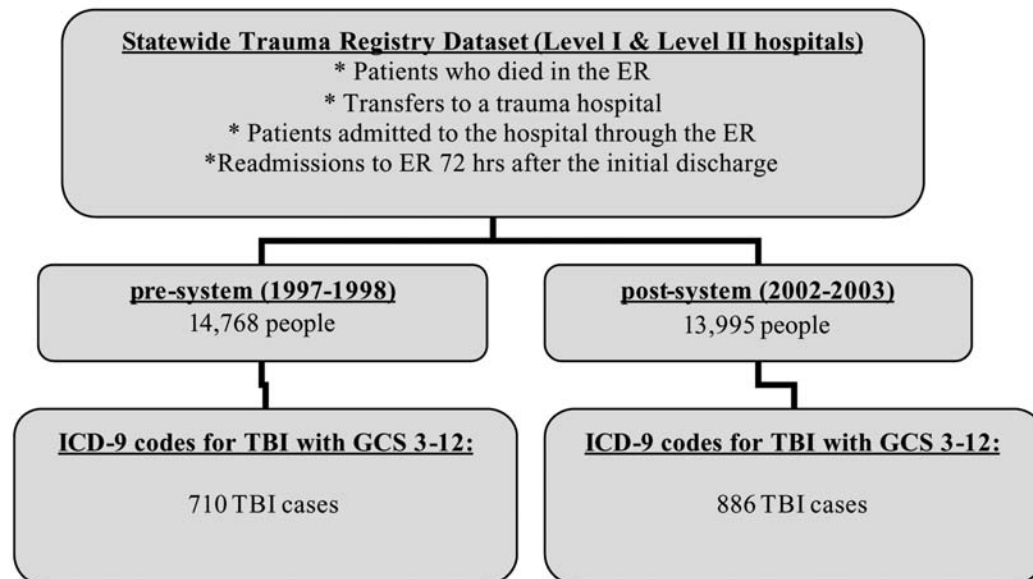


FIG. 1. Flowchart of patient population and cohort used in analysis.

ment of Public Health, 2005). This analysis was restricted to data from the two Level I and seven Level II hospitals participating in the STR (Fig. 1). These hospitals had neurosurgical coverage during the time period of the study.

Patient Population

The subjects in this study were patients with a TBI, retrospectively identified from the database using either ICD9-CM codes or Abbreviated Injury Scale (AIS) codes listed anywhere in the available 12 diagnosis codes. ICD-9CM codes included were as follows: 800–801.99, 803–804.99, and 850–854.19. AIS codes included were as follows: 115099.9, 113000.6, 115299.9, 116002.3, 116004.5, 120202.5–122899.3, 140202.5–140799.3, 150000.2–150408.4, and 160202.2–161000.2. This included 710 TBI patients in the pre-system years and 886 TBI patients in the post-system years (Fig. 1).

TBI severity was assessed using the Glasgow Coma Scale (GCS) score measured in the ED (www.trauma.org/archive/scores/gcs.html). According to this measurement, GCS scores of 13–15 define mild head injury; of 9–12 moderate head injury; and of 3–8 severe head injury. The overall severity of the injury was assessed using the Injury Severity Score (ISS) and the AIS (Baker et al., 1974; AAAM, 1990). The AIS indicates threat to life, and ranges from 1 to 6, with 6 as non-survivable injury (1990). ISS scores were calculated by summing the squares of AIS scores of the most severe injuries in up to three body regions (Baker et al., 1974). The ISS takes on values from 1 to 75, with higher numbers representing more severely injured patients (Baker et al., 1974). This analysis was restricted to those with a moderate, GCS 9–12, or severe, GCS 3–8, head injury (Fig. 1).

Definition of Variables

The major outcomes considered were mortality in the ED, mortality within 72 hours, mortality within 30 days, and mortality during hospitalization. Length of stay (LOS) and disposition were also examined. The independent variable was the pre-system period (1997–1998) or post-system (2002–2003), defined as a dichotomous variable. Covariates considered in the analysis included patient demographics such as gender, race (white and other), and age (continuous). Also included were injury descriptives such as external cause of injury, multiple injury (yes/no), injury severity (ISS, AIS, GCS), and type of TBI (blunt versus penetrating). Blood alcohol measure (positive yes or no) and arrival in the ED (ambulance, helicopter, personal vehicle, or other) were also included. Finally, the amount of time, in hours, from the injury to definitive care was examined, as well as the number of miles traveled to definitive care.

A risk of death variable was composed from ISS values and physiologic criteria, and was categorized into high, moderate, and low. Those with a high risk of death had either an ISS greater than 41, a probability of survival less than 20%, or abnormal physiologic criteria. Those with a moderate risk of death had either an ISS of 16–41 or a probability of survival of 20–49%. Those with a low risk of death had either an ISS less than 16, a probability of survival greater than 49%, or physiological criteria within the normal range.

Finally, analyses were stratified by whether the patient was a transfer from a lower level trauma hospital or community hospital ($n = 678$) or a non-transfer ($n = 744$). However, by doing so, 174 TBI patients were excluded from the analysis since they were not classifiable as transfer or non-transfer (42 from pre-system years and 132 from the post-system years).

Statistical Analysis

Characteristics of the TBI patients were measured using descriptive statistics such as proportions, means, and standard deviations, and compared between the pre- and post-system years using Pearson chi-square tests for categorical data and *t*-tests for continuous variables. This analysis was stratified by transfer status (transfer and non-transfer).

The effect of the trauma system on mortality and discharge outcomes was compared between the pre- and post-system years. Outcomes considered included death in the emergency department (ED), death in 72 h, death in 30 days, death anytime in the hospital, discharge disposition, and length of stay (LOS). Proportions were compared between the pre- and post-trauma system years using Pearson chi-square tests. This analysis was also stratified by transfer status (transfer and non-transfer).

Multivariate logistic regression was used to assess the implementation of the trauma system on the 72-h survival of TBI patients while adjusting for the potential confounding variables of age, ISS, GCS, type of injury, risk of death, race, and gender. Multicollinearity and model fit were assessed using the approach of Hosmer and Lemeshow (1989). Models were run separately for transfers and non-transfers. All analyses were performed with SAS, version 9.1 (SAS Institute, Cary, NC).

RESULTS

Characteristics of TBI Patients Pre- and Post-System

The total number of TBI patients treated in Level I or II hospitals increased 20% from the pre-system years ($n = 710$) to the post-system years ($n = 886$). There were

few differences in the demographics of the TBI patients between the pre- and post-system years; though patients in the post-system years were 2.8 years older on average ($p = 0.019$; Table 1). In the post-system years, TBI patients were more likely to have arrived in the ED by ambulance ($p = 0.003$), have multiple injuries ($p = 0.0002$), and have a more serious TBI as measured by GCS ($p = 0.008$).

Demographics and Injury Characteristics between Transfers and Non-Transfers

Implementation of the trauma system also resulted in a significant increase in the percentage of TBI patients that were transfers. Transfers comprised 45% ($n = 299$) of the pre-system patients and 50% ($n = 379$) of the post-system patients ($p = 0.04$). Characteristics between transfers and non-transfers were examined by the pre- and post-system periods (Table 2). Transfers had significantly higher ISS scores ($p = 0.0004$) and significantly lower GCS scores ($p < 0.0001$) in the post-system than the pre-system years, indicating an increase in injury severity from the pre- to the post-system years. However, non-transfers had no significant increases in either the overall injury severity or in the severity of the TBI from the pre- to the post-system years ($p = 0.193$, $p = 0.177$, respectively).

Transport time to the Level I or Level II hospital for patients that were transferred decreased from the pre-system years (average 174 min) to the post-system years (average 162 min, $p = 0.25$). For non-transfers, transport time to the trauma hospital increased ($p = 0.07$; average 40 min pre and 48 min post). Transfers came from approximately the same distance away between the pre- and

post-system years ($p = 0.546$). However, a greater percentage of non-transfers came from over 25 miles away in the post-system years, though this difference was not significant ($p = 0.253$).

Univariate Analysis: Mortality and Other Outcomes

Overall, 30% of TBI patients died in 72 h in the pre-system years and 25% died in 72 h in the post-system years (data not shown). Mortality outcomes (death in ER, death in 72 h, death in 30 days, and death in the hospital) were compared between the transfers and non-transfers (Table 3). While there were no significant trends for mortality outcomes within transfers, the risk of dying in the ED decreased slightly from the pre- to the post-system years ($p = 0.057$). Non-transfers had a significant decreased risk of death in 72 h in the post-system years ($p = 0.006$) and a significant decreased risk for overall death in the hospital ($p = 0.029$) in the post-system years.

Comparing mortality in 72 h by the severity of the TBI showed similar trends between transfers and non-transfers (Table 3). Regardless of transfer status, the most severe TBI patients (GCS of 3–5) experienced a significant decrease in mortality within 72 h after trauma system implementation (decrease of transfers from 42% to 29%, $p = 0.007$; decrease of non-transfers from 65% to 42%, $p < 0.0001$). No significant trends for 72-h mortality were found in those TBI patients with a GCS of 6–8.

Thirty-three percent and 27% of the transfers were discharged to home in the pre- and post-system periods, respectively ($p = 0.12$). Non-transferred patients were discharged to home 22% of the time in the pre-system years and 31% of the time in the post-system years ($p = 0.04$).

TABLE 1. DEMOGRAPHIC AND INJURY CHARACTERISTICS OF 710 PRE-TRAUMA SYSTEM TBI PATIENTS AND 886 POST-TRAUMA SYSTEM TBI PATIENTS

Variable	Pre-trauma system (1997–1998), n = 710	Post-trauma system (2002–2003), n = 886	p-value
Demographics			
Mean age (SD)	35.0 (23.2)	37.8 (23.9)	0.019
Male (%)	499 (70%)	623 (70%)	0.99
Caucasian race (%)	642 (90%)	779 (88%)	0.11
Injury characteristics			
Mean ISS (SD)	25.2 (13.9)	26.0 (13.1)	0.23
Mean GCS in ED (SD)	6.0 (3.1)	5.6 (3.1)	0.008
Motor-vehicle accident (%)	437 (62%)	510 (58%)	0.11
Multiple injuries (%)	826 (88%)	828 (94%)	0.0002
Arrived in ED by ambulance	260 (37%)	471 (53%)	0.003
Positive blood alcohol test (%)	183 (26%)	260 (29%)	0.35

TBI, traumatic brain injury; ISS, Injury Severity Score; GCS, Glasgow Coma Scale; ED, Emergency Department; SD, standard deviation.

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TABLE 2. DIFFERENCES BETWEEN TRANSFERS AND NON-TRANSFERS BY PRE- AND POST-TRAUMA PERIOD

Variable	Transfers			Non-transfers		
	Pre-trauma system (n = 299)	Post-trauma system (n = 379)	p-value	Pre-trauma system (n = 369)	Post-trauma system (n = 375)	p-value
Injury characteristics						
Mean ISS (SD)	23.3 (12.5)	27.2 (11.9)	0.0004	27.7 (14.8)	26.3 (15.2)	0.193
Mean GCS (SD)	6.0 (3.0)	5.2 (2.8)	<0.0001	6.8 (3.0)	5.5 (3.3)	0.177
Time and distance						
Median time (in hrs) from injury to arrival at trauma hospital (SD)	2.9 (4.9)	2.7 (6.1)	0.25 ^a	0.67 (4.2)	0.80 (14.6)	0.07 ^a
No. (%) arriving from less than 10 miles away				185 (53%)	170 (50%)	0.253
No. (%) arriving from 13–25 miles away				99 (29%)	90 (27%)	
No. (%) arriving from greater than 25 miles away				64 (18%)	80 (24%)	
No. (%) arriving from less than 50 miles away	59 (30%)	52 (26%)	0.546			
No. (%) arriving from 50–75 miles away	78 (40%)	80 (40%)				
No. (%) arriving from greater than 75 miles away	57 (30%)	67 (34%)				

^ap-value from median two-sample test.

ISS, Injury Severity Score; GCS, Glasgow Coma Scale; SD, standard deviation.

There were no significant differences in the length of stay (LOS) between the pre- and post-system periods for the transfers ($p = 0.996$); however, non-transfers had a significant decrease in the mean LOS of TBI patients ($p = 0.009$).

Survival curves were calculated for the transferred TBI patients and non-transferred TBI patients, and compared between the pre- and post-system years (Fig. 2). The estimated 30-day mortality rate was 26% for transferred pa-

TABLE 3. UNADJUSTED COMPARISON OF OUTCOMES STRATIFIED BY TRANSFER STATUS

	Transfers (n = 678)			Non-transfers (n = 744)		
	Pre (n = 295)	Post (n = 379)	p-value	Pre (n = 369)	Post (n = 375)	p-value
Mortality outcomes						
Death in ER	12 (4%)	6 (2%)	0.057 ^a	63 (17%)	53 (14%)	0.269
Mortality in 72 h	66 (22%)	77 (20%)	0.578	140 (38%)	107 (29%)	0.006
Death in 30 days	77 (28%)	104 (28%)	0.936	90 (33%)	126 (34%)	0.32
Death in hospital	91 (30%)	105 (28%)	0.449	155 (42%)	128 (37%)	0.029
Mortality by TBI severity						
No. (%) died in 72 h with GCS 3–75	61 (42%)	66 (29%)	0.007	125 (65%)	96 (42%)	<0.0001
No. (%) died in 72 h with a GCS 6–8	5 (6%)	10 (11%)	0.264 ^a	12 (13%)	7 (11%)	0.746 ^a
Discharge disposition and LOS						
No. (%) discharged to home	100 (33%)	103 (27%)	0.121	82 (22%)	115 (31%)	0.044
Mean LOS (SD)	12.7 (18.1%)	12.7 (14.5%)	0.996	11.4 (15.7)	8.8 (12.3)	0.009

^aFisher's exact test.

ER, Emergency room; TBI, traumatic brain injury; GCS, Glasgow Coma Scale; LOS, length of stay; SD, standard deviation.

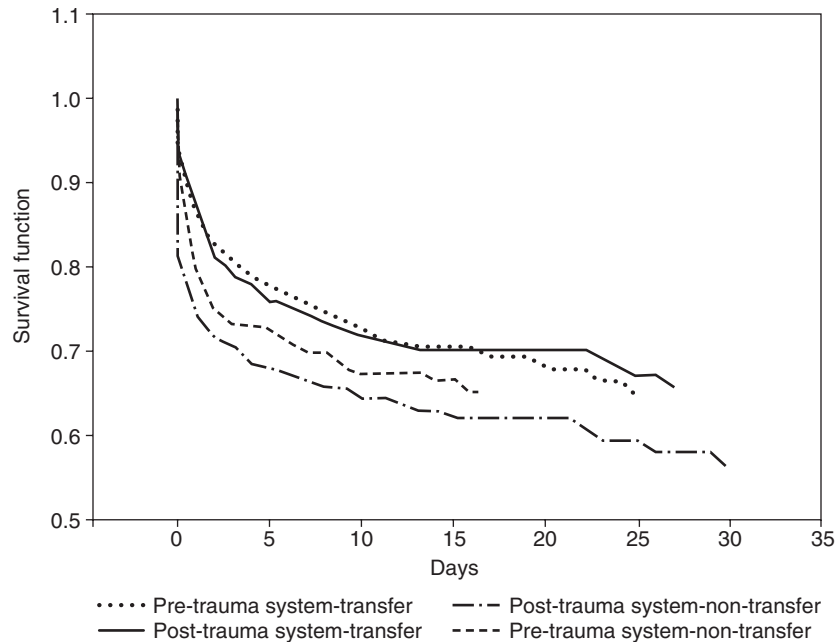


FIG. 2. Unadjusted survival curves for time until death or discharge between time periods, stratified by transfer status.

tients, pre-system, and 27% in the post-system years. For non-transferred TBI patients, the mortality rate was 24% and 34%, respectively. For transferred TBI patients, the log-rank test was not significant ($p = 0.75$), and for non-transferred patients, the test was significant ($p = 0.0011$).

Multivariate Analysis

To investigate the effects of possible confounding variables on the risk of mortality in 72 h from a TBI, a multivariate logistic regression analysis was performed (Table 4). The final model was chosen by entering all variables significant in the bivariate analysis in a full

model and using likelihood ratio tests to choose the best overall model. Models were run independently for transfers and non-transfers. For both transfers and non-transfers, the risk of mortality in 72 h significantly decreased in the post-system years after controlling for injury severity, GCS, age, type of injury, risk of death, and race. For transfers, the risk of mortality in 72 h decreased 44% (odds ratio [OR] = 0.56; 95% confidence interval [CI] = 0.36, 0.88) and for non-transfers, the risk of mortality in 72 hours decreased 50% (OR = 0.50; 95% CI = 0.32, 0.79).

A similar analysis was performed on death in the hospital with consistent results (Table 5). For both transfers

TABLE 4. FACTORS PREDICTING DEATH WITHIN 72 HOURS, BY TRANSFER STATUS, IOWA STATEWIDE TRAUMA REGISTRY, 1997–1998 AND 2002–2003

Variable	Transfers (n = 678), OR (95% CI)	Non-transfers (n = 744), OR (95% CI)
Pre trauma system vs. post trauma system	0.56 (0.36, 0.88)	0.50 (0.32, 0.79)
ISS	1.00 (0.97, 1.02)	1.02 (1.00, 1.03)
Age	1.02 (1.01, 1.03)	1.02 (1.00, 1.03)
GCS taken in ED	0.65 (0.57, 0.74)	0.64 (0.54, 0.75)
GCS taken pre-hospital	—	0.83 (0.74, 0.93)
Blunt/penetrating injury (penetrating = 1)	4.18 (1.71, 10.26)	—
Medium risk versus low risk	2.36 (1.38, 4.11)	2.98 (1.49, 5.96)
High risk versus low risk	38.3 (4.63, 312.5)	8.61 (1.77, 41.67)
Other race versus white race	2.43 (1.21, 4.88)	—

ISS, Injury Severity Score; GCS, Glasgow Coma Scale; ED, Emergency Department; OR, odds ratio; CI, confidence interval.

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TABLE 5. FACTORS PREDICTING DEATH IN HOSPITAL, BY TRANSFER STATUS, IOWA STATEWIDE TRAUMA REGISTRY, 1997–1998 AND 2002–2003

<i>Variable</i>	<i>Transfers (n = 678), OR (95% CI)</i>	<i>Non-transfers (n = 744), OR (95% CI)</i>
Pre trauma system vs. post trauma system	0.51 (0.34, 0.78)	0.54 (0.35, 0.86)
ISS	1.00 (0.99, 1.03)	1.02 (1.00, 1.04)
Age	1.03 (1.02, 1.04)	1.03 (1.01, 1.04)
GCS taken in ED	0.74 (0.68, 0.81)	0.65 (0.56, 0.75)
GCS taken pre-hospital	—	0.85 (0.77, 0.94)
Blunt/penetrating injury (penetrating = 1)	3.30 (1.39, 7.83)	—
Medium risk versus low risk	2.93 (1.34, 4.95)	2.66 (1.38, 5.15)
High risk versus low risk	17.86 (4.56, 69.9)	7.62 (1.91, 30.30)
Other race versus white race	2.44 (1.23, 4.88)	—

ISS, Injury Severity Score; GCS, Glasgow Coma Scale; ED, Emergency Department; OR, odds ratio; CI, confidence interval.

and non-transfers, the risk of mortality significantly decreased in the post-system years after controlling for injury severity, GCS, age, type of injury, risk of death, and race. For transfers, the risk of mortality decreased 49% (OR = 0.51, 95% CI = 0.34, 0.78), and for non-transfers, the risk of mortality decreased 46% (OR = 0.54, 95% CI = 0.35, 0.86).

DISCUSSION

We measured the effects of an inclusive rural trauma system on both the triage and mortality of patients with moderate and severe TBI. We found that the injury profile of TBI patients in the post-system years significantly shifted to that of a more serious nature. Implementation of the trauma system was associated with a significant decreased risk of death overall, and within 72 h, regardless of the transfer status of the TBI patient. This decreased risk for death remained after controlling for important confounders such as injury severity.

The Iowa Trauma System was successful in getting the more severely injured patients to Level I and II hospitals, where optimal care is immediately available. We found a significant increase in the number of patients that were transferred from a local or community hospital to a trauma hospital in the post-system years. We also found a significant increase in the percentage of patients with severe TBI presenting to the Level I and II hospitals in the post-system years. Finally, for TBI patients that were transferred from a local or community hospital, they had significantly higher average ISS scores and lower GCS scores in the post-system years. No significant differences in injury severity were found for non-transferred TBI patients.

We also found that, in the pre-system years compared to the post-system years, non-transfers traveled a further

distance to arrive at a Level I or II hospital. Additionally, in the post-system years, these patients took, on average, 13 min longer to arrive at the trauma hospital. For those transferred patients, there were no significant differences in the miles traveled to arrive at definitive care between the pre-system years and post-system years. Transferred TBI patients experienced a decrease in the amount of time from injury to arrival at the trauma hospital in the post-system years. While it is unclear if these minor differences in time and distance traveled impacted the TBI patients' mortality outcomes, it further demonstrates why pre-hospital care of the severely injured in rural areas is a highly debated topic (Lewis, 2004).

Studies in predominately rural areas demonstrate that stabilization at outlying hospitals before transfer to higher level trauma centers does not adversely affect injury mortality (Rogers et al., 1999a,b; Certo et al., 1983; Kearney et al., 1991). One study found that patients transferred from rural outlying hospitals had the same mortality rate as those admitted directly to the trauma hospital (Certo et al., 1983). Yet, other studies in more urban settings have found that those with severe head injuries should be admitted directly to a Level I trauma center and not be transferred by local hospitals (Wright et al., 1996). It is unknown if a patient injured in a rural area should be stabilized at the nearest medical facility and then transported to a higher level trauma center, or be transported directly from the scene to such a site for definitive care (Grossman et al., 1995).

While current consensus TBI guidelines recommend rapid transport to trauma care centers with imaging and treatment capabilities, some researchers believe it does not result in reductions in mortality in rural areas, possibly due to the longer distances from the injury scene to a trauma care center (Chestnut et al., 1993; Bullock et al., 1996). We believe the reason why non-transferred TBI patients traveled further and took longer to get to

trauma care in the post-system years was due to emergency medical transport providers taking brain-injured patients directly to the highest level trauma hospitals, regardless of the location of local hospitals in the post-system years. However, this practice did not have an impact on the risk for mortality in non-transferred patients.

Further research is needed to clarify these questions in relation to pre-hospital treatment for rural TBI patients. We believe these findings support the use of rural lower-level hospitals in the intermediate care and stabilization of severely injured patients, including TBI patients. We hope to further explore this hypothesis in future work by evaluating the relationships between distance, time, and processes of care, such as head CT scans, in the local and community hospitals.

There are several limitations to this study. First, this was a longitudinal study comparing the pre- and post-trauma system period rather than a simultaneous comparison of systems. Second, the data analysis was limited by the availability and completeness of data elements, particularly in the pre-trauma system period. Third, the major outcome evaluated here was mortality and while this is an essential outcome, other outcomes such as morbidity or functional status after discharge are also important to consider. Fourth, our findings could be explained by a patient selection effect such that a higher percentage of patients from the more distant regions of the state died before transfer was initiated; therefore elevating the percentage of deaths in the directly admitted group (Sollid et al., 2003). Finally, the analysis was dependent upon trauma registry data which only included trauma system patients from Level I and Level II hospitals in the state of Iowa. Several papers have discussed the possible biases associated with studies based on trauma registry data (Payne and Waller, 1989; Waller, 1988).

A strength of this study is the comprehensive nature of a single trauma system throughout the state of Iowa. Trauma triage and transfer protocols and ATLS training were performed in all hospitals, regardless of trauma status (ACS, 1999). Also, the study utilizes a standardized database with the uniform data definitions used between both time periods and data recording of these elements consistently performed by trained trauma nurse coordinators. Finally, all hospitals in the state of Iowa with neurosurgical coverage were included in this analysis (Esposito et al., 2005).

Implementation of the Iowa trauma system was successful and had a major influence on the triage and transfer of TBI patients. Furthermore, the trauma system reduced the risk of death for both transferred and non-transferred TBI patients. We believe these findings support the use of rural lower-level hospitals in the intermediate care and stabilization of TBI patients. As more

rural states develop trauma systems, the role of the community hospital as an opportunity for stabilization and appropriate transfer remains controversial (Grossman et al., 1995).

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