Hospital Characteristics Associated with Trauma Outcomes

Stephen M. Bowman

A dissertation
submitted in partial fulfillment of the
requirements for the degree of

Doctor of Philosophy

University of Washington

2006

Program Authorized to Offer Degree:
Public Health and Community Medicine - Health Services

University of Washington
Graduate School

This is to certify that I have examined this copy of a doctoral dissertation by

Stephen M. Bowman

and have found that it is complete and satisfactory in all respects,
and that any and all revisions required by the final
examining committee have been made.

Chair of the Supervisory Committee:

Diane P. Martin

Reading Committee:

Margaret W. Baker

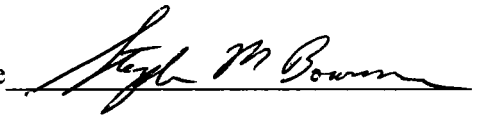
Diane P. Martin

Sam R. Sharar

Frederick J. Zimmerman

Date: 5-11-2006

In presenting this dissertation in partial fulfillment of the requirements for the doctoral degree at the University of Washington, I agree that the Library shall makes its copies freely available for inspection. I further agree that extensive copying of the dissertation is allowable only for scholarly purposes, consistent with "fair use" as prescribed in the U.S. Copyright Law. Requests for copying or reproduction of this dissertation may be referred to ProQuest Information and Learning, 300 North Zeeb Road, Ann Arbor, MI 48106-1346, 1-800-521-0600, to whom the author has granted "the right to reproduce and sell (a) copies of the manuscript in microform and/or (b) printed copies of the manuscript made from microform."

Signature 

Date 5-16-2006

University of Washington

Abstract

Hospital Characteristics Associated with Trauma Outcomes

Stephen M. Bowman

Chair of the Supervisory Committee:
Professor Diane P. Martin
Department of Health Services

Trauma is the leading cause of death among Americans younger than 45 years. Regional and state trauma care systems have been developed to reduce the mortality attributable to severe injuries. Trauma care systems can reduce the preventable trauma death rate by as much as 30% for patients who reach the hospital alive. While trauma system evaluations typically assess overall trauma care between states with and without organized trauma systems, minimal attention has been given to the components that may account for observed differences.

This dissertation examined trauma systems by focusing on three specific aims: 1) to evaluate the hospital characteristics associated with pediatric splenic injury management practices (splenectomy vs. spleen-conserving practice), 2) to examine the association between race/ethnicity and in-hospital mortality in patients with moderate to severe traumatic brain injury (TBI) and utilization of post-acute rehabilitation services for survivors of severe TBI, and 3) to examine rural trauma care and the impact of hospital trauma designation on in-hospital mortality and likelihood of transfer after admission.

Secondary data from the Healthcare Cost and Utilization Project (Kid's Inpatient Database and the National Inpatient Sample) and the American College of Surgeons (National Trauma Data Bank) were examined using multivariable logistic regression to identify

associations between trauma outcomes and hospital characteristics, adjusting for patient, injury and hospital characteristics.

This dissertation produced significant results. First, splenectomy was found to be more likely among children treated at general hospitals than among children treated in children's hospitals and more common among children treated at for-profit general hospitals than in not-for-profit general hospitals. Compared to White for traumatic brain injury, Blacks were more like to die in level II hospitals, while Asians and Hispanics were more likely to die in both level I and II hospitals. Compared to Whites, Blacks and Hispanics also appeared less likely to be discharged to a rehabilitation service from either level I or II hospitals.

This dissertation identified opportunities for trauma system improvement in the areas of pediatric spleen management, racial/ethnic disparities in traumatic brain injury outcomes, and rural trauma care.

TABLE OF CONTENTS

Page

LIST OF FIGURES

Figure Number Page

LIST OF TABLES

ACKNOWLEDGEMENTS

I wish to extend my deepest appreciation to Dr. Diane Martin for her support and encouragement while serving as my mentor and chair. I would also like to thank Dr. Fred Zimmerman and Dr. Sam Sharar for their guidance, patience and support in the development of my dissertation. For her willingness to serve as my Graduate School Representative, a special thanks is extended to Dr. Maggie Baker.

My appreciation is offered to the School of Nursing and the Quentin N. Burdick Traineeships in Rural Interdisciplinary Health Care program. This dissertation was partially supported by funds from the Division of State, Community, and Public Health (DSCPH), Bureau of Health Professions (BHPr), Health Resources and Services Administration (HRSA), Department of Health and Human Services (DHHS) under grant # 1 D36 HP 10027, titled "Enhancing Health Care in Western Washington's Rural Areas" (total award amount $839,724). The information or content and conclusions are those of the author and should not be construed as the official position or policy of, nor should any endorsements be inferred by the DSCPH, BHPr, HRSA, DHHS, or the US Government.

DEDICATION

To Marilyn and Christopher

Chapter 1: Introduction

Trauma is the leading cause of death of Americans younger than 45 years.[1] In 1966, the National Academy of Sciences and National Resource Council published a report that characterized trauma as "the neglected disease of modern society."[2] During both the Korean and Vietnam Wars, advances in trauma care led to increases in survival rates, compared to the outcomes of World War I. The concept of the 'golden hour' of trauma emerged, with recognition that a patient's chance of survival increased dramatically if surgical intervention was made available to stop bleeding and restore hemodynamic stability. Helicopters staffed by trained paramedics brought advanced life support to the victim and subsequent transport to Mobile Army Surgical Hospital (MASH) units. In comparison to military emergency medical capabilities, civilian resources in the 1960s were primitive. More people were dying on U.S. streets than in the war.

Over the past 30 years, regional and state trauma care systems and specialized trauma centers have been developed to reduce the mortality attributable to severe injuries. Studies have demonstrated that trauma care systems can reduce the preventable trauma death rate by as much as 30% for patients who reach the hospital alive.[3,4,5,6] A systematic review of published evidence regarding trauma system effectiveness also concluded that hospital mortality is reduced with the implementation of a trauma system in urban areas.[7] Similarly, systematic reviews of population-based research and panel studies assessing the effectiveness of trauma systems report modest improvements in survival as a result of trauma system implementation.[8,9]

The goal of a trauma system is to assure that the 'right patient' reaches the 'right resources' in the 'right amount of time.'[10] Formal trauma systems address the continuum of

care, including injury prevention, emergency medical services (EMS) care, hospital resuscitation, stabilization and transfer, hospital definitive care, and rehabilitation services. Figure 1.1 illustrates the conceptual model of a formal trauma system.

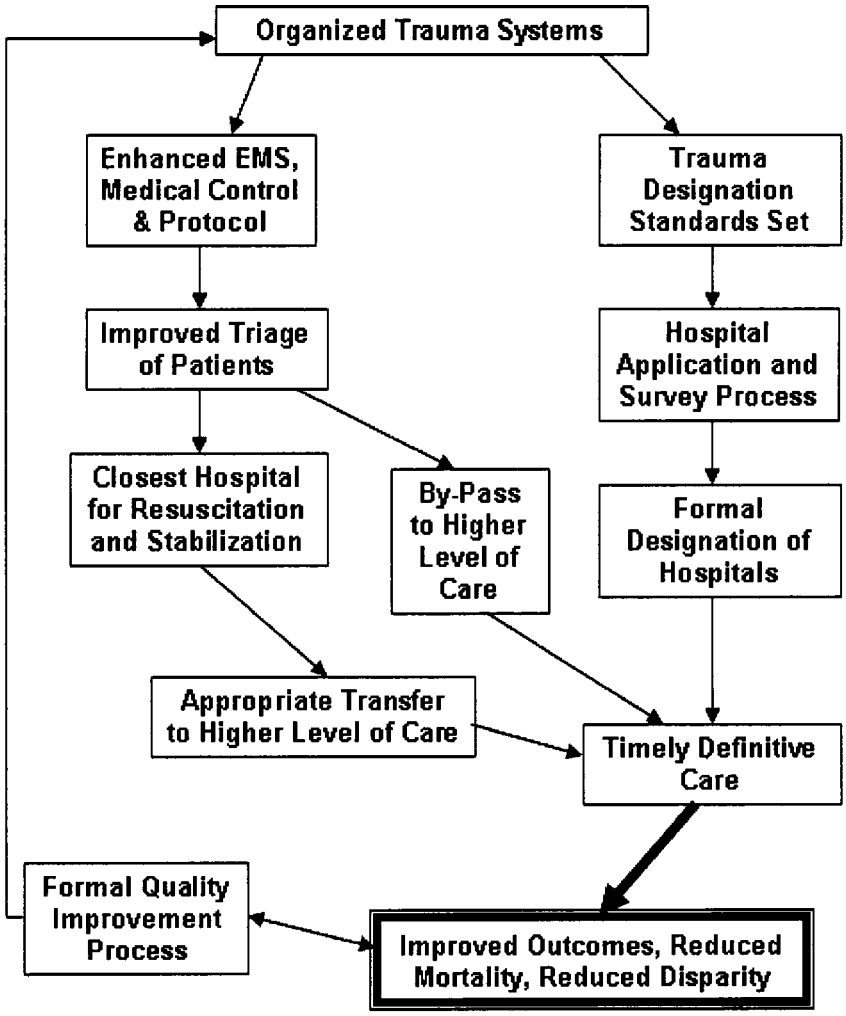


Figure 1.1. Conceptual Model of Organized Trauma Systems

As implemented, trauma systems are complex and varied. While evaluations of trauma system effectiveness typically assess overall trauma care between states with organized trauma systems and states without such systems, minimal attention has been given to the components of these systems that may be responsible for observed differences. This study

examines trauma systems effectiveness by focusing on three aspects: 1) hospital characteristics associated with best practice in the areas of pediatric splenic injury management, 2) racial and ethnic disparity in outcomes of persons with traumatic brain injury, and 3) rural trauma care and the benefit associated with trauma designation.

The specific aims of this dissertation are as follows:

1. To evaluate the hospital characteristics associated with pediatric splenic injury management practices (splenectomy vs. spleen-conserving practice);
2. To examine the association between race/ethnicity and in-hospital mortality in patients with moderate to severe traumatic brain injury (TBI) and utilization of post-acute rehabilitation services for survivors of severe TBI;
3. To examine rural trauma care and the impact of hospital trauma designation on in-hospital mortality and likelihood of transfer after admission.

In Chapter 2, Specific Aim #1 is addressed with the objectives of a) determining factors associated with the management of pediatric spleen injuries, b) testing the hypothesis that children are more likely to receive non-operative, conservative management in children's hospitals than in general hospitals, and c) testing the hypothesis that children are more likely to receive splenectomies in for-profit hospitals than in hospitals of other ownership. This research may prove useful to government or health systems administrators in making the decision of whether or not to intervene in the clinical decision process. By demonstrating the level of variability in current splenic injury management practices, information will be available to decision-makers on the potential for improved care through the adoption of a decision rule.[11] By identifying factors associated with variation in pediatric spleen management, state and/or local governments can implement targeted interventions aimed towards hospitals with characteristics associated with suboptimal care.

Chapter 3 addresses Specific Aim #2, examining the association between race/ethnicity and outcomes among patients with TBI. The objectives include determining whether racial and/or ethnic disparities exist in a) in-hospital mortality for patients with moderate to severe TBI and b) utilization of post-acute rehabilitation services for survivors with severe TBI. In addition, hospital characteristics associated with differences in TBI outcomes for people of color versus Caucasians are identified to determine among people with traumatic brain injury whether outcomes are associated with race. Specifically, this chapter aims to test the hypotheses that 1) people of color who experience traumatic brain injury are more likely to experience in-hospital death than Caucasians, after controlling for injury severity, patient demographics and hospital characteristics, 2) people of color are less likely to be discharged to rehabilitation services, 3) racial disparities in the care of patients with TBI are less in hospitals with level I trauma designation than in level II hospitals. Racial and ethnic disparities in health care are well documented, with higher mortality rates for diseases such as cancer, diabetes, heart disease and stroke.[12,13,14,15,16] Little is known about racial/ethnic disparities in outcomes for hospitalized people with TBI. A major goal of organized trauma systems is to assure timely access to appropriate trauma care resources for people of all races and ethnicities.

In Chapter 4, Specific Aim #3 is addressed with the examination of rural trauma care and the impact of hospital trauma designation on in-hospital mortality and likelihood of transfer after admission. Two hypotheses are tested: 1) in-hospital mortality is less at rural hospitals with trauma designation than at similarly sized and located hospitals without trauma designation, after controlling for demographic, severity and other covariates, and 2) transfers after admission (delayed transfers) are more frequent at rural hospitals without trauma designation than at similar hospitals with trauma designation. Figure 1.2 provides a conceptual framework for rural trauma care outcomes. Patient characteristics, such as age, gender, alcohol

and/or drug use, and preexisting conditions (co-morbidities) are independent predictors of trauma outcomes. Injury characteristics such as mechanism (external cause of injury), injury severity, injury type (blunt or penetrating) and extrication of the patient at the scene are all predictors of outcome. Environmental factors, such as extreme weather and/or inaccessible terrain, may also influence outcomes.

Patient and injury characteristics are related in trauma in that certain mechanisms of injury are related to age and/or gender. Young males represent a disproportionate share of the alcohol-related motor vehicle trauma. Similarly, older females are more likely to present with fall-related injuries. Interpersonal firearm injuries are more common among young males, while suicide by firearm is more common among older males. Environmental factors are also sometimes related to patient and injury characteristics. For example, inexperienced younger drivers are at risk of motor-vehicle crash trauma during times of inclement weather (slippery roads, night driving conditions, etc.).

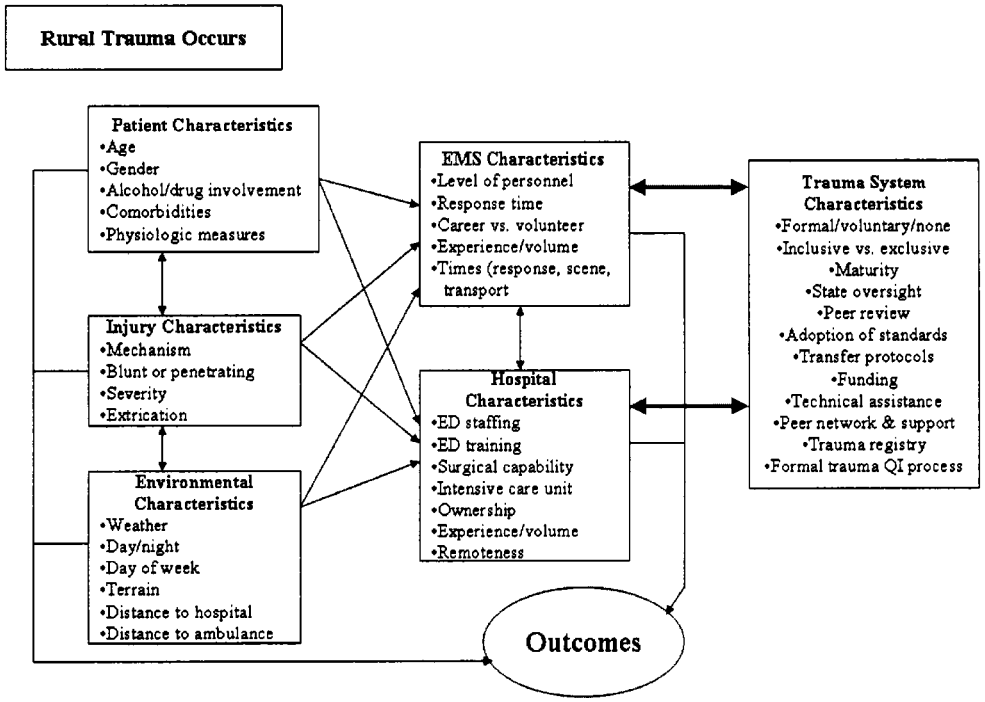


Figure 1.2. Conceptual Model of Rural Trauma Outcomes

Hospital characteristics affect outcomes through resources and capabilities, such as the availability of technology and the adequacy of staff training. In addition, the hospital's physician resources may impact outcomes. Evidence is mixed on the relationship between trauma center volume and outcomes, but these studies focused on level 1 and 2 trauma centers located primarily in urban settings.[17,18,19,20] Gandjour, et al. conducted a meta-analysis of threshold volumes associated with higher survival in health care and provide evidence for a volume-mortality relationship for hospitals and physicians; however, they did not find supporting evidence for major trauma.[21] No studies were identified on the relationship between volume and trauma outcomes in rural hospitals.

Lastly, Chapter 5 addresses the potential policy implications of this research and offers some recommendations for translating these findings into practice.

Chapter 2: Hospital Characteristics and Pediatric Splenic Injury Management

Summary

Despite substantial evidence that over 90 percent of pediatric splenic injuries can be successfully managed non-operatively, significant practice variation remains. As asplenic children are at increased risk of overwhelming post-splenectomy infection, non-operative management remains an important quality indicator.

We tested two *a priori* hypotheses: 1) children are more likely to receive splenectomy in general hospitals than in children's hospitals, and 2) children are more likely to receive splenectomy in for-profit than in not-for-profit general hospitals. Using a retrospective cohort study design with data from the Kid's Inpatient Database (KID) for year 2000, we used multivariable regression, controlling for patient and hospital characteristics. A Cox maximum likelihood proportional hazards model was used to compare splenectomy between general and children's hospitals. All children aged 0-16 years who were hospitalized with a traumatic (non-iatrogenic) spleen injury in nonfederal short-stay hospitals in any of the 27 states participating in KID were included in the study (N=2,851). The main outcome measures were splenectomy performed within one day of arrival for the multivariable logistic regression and splenectomy performed at any time during the hospitalization for the Cox analysis.

A total of 378 children (13%) received splenectomies within 1 day of arrival. In logistic regression analyses adjusting for patient characteristics, injury severity and hospital characteristics, splenectomy was found to be more likely among children treated at general hospitals (OR, 5.01; 95% CI, 2.21-11.36) than among children treated in children's hospitals. Splenectomies were also found to be more common among children treated at for-profit general hospitals (OR, 2.70; 95% CI, 1.49-4.89) than in not-for-profit general hospitals. In the

Cox analysis, splenectomy was also found to be more common in general hospitals than in children's hospitals (HR 3.13, 95% CI 1.70-5.79).

Variation in the management of pediatric splenic injuries remains. It may be that children's hospitals have more readily adopted non-operative spleen management practices. For-profit hospitals appear to perform more splenectomies than not-for-profit hospitals. Additional pediatric education and training for providers in general hospitals and especially in for-profit hospitals may be needed to increase the use of spleen-conserving management practices.

Introduction

Non-operative management of spleen injuries is successful in over 90 percent of pediatric trauma cases.[22,23,24,25] Evidence-based practice guidelines for the management of pediatric spleen injuries recommend non-operative management for hemodynamically stable patients.[26] However, the percentage of pediatric patients with splenic injury who are managed non-operatively is below 90%, with one recent study reporting as few as 39% of children managed without surgery.[27]

Nationally, an estimated 1,700 splenectomies are performed each year on the 7,000 children with spleen injuries.[28] Based on these estimates, about 76% of pediatric spleen injuries are managed non-operatively. Increasing non-operative management to 90% could mean an annual reduction of up to 1,000 splenectomies in children. The short-term benefits of non-operative management of injured spleens may include the avoidance of surgery costs, fewer blood transfusions and shorter hospital lengths of stay. Long-term benefits may include lower mortality rates as children without spleens have a life-long increased risk of severe infectious complications.[29] The estimated lifetime risk for developing overwhelming post-splenectomy infection (OPSI) ranges from 1% to 11%, with a mortality of up to

50%.[30,31,32,33,34] Based on these estimates, an estimated 10-100 cases of OPSI and up to 5-50 associated deaths, potentially could be prevented through the use of non-operative (i.e., spleen-conserving) management.

Long-term cost savings of non-operative management may include decreased prescription drug costs associated with the prophylactic administration of antibiotics to reduce the likelihood of OPSI. Additional long-term cost savings may include decreased hospitalizations associated with OPSI, as well as family/caregiver time and expense. Non-operative management as opposed to splenectomy may also help prevent premature death. Based on the estimates of OPSI (1%-10%), between 10 and 100 cases of OPSI potentially could be prevented annually through the use of non-operative (i.e., spleen-conserving) management.

Because of these potential clinical and economic benefits of non-operative management, the identification of factors associated with variability in splenic injury management practice should prove useful in efforts to design and implement targeted interventions. These interventions can focus on reducing sub-optimal care in the groups of hospitals and providers who are not currently practicing in accordance with national evidence-based guidelines for the management of pediatric spleen injuries.

The explanation for this low rate of non-operative management is unclear, but individual surgeon experience in dealing with pediatric trauma patients may be a factor.[35] Other factors such as hospital characteristics may also contribute to the variation in splenic injury management. These factors may include volume, location, ownership/control, teaching status, hospital type (general vs. pediatric), and level of trauma designation.[36,37,38,39] For-profit hospitals have been shown to produce larger bills for services and are more likely to use expensive, high-technology procedures.[40,41] However, to what extent observed variation in splenic injury management can be explained by hospital ownership is unknown.

We conducted a study to investigate hospital factors by examining national variations in the non-operative management of splenic injuries using a large, national database of child hospitalizations and procedures. We formally sought to test two hypotheses: 1) children are more likely to receive splenectomy in general hospitals than in children's hospitals, and 2) children are more likely to undergo splenectomy in for-profit general hospitals than in not-for-profit general hospitals.

Design and Methods

Data source

In this study, we use inpatient discharge data from the 2000 Kids' Inpatient Database (KID) of the Healthcare Cost and Utilization Project, sponsored by the Agency for Healthcare Research and Quality, Rockville, MD. The KID was designed to allow analyses of pediatric-specific discharge data. KID data are provided by public and private statewide data organizations as part of a federal-state-private collaboration.[42]

KID data are collected and compiled in a uniform format from the 27 participating states. These states include Arizona, California, Colorado, Connecticut, Florida, Georgia, Hawaii, Iowa, Kansas, Kentucky, Maine, Maryland, Massachusetts, Missouri, New Jersey, New York, North Carolina, Oregon, Pennsylvania, South Carolina, Tennessee, Texas, Utah, Virginia, Washington, Wisconsin, and West Virginia. The KID contains data from 2,784 hospitals and includes more than 2.5 million unweighted pediatric discharge records. The sampling frame includes pediatric discharges from non-federal, short-term hospitals (excluding rehabilitation hospitals and hospital units of institutions[43]) in the United States. Federal hospitals (Veterans Administration, Department of Defense, and Indian Health Service hospitals) are not included in KID. The KID data are comprised of a ten percent

sample of uncomplicated births and an 80% sample of other hospitalizations for children 20 years and younger from all hospitals in the sampling frame.

The KID includes a patient core set of data found in a typical discharge abstract, such as demographics (e.g., age, gender), admission type and source, diagnostic codes, procedure codes, payer and financial data, length of stay and discharge disposition. A KID hospital data file with facility characteristics (e.g., children's hospital, ownership, number of beds, urban/rural, geographic region, and teaching status) can be linked to the patient core data. The KID does not contain physiologic or laboratory patient data.

Eligibility

For this study, eligibility was limited to children who were less than 17 years of age at admission and who were hospitalized with an *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD9-CM) code for spleen injury (865) in any of the up to 15 diagnoses on the discharge record. In-hospital deaths for patients with pediatric spleen injuries were included.

Dependent variable

In the multivariable logistic regression analysis, splenectomies were identified by an ICD9-CM procedure code of 41.5 in any of the up to 15 procedures listed in the discharge record and with a time to procedure less than or equal to 1 day from arrival. We imputed time to procedure for the 45 missing times, using multivariable regression with available patient and injury variables. Hospital type was not included in the imputation. The imputed missing times were all estimated to have occurred within one day of arrival. Splenectomies performed at day 2 or later were considered initial attempts at non-operative management. Splenorrhaphy, partial splenectomies and other spleen-conserving procedures were excluded from the splenectomy group and included as non-operative management. We created a binary outcome variable to indicate whether a splenectomy was performed. In the Cox survival

analysis, we identified all splenectomies by the presence of an ICD9-CM procedure code of 41.5.

Independent variables

We created indicator variables for children's hospital including children's specialty hospitals, and general hospital using the classification of the National Association of Children's Hospitals and Related Institutions. We identified for-profit hospitals based on hospital ownership/control (AHA Annual Survey of Hospitals). We imputed missing values for the 2.7% of hospitals with missing hospital type or ownership and also conducted sensitivity analyses to model the effect of the missing data.

Control and confounding variables

Indicator variables were created for Medicaid as payer, rural hospital, teaching hospital, and received-in-transfer patient. We also derived control variables for massive spleen disruption (ICD9-CM 865.04, 865.14), blood transfusion (ICD9-CM procedure 99.0), volume of pediatric spleen cases, and penetrating injury (E-code for firearms, knives, cuts). Because this administrative database does not include vital signs such as systolic blood pressure, we included receiving a blood transfusion as a surrogate for hypotension. An injury severity score (ISS) was calculated for each record using the ICDMAP-90 software[44] The ISS is widely accepted as a valid measure of injury severity and is used as a control variable in this analysis.[45,46] Other control variables include patient-specific variables such as age, gender, race and admission type.

Trauma designation level is not identified in the KID dataset, but is of interest as a potential confounder. To identify hospital trauma designation level, we used data from the American Trauma Society's national trauma service inventory. The American Trauma Society surveyed all hospitals nationwide to ascertain trauma designation levels. These data include the American Hospital Association's hospital identification number for each facility that

allowed linking to the KID hospital file. In the KID data, eight states do not provide hospital identifiers. As such, trauma designation is unknown for about 25% of records. We created indicator variables for missing trauma designation, for higher levels of trauma designation (level 1 and 2), and for a combined group of all lower levels of designation (e.g., levels 3, 4, 5).

Data Analysis

To identify significant associations between patient or hospital factors and performance of splenectomy, we used logistic regression with splenectomy as the dependent variable and the independent and control variables described above. We adjusted for clustering on hospital identifier to account for correlation of individual outcomes within hospitals using the cluster option in Stata 8.0 (College Station, Texas). Explanatory variables are presented as odds ratios, with p-values and confidence intervals.

To assess potential impact of the state in which the hospital is located, we ran a conditional fixed-effects logistic regression with the splenectomy as the dependent variable and included the independent and control variables from the original model. We used the state in which the hospital resides as the independent unit for this fixed-effects model. To assess hospital effects, we performed another conditional fixed-effects logistic regression with hospital identifier as the independent unit.

We also assessed relationship of splenectomy and hospital type using multivariable Cox proportional hazard regression analysis. The relative hazard ratio (HR) of splenectomy after splenic injury was compared between general and children's hospitals. Survival was measured as the time from arrival to splenectomy, with censoring at hospital discharge. The proportional hazards assumption was confirmed by inspection of the Schoenfeld residuals and the log-rank test.

Results

Overall

We identified a total of 2,851 hospitalizations with spleen injuries among children less than 17 years of age. Almost all (333) of the 394 splenectomies performed during these hospitalizations occurred on day 0 or 1, and 16 were performed at day 2 or later. These delayed splenectomies were considered non-operative management and were included in the non-operative management group in the logistic regression analysis. We also performed two sensitivity analyses: 1) assigning all cases with missing time to the non-operative management group, and 2) assigning cases with missing time to the splenectomy group for children's hospitals and to the non-operative management group for general hospitals. In both cases, our results remain significant. Table 2.1 presents the relative frequencies of patient risk factors and their bivariate relationships with general versus children's hospital.

Age, Gender, Race/Ethnicity, Payer

Splenectomies were more common in older children, with the oldest age group (15-16 years) representing 31.4% of spleen hospitalizations and 47.4% of the total splenectomies. The youngest age group (0-4 years) represented 8.0% of spleen hospitalizations and 3.2% of splenectomies. Twenty percent of the oldest children received splenectomy, compared to 5.2 percent of children in the 0-4 age group. We did not observe a difference in management by gender. Children with missing race/ethnicity appeared over-represented in the group receiving splenectomies, representing 18% of spleen hospitalizations and 24.3% of splenectomies ($p=.007$), although this may speak more to the challenges of coding race/ethnicity and/or the individual hospital decision to collect or not collect this information. We did not observe a difference in management by primary payer.

Injury Characteristics

Mean injury severity score was significantly larger in children receiving splenectomies compared to those in the non-operative management group (25.4 vs. 13.1, $p<.001$). Children receiving splenectomies were also significantly more likely to have a massive disruption of the spleen and to have received blood products at any point during their hospitalization. We did not observe a difference in the proportion of cases coded as emergency admissions. Thirty-seven (1.3%) of spleen hospitalizations were due to penetrating injuries, and these children were more likely to receive a splenectomy.

Hospital Characteristics

Table 2.2 presents the relative frequencies of hospital characteristics and their bivariate relationships with splenectomy versus non-operative management. Most notably, children's hospitals represented 12.7% of pediatric spleen hospitalizations, but only 2.4% of splenectomies. Teaching hospitals cared for 63.6% of the spleen-injured children, but accounted for 47.9% of the splenectomies. Rural hospitals represented 10.1% of spleen hospitalizations and 14.3% of all splenectomies. Children cared for at hospitals with higher volume of pediatric spleen discharges were less likely to receive splenectomies than those in hospitals with fewer cases, although this finding was not significant in the multivariate analysis. In the bivariate analysis, level 1 or 2 trauma designation was associated with more non-operative management, while other levels of designation were associated with more splenectomies. No significant difference was observed in the hospitals with missing trauma designation. For-profit hospitals represent 4.3% of the spleen hospitalizations, but 9.5% of all splenectomies.

Multivariable Logistic Regression

Table 2.3 presents the results of a logistic regression modeling splenectomy using the patient and hospital risk factors presented in Tables 1 and 2. We initially included

race/ethnicity in the model, with an increased risk of splenectomy observed only for patients with missing race (OR 1.57, p=.011). Concerns over the quality of race/ethnicity coding supported our decision to drop this variable from the model. Excluding race/ethnicity did not significantly change the effect size of our factors of interest, but did result in an improved overall fit of the model. Similarly, we dropped the Medicaid payer status variable from the model as the odds ratio was close to one and insignificant (OR 1.02, p=.931). The fit of the logistic regression model clustered by hospital was very good, with an area under the receiver operating curve of .85 and a p value for the Hosmer-Lemeshow test of 0.72. Table 2.3 also reports the results of the fixed effects model conditioning on state. These results were similar to those clustered by hospital.

After adjusting for all model covariates including injury severity, children with spleen injuries were significantly more likely to receive a splenectomy if cared for at a general hospital compared to a children's hospital (OR 5.01, $p<.001$). Controlling for state in the fixed effects model, general hospitals remained more likely to perform splenectomies than to manage patients non-operatively (OR 5.59, $p<.001$). Other hospital characteristics (e.g., urban location, trauma designation) were not significant. We observed an increased risk of splenectomy in older children, in penetrating trauma, in children with massive spleen disruptions, in those with more severe injuries (higher ISS) and in children who received blood products. These findings have previously been reported and were included in our models primarily to control for confounding.

We next compared outcomes between children receiving splenectomies and those receiving non-operative management. Controlling for the same patient and hospital characteristics as in Table 2.3, children receiving splenectomies were at increased risk for in-hospital death compared to children receiving non-operative management (OR 3.96, 95% CI 1.99-7.88, p<.001). While length of hospital stay appeared greater in the splenectomy group

in the bivariate analysis (p=.021), no significant difference was observed after controlling for patient and hospital characteristics (p=.51). Mean hospital charges were $39,568 for patients receiving splenectomy compared to $23,575 for patients receiving non-operative management.

Multivariable Cox Proportional Hazard Regression

Table 2.4 presents the results of our multivariable Cox proportional hazard regression modeling time to splenectomy as the failure event. Children cared for at general hospitals were more likely to receive a splenectomy at some time during their stay than children receiving care at children's hospitals (hazard ratio 3.16, 95% CI 1.71-5.85). Most of the difference in splenectomy rates occurred within the first day of arrival, with few splenectomies performed after day one in either general or children's hospitals. We observed an increased hazard of splenectomy in older children, in penetrating trauma, in children with massive spleen disruptions, in those with more severe injuries (higher ISS) and in children who received blood products. Figure 2.1 depicts time to splenectomy by hospital type (general vs. children's).

Table 2.5 only includes children cared for at general hospitals, and for-profit hospital ownership is associated with an increased risk of splenectomy in the clustered logistic regression (OR 2.70, p=.001) as well as in the state fixed effects model (OR 3.19, p<.001). Teaching status and rural/urban hospital location were not significant predictors of splenectomy in either model. These results are similar to table 3, with the exception of the non-teaching hospital variable that is not significant in table 5.

In other analyses not reported here, we found that the results for hospital type and profit status were robust with respect to inclusion or exclusion of hospital trauma status and injury type, and in analyses including children up to 18 years old. We also conducted additional analyses modeling propensity to receive care at a general hospital and observed similar effect sizes and significance (results not shown).

Discussion

Despite the fact that non-operative management of hemodynamically stable children with splenic injuries is the standard of care, management variation persists. To our knowledge, this is the first study to compare risk of splenectomy between children's and general hospitals, after controlling for hospital trauma designation and other observable potential confounders. While we believe that our model adequately adjusts for patient and hospital characteristics, we cannot rule out the possibility of unmeasured covariates that could further distinguish the treatment groups.

We found treatment at children's hospitals was associated with a lower risk for splenectomy. Potoka and colleagues previously examined 1993-97 trauma registry data for Pennsylvania and documented more non-operative management of splenic injuries at pediatric trauma centers.[47] That study was limited to designated trauma services. Most states do not include separate designation for pediatric centers, and some children's hospitals may not meet the general designation requirements and may thus not be trauma designated. Mooney and Forbes examined variation in the management of pediatric splenic injuries in six New England states and observed increased risk for splenectomy in children cared for by general surgeons compared to children cared for by surgeons with specialty pediatric training.[48] This same study observed an increased risk for splenectomy at trauma centers, but did not include children's hospital as a predictor. Our study showed no association between trauma designation and splenectomy.

We also found that for-profit status was associated with increased likelihood of performing splenectomies among general hospitals. Although others have previously documented differences in medical care by profit status of hospital, our finding that pediatric

splenectomy rates vary warrants further study particularly given the rising growth of for-profit hospital ownership.[49,50]

There are several limitations to our study. First, we lacked physiologic and laboratory data, such as systolic blood pressure and hematocrit. Second, we relied on ICD9cm diagnostic codes to control for spleen injury severity, rather than the preferred, but unavailable, spleen injury grade. About 9% of splenectomies occurred in children with injuries coded as unspecified splenic injury (unspecified codes of 865.00, 865.10), with the potential for misclassification. We also used blood transfusion as a surrogate for hypotension and blood loss, but we do not know the extent of transfusions (i.e., number of units received) or the time course of transfusions (i.e., in the emergency room, in the operating room, or in the intensive care unit or ward setting). We also do not have strong evidence in support of blood transfusion as a predictor of hypotension in administrative data as this issue has not received much attention in the literature.

Third, we do not know whether the initial management plan was to manage non-operatively. Time to procedure appears reasonable as a surrogate, but 11% of splenectomies required imputation of time to procedure. While we used multivariable Cox proportional hazards regression to examine time to splenectomy, most procedures occurred within one day of arrival. Also, our data included time to procedure in days, and as such, we lacked the ability to detect smaller differences in time to splenectomy (e.g., hours). We also performed a sensitivity analysis assuming that all of these cases were failures of non-operative management rather than early splenectomies; the results were comparable to the original model with no significant differences.

We cannot rule out the possibility of selection bias in this sample, with seriously injured children potentially being transported more often to pediatric facilities. However, if this bias does exist in this data, we expect that the direction would be towards the null. We

also cannot rule out the possibility that the most seriously injured children were too unstable to be transported to a children's hospital, although we believe that controlling for injury severity, massive disruption of the spleen, other injury in the abdomen region, penetrating mechanism and receipt of blood products should reasonably control for this potential. We also cannot rule out the possibility of omitted variable bias.

The clinical decision to perform early operative versus non-operative management of splenic injury may depend on the training and experience of the physician provider. For example, pediatric surgeons or pediatric intensivists are more likely to be found in children's hospitals and may possess skill sets and/or experience that favor non-operative management. However, we do not have information on individual providers who managed the children in the KID database (e.g., general surgeon, pediatric surgeon, intensivist, etc.). As our study examines hospital characteristics associated with pediatric spleen management, we cannot rule out the influence of individual provider characteristics, including specialty and training.

Our study suggests that children's hospitals have adopted non-operative management practices. Additional pediatric education and training for providers in general and for-profit hospitals may increase the adoption of non-operative spleen management guidelines such as those developed by the Eastern Association for the Surgery of Trauma (EAST).[51]

Table 2.1. Characteristics of pediatric spleen injury hospitalizations by hospital type

Risk Factor	General Hospital No. (%) (n=2488)	Children's Hospital No.(%) (n=36378)	P-value
Female	679 (27.3)	111 (30.6)	.204
Age y (mean)	11.8 years	9.1 years	<.001
0-4	166 (6.7)	63 (17.4)	
5-9	507 (20.4)	121 (33.3)	
10-14	959 (38.6)	139 (38.3)	
15-16	856 (34.4)	40 (11.0)	
Race/ethnicity			
White	1522 (61.2)	206 (56.8)	.112
Black	148 (5.9)	35 (9.6)	.023
Latino	208 (8.4)	44 (12.1)	.038
Other	123 (4.9)	28 (7.7)	.06
Unknown	487 (19.6)	50 (13.8)	.004
Medicaid Primary Payer	431 (17.3)	94 (25.9)	<.001
Penetrating Injury	32 (1.3)	5 (1.4)	.889
Injury Severity Score			
Mean	14.9	13.5	.037
1-8	1061 (42.6)	178 (49.0)	
9-15	283 (11.4)	35 (9.6)	
16-24	491 (19.7)	89 (24.5)	
25-75	653 (26.3)	61 (16.8)	
Splenectomy	383 (15.4)	11 (3.0)	<.001
Day <=1	325 (13.1)	8 (2.2)	
Day >=2	14 (0.6)	3 (0.8)	
Unknown time to procedure	44 (1.8)	1 (0.3)	

Table 2.2. Patient and hospital characteristics associated with splenectomy and non-operative management

Risk Factor	Non-operative Management No. (%) (n=2473)	Splenectomy within 1 day No.(%) (n=378)	P-value
Age (mean)	11.2	13.2	<.001
Female	684 (27.7)	106 (28.0)	.877
Hospital Type			
General Hospital	2119 (85.7)	369 (97.6)	<.001
Children's Hospital	354 (14.3)	9 (2.4)	<.001
Teaching Hospital	1631 (66.0)	181 (47.9)	<.001
Rural Hospital	235 (9.5)	54 (14.3)	.012
Hospital volume of spleen injuries			
Mean per year	14.0	10.5	<.001
<10	1144 (46.3)	244 (64.6)	<.001
10-19	694 (28.1)	62 (16.4)	<.001
>=20	635 (25.7)	72 (19.1)	.003
Trauma Designation			
Level 1 or 2	1010 (40.8)	121 (32.0)	<.001
Other designation	148 (6.0)	32 (8.5)	.101
Not designated	656 (26.5)	120 (31.8)	.042
Missing	659 (26.6)	105 (27.8)	.648

Note: The sample includes 26 children's hospitals and 859 general hospitals.

Table 2.3. Factors associated with splenectomy in children 0-16 years

Risk Factor[2]	Logistic Regression[1] Clustered by Hospital† OR (95% CI)	*P* Value	State Fixed Effects OR (95% CI)	*P* Value
Children's hospital	1.0 (reference)		1.0 (reference)	
General hospital	5.01 (2.21-11.36)	<.001	5.59 (2.58-12.11)	<.001
Age				
0-4	1.0 (reference)		1.0 (reference)	
5-9	1.17 (0.58-2.39)	.659	1.28 (0.61-2.68)	.508
10-14	2.06 (1.10-3.86)	.023	2.27 (1.14-4.51)	.019
15-16	2.82 (1.42-5.57)	.003	3.10 (1.57-6.15)	.001
Female	1.08 (0.81-1.43)	.603	1.07 (0.80-1.43)	.653
Blood products received	2.40 (1.64-3.50)	<.001	2.42 (1.66-3.52)	<.001
Massive disruption of spleen	4.32 (2.96-6.30)	<.001	4.73 (3.33-6.73)	<.001
Other injury to abdomen region	1.94 (1.46-2.59)	<.001	1.93 (1.47-2.54)	<.001
Penetrating injury	4.32 (1.87-9.96)	.001	4.04 (1.83-8.90)	.001
Injury severity score	1.05 (1.03-1.07)	<.001	1.05 (1.03-1.06)	<.001
Non-Teaching hospital	1.57 (1.14-2.18)	.006	1.46 (1.05-2.01)	.023
Urban hospital	1.10 (0.72-1.69)	.664	1.19 (0.79-1.80)	.409
Not transferred in from another hospital	4.61 (1.64-12.99)	.004	4.81 (1.80-12.83)	.002
Trauma Designation				
Level 1 or 2	1.0 (reference)		1.0 (reference)	
Other designation level	1.25 (0.67-2.30)	.481	1.14 (0.62-2.12)	.672
Not designated	1.04 (0.70-1.54)	.860	1.16 (0.78-1.72)	.471
Missing designation	0.92 (0.63-1.33)	.654	dropped – no state variation	

[1]Splenectomy is defined as an ICD9-cm procedure of 41.5 occurring on day of arrival or on first day of stay. Time to splenectomy was imputed for cases with unknown days to procedure. Splenectomies occurring on day 2 or later are excluded as non-operative management attempts.

[2]Each variable was adjusted for all other variables listed.

†c=.85, Hosmer-Lemeshow test =5.07 (*P*=.75). OR indicates odds ratio; CI, confidence interval.

Table 2.4. Cox proportional hazards of splenectomy after splenic injury

Variable	Adjusted* Hazard Ratio (95% Confidence Interval)
Children's hospital	1.0 (reference)
General hospital	3.16 (1.71-5.85)
Age	
0-4	1.0 (reference)
5-9	1.15 (.60-2.18)
10-14	1.92 (1.06-3.47)
15-16	2.15 (1.19-3.88)
Female ‡	1.02 (0.82-1.28)
Blood products received‡	1.77 (1.37-2.30)
Massive disruption of spleen‡	3.09 (2.39-4.00)
Other abdominal injury‡	1.54 (1.25-1.90)
Penetrating injury mechanism‡	2.46 (1.48-4.09)
Injury severity score†	1.03 (1.02-1.04)
Non-teaching hospital‡	1.41 (1.11-1.80)
Urban hospital‡	1.08 (0.80-1.47)
Not transferred from another hospital‡	3.62 (1.49-8.80)
Level 1 or 2 trauma designation	1.0 (reference)
Other trauma designation level	1.15 (0.75-1.76)
No trauma designation	1.03 (0.78-1.37)
Unknown trauma designation	0.96 (0.74-1.25)

* Each variable was adjusted for all other variables listed.

† The hazard estimate is for each increase in 1 unit compared with the value before it.

‡ The hazard estimate is for the presence of this variable compared with those who were not positive for this variable.

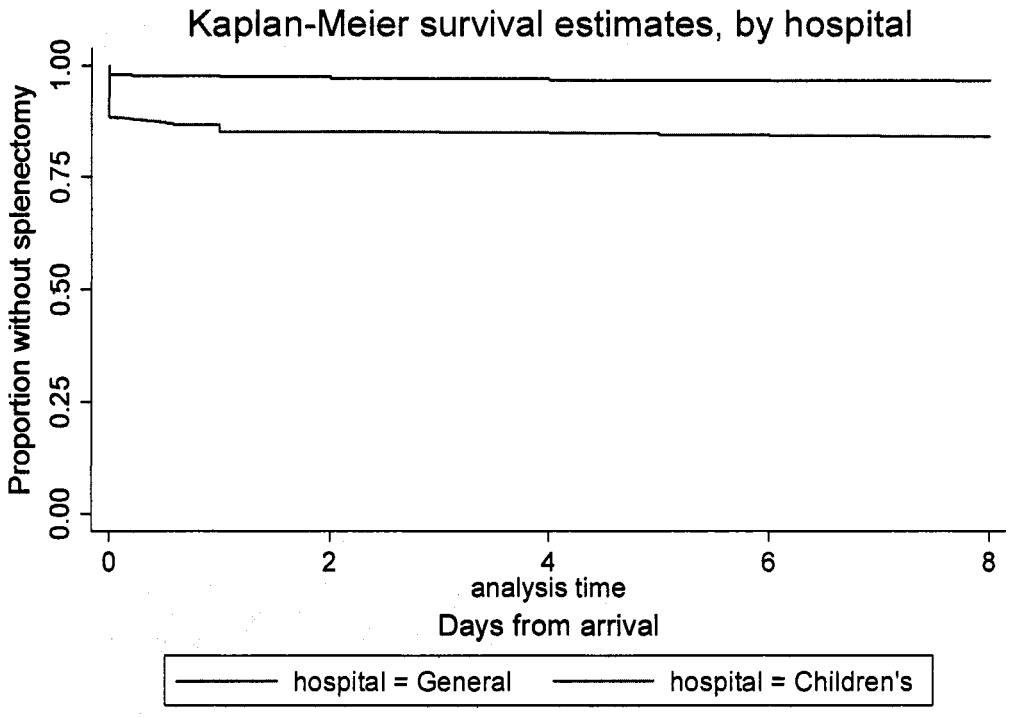


Figure 2.1. Proportion of children not receiving splenectomy after splenic injury

Table 2.5. Predictors of splenectomy in children 0-16 years receiving care at general hospitals only

	Logistic Regression[1] Cluster by Hospital†		State Fixed Effects	
Risk Factor	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
For-profit hospital	2.70 (1.49-4.89)	.001	3.19 (1.85-5.52)	<.001
Age y				
0-4	1.0 (reference)		1.0 (reference)	
5-9	1.16 (0.53-2.51)	.709	1.29 (0.58-2.90)	.534
10-14	2.29 (1.14-4.58)	.019	2.57 (1.21-5.46)	.014
15-16	3.22 (1.52-6.80)	.002	3.63 (1.72-7.67)	.001
Female	1.13 (0.84-1.51)	.414	1.15 (0.85-1.55)	.375
Blood products received	2.57 (1.74-3.79)	<.001	2.64 (1.80-3.88)	<.001
Massive disruption of spleen	4.42 (2.95-6.63)	<.001	4.82 (3.35-6.93)	<.001
Other injury to abdomen region	1.95 (1.46-2.62)	<.001	1.94 (1.47-2.57)	<.001
Penetrating injury	3.23 (1.23-8.47)	.017	2.99 (1.27-7.04)	.012
Injury severity score	1.05 (1.03-1.07)	<.001	1.05 (1.03-1.06)	<.001
Non-teaching hospital	1.35 (0.96-1.90)	.084	1.27 (0.90-1.79)	.169
Urban hospital	1.02 (0.66-1.57)	.928	1.14 (0.75-1.73)	.540
Not transferred in from another hospital	5.74 (1.63-20.25)	.007	6.44 (2.10-19.81)	.001
Trauma designation				
Level 1 or 2	1.0 (reference)		1.0 (reference)	
Other designation level	1.22 (0.65-2.28)	.538	1.05 (0.56-1.98)	.881
Not designated	0.99 (0.66-1.47)	.942	1.08 (0.72-1.63)	.704
Unknown designation	0.82 (0.56-1.19)	.293	dropped – no state variation	

[1]Splenectomy is defined as an ICD9cm procedure of 41.5 within one day of arrival. Splenectomies occurring on day or later are excluded as non-operative management attempts. †c=.85, Hosmer-Lemeshow test = 9.33 (*P*=.32). OR indicates odds ratio; CI, confidence interval.

Chapter 3: Racial Disparities in Traumatic Brain Injury Outcomes

Summary

Each year in the United States, of the estimated 1.5 million people who experience a traumatic brain injury (TBI), about 230,000 are hospitalized and 16,000 die in-hospital. With up to 90,000 TBI survivors experiencing permanent disability from their injuries each year, an important component of the quality of care in TBI is the access to and utilization of rehabilitative services. These services are currently under-utilized. While differences in hospital outcomes and the use of major procedures by patient race are well known for other medical conditions such as cardiovascular disease, they have not yet been explored for TBI.

We retrospectively analyzed data from 71,673 patients with a moderate to severe TBI who were hospitalized in any of the 271 level I or II trauma-designated hospitals participating in the National Trauma Data Bank during 2000-2003. We examined racial and ethnic disparities in in-hospital mortality and the likelihood of receiving post-acute rehabilitation services for survivors. Multivariable logistic regression was used to control for patient, injury type and severity, and hospital characteristics, with clustering on hospital to account for correlation of outcomes within individual hospitals. Main dependent variables were in-hospital mortality for admitted patients with moderate to severe TBI and discharge to rehabilitation for survivors with severe TBI. The primary independent variable was race, with indicator variables for White, Black, Hispanic, Asian/Pacific Islander, and 'Other' race.

Controlling for injury type and severity, we observed an increased risk of death for Blacks compared to Whites in level II hospitals (OR 1.32, p=.012), but not in level I hospitals (OR 1.14, p=.173). Asians were at increased risk of death in both level I and II hospitals (OR 1.41, p=.053 and OR 1.47, p=.008 respectively). We observed a trend toward significance for a result of Hispanics appearing more likely to die in both level I and II hospitals (OR 1.37,

p=.064 and OR 1.24, p=.068 respectively). For survivors in both level I and II hospitals, Blacks were less likely to be discharged to a rehabilitation service (OR 0.66, p=.002 and OR 0.60, p=.015). Hispanics were also less likely to be discharged to rehabilitation, although these findings were significant in level II hospitals only (OR 0.73, p=.091 for level I hospitals and OR 0.63, p=.020 for level II hospitals).

Racial and ethnic disparities exist both in mortality and in the use of rehabilitation services among persons with moderate to severe TBI. These disparities appear greatest in level II community hospitals. Further research is needed to understand the underlying causes of these disparities. Delivering focused educational interventions and adopting clinical practice guidelines may prove useful in reducing disparities in the TBI population.

Introduction

Each year in the United States, an estimated 1.5 million people experience a traumatic brain injury (TBI), of whom about 230,000 are hospitalized and 16,000 die in-hospital.[52,53,54] One-third of all injury deaths are attributable to TBI (~50,000 deaths per year), and in addition about 80,000 to 90,000 people annually experience long-term or lifelong disability associated with TBI.[55] Traumatic brain injuries are a significant risk factor for in-hospital deaths: TBI is present in only 25% of trauma cases, yet 60% of in-hospital trauma deaths include a TBI diagnosis.[56] Because of the significant impact of TBI on trauma-related mortality and morbidity, organized trauma systems are required to provide neurosurgical services at both level I and level II designated trauma services, in an effort to improve outcomes following TBI. The primary difference between such levels of service is that level I hospitals are also required to provide postgraduate medical education and engage in research. Thus, level I trauma services are more likely to be located in academic hospitals, while level II trauma services are more often found in community hospitals. However, in both of these

settings, TBI victims are likely to span a wide spectrum with respect to race, ethnicity, and socioeconomic status.

Racial disparities in TBI-related mortality have also been documented, with the highest death rate from TBI among African Americans.[4] African-American teenagers are more likely to die from homicide than from any other cause, and injury rates for African Americans in general are higher than for most racial and ethnic groups.[7] Estimated TBI incidence rates for African-American children ages 0 to 4 are 40% higher than for white children.[4] Poverty and socioeconomic status are believed to contribute to racial disparities in a variety of health care outcomes, but evidence suggests that bias, prejudice, and stereotyping on the part of health care providers may also contribute to disparities in health care outcomes.[57] Despite the evidence for increased risk of TBI injury and death among people of color, no research has been published reporting on racial and ethnic disparities in the hospitalized population with TBI.

In this study, we investigate the potential racial and ethnic disparities in the care of patients with moderate to severe TBI and identify hospital characteristics associated with differences in care and outcomes. We stratify our analyses to determine whether racial disparities differ across designated levels of trauma service. The identification of such factors can provide important information for use in reducing racial disparities among this population.

Design and Methods

Study Population

We obtained data from the National Trauma Data Bank (NTDB), which is maintained by the American College of Surgeons. The NTDB contains information from over one million records voluntarily submitted from more than 400 designated trauma centers in the United States.[58] Records in the NTDB include information on patient demographics, pre-

existing conditions, injury characteristics including diagnoses and severity, prehospital care, emergency department care, surgical procedures performed, intensive care unit stays, outcomes and financial data. The NTDB also includes hospital characteristics such as trauma designation level, bed size, teaching type, and public/private ownership.

We included major trauma patients of all ages who were hospitalized with a TBI in any of the level I or II participating NTDB hospitals between 2000 and 2003. Major trauma was defined by the presence of an Injury Severity Score of 16 or greater. Traumatic brain injury was defined using the Centers for Disease Control and Prevention (CDC) framework (ICD-9-CM diagnostic code of 800.0-801.9, 803.0-804.9, 850.0-854.1.[59]) We restricted our study to patients with moderate to severe TBI as defined by an Abbreviated Injury Scale of 3 or greater to the head region. Patients with major burns were excluded from this study to reduce the distortion caused by the intense and specialized care associated with burn treatment. Each data year included approximately 15,000 major trauma patients with TBI. Patients who were transferred out of the hospital, either from the emergency department or after admission, were excluded, as we were unable to link records between the sending and receiving hospitals in the NTDB. Including these cases would artificially reduce the mortality rate for hospitals that transfer patients. Only records from levels 1 and 2 hospitals and not hospitals with lesser trauma designation were included in this study as these hospitals are most likely to provide definitive neurosurgical care for patients with moderate to severe TBI.

Study Variables

Our main dependent variables were in-hospital mortality for admitted patients and discharge to rehabilitation for survivors. Our primary independent variable was race (White, Black, Hispanic, Asian/Pacific Islander, Other) as coded by the submitting hospitals from medical charts and records. We included an indicator variable for 'missing race' in our multivariable models.

We included variables in multivariable analytic models based on an *a priori* assessment of clinical relevance. Indicator variables were created for payer status (Medicare, Medicaid, self-pay, missing payer, all other payers), the presence of a spinal cord injury diagnosis, hypotension (systolic blood pressure less than 90 mmHg in the emergency department), blood transfusion (ICD9-CM procedure 99.0), and relevant co-morbidities (i.e., heart disease, chronic obstructive pulmonary disease, diabetes). We also included age, gender, Glasgow Coma Scale on arrival, injury type (i.e., blunt, penetrating), injury intent (i.e., unintentional, self-inflicted, assault), injury severity, annual hospital volume of TBI patients, trauma designation, hospital ownership (public/private), and hospital teaching status. We determined patient injury severity using the ICDMAP-90 software which codes each injury to the Abbreviated Injury Scale (AIS) and calculates the Anatomic Profile (AP) for each record.[60] The AP components (A, B, C) summarize serious injuries (greater than AIS 2) to the head/brain or spinal cord, to the thorax or front of neck, and all other serious injuries; the AP component D summarizes all non-serious injuries (AIS<2).[61] The AIS is an anatomically based system that classifies individual injuries by body region on a 6-point ordinal severity scale ranging from AIS 1 (minor) to AIS 6 (fatal). The AP summarizes the AIS scores and creates a valid measure of injury severity for use in comparing groups of patients with similar injuries; the AP is preferable to the Injury Severity Score in patients with TBI.[10,62,63,64]

Statistical Analysis

Univariate and bivariate analyses were completed using t-tests for continuous variables and chi-square testing for categorical variables. To identify significant associations between patient or hospital factors and in-hospital outcomes, we used logistic regression with in-hospital death as the dependent variable and the independent and control variables described above. As the requirement for level I trauma hospitals to conduct research and teaching may lead to differences between level I and II settings, our analyses were stratified

on trauma designation level. We adjusted for clustering on hospital identifier to account for correlation of individual outcomes within hospitals using the cluster option in Stata 9.1 (College Station, Texas). Odds ratios are presented for explanatory variables, with p-values and confidence intervals.

We analyzed the odds of discharge to a rehabilitation service by race for patients with severe TBI (i.e., AIS score of 5 to the head), controlling for other patient, injury and hospital characteristics. The NTDB includes rehabilitation within the discharge disposition field. Deaths are excluded from this analysis.

Results

Patient, Injury and Hospital Characteristics

We identified 71,684 admissions of patients with a TBI diagnosis, including 15,478 (21.6%) who died in hospital. Table 3.1 presents relative frequencies of patient, injury and hospital characteristics and their relationships with in-hospital mortality. Patients who died were older than those discharged alive (45.8 vs. 38.8 years, $p<.001$), more likely to be male and more likely to be Black, Hispanic or Asian. Patients with Medicare or self-pay were more likely to die, while Medicaid recipients were more likely to survive. Mean injury severity score was significantly higher in patients who died compared to survivors (32.1 vs. 23.5, $p<.001$). Patients with self-inflicted or interpersonal violence were more likely to die than patients receiving unintentional injuries. About 5.8% (4,171) of patients received penetrating injuries with an in-hospital mortality of 59.3% compared to 19.3% in the blunt trauma group. Patients who died were more likely to have a history of cardiovascular disease and/or diabetes than were survivors. The presence of hypotension and receipt of blood products were both more common in patients who died.

Hospital teaching status was not associated with in-hospital mortality. Patients were slightly more likely to die in public hospitals than private hospitals (22.2% vs. 21.1%, p<.001). We did not observe a difference in outcome by annual volume of TBI cases or by trauma designation level. Patients received in transfer were less likely to die than patients received directly (22.2% vs. 27.1%, p<.001).

Table 3.2 presents relative frequencies by race/ethnicity. Overall, females represent 32% of trauma, with Asians more likely to be female than Whites (37.1% vs. 32.5%, p<.001) and Blacks, Hispanics, Native Americans and 'Other' race less likely to be female. With the exception of Asians, people of color were younger on average than Whites. People of color were more likely to have Medicaid or self-pay as primary payer, while Whites were more likely to have other insurance or Medicare. Whites and Blacks did not differ significantly with regard to injury severity score (mean ISS 25.3 for both groups), although Blacks were more likely to have experienced a penetrating trauma (14.2% vs. 3.8%, p<.001). Hispanics and Asians had slightly more severe injuries compared to Whites, while Native Americans had injuries that were slightly less severe than Whites. Blacks were less likely to receive care at a level II trauma center compared to Whites (16.1% vs. 34.3%, p<.001). Blacks, Hispanics and Asians were all more likely to die than Whites, and people of all racial groups were less likely to be discharged to a rehabilitation service than were Whites.

Multivariable Logistic Regression

Table 3.3 presents the adjusted stratified results of a logistic regression model evaluating the odds of death based on patient and hospital risk factors identified in Tables 1 and 2. The fit of the logistic regression models was good, with an area under the receiver operating curve of .89 and a *p* value for the Hosmer-Lemeshow test of 0.64 for the level II model and an area of .88 and *p* value of .37 for the level I model.

In level II hospitals, Blacks and Asians were more likely than Whites to die in-hospital (OR 1.32, 95% CI 1.06, 1.64 and OR 1.47, 95% CI 1.11, 1.96 respectively). Hispanics appeared more likely to die than Whites, but this finding was of borderline significance (OR 1.24, p=.068). No significant difference was observed for Native Americans or people of other races although small subgroup sizes may have limited our ability to detect a significant difference. In level I hospitals, we did not observe a difference in mortality for Blacks, Native Americans or 'Other' race compared to Whites. However, compared to Whites, we did observe some evidence suggesting an increased risk of death for Hispanics and Asians although these findings were of borderline significance (OR 1.37, p=.064 and OR 1.41, p=.053 respectively). Penetrating injury, hypotension and receipt of blood products were all significantly associated with increased mortality risk in both level I and II trauma services. Compared to those with private insurance, self-pay patients were also more likely to die in both level I and II hospitals (OR 2.07, p<.001 and OR 1.39, p=.01 respectively), whereas Medicaid patients were at lower risk of death (OR .76, p=.01 and OR .69, p=.017 respectively).

In our analysis of patients discharged alive (Table 3.4), Blacks were significantly less likely than Whites to be discharged to a rehabilitation center in both level I and II hospitals (OR 0.66, p=.002 and OR 0.60, p=.015 respectively). Hispanics were also significantly less likely to be discharged to rehabilitation in level II hospitals (OR 0.63, p=.02), but not in level I hospitals (OR 0.73, p=.091). We did not observe a difference between Asians and Whites in either level I or II hospitals. Native Americans appeared less likely to be discharged to a rehabilitation center in level I hospitals (OR 0.55, p=.057) although this finding was of borderline significance. Medicaid, Medicare and self-pay were all associated with lower odds of discharge to rehabilitation when compared to patients with other insurance, regardless of race or ethnicity. Patients with both TBI and a spinal cord injury were more likely to be

discharged to a rehabilitation service at both level I and II hospitals (OR 2.83, p<.001 and OR 2.42, p=.006 respectively).

Discussion

Traumatic brain injury hospitalizations have previously been reported to be higher for people of color than for Whites.[8,65] People of color who experience a TBI have also been reported to receive fewer rehabilitation therapy services than Whites.[66] To our knowledge, this is the first study to compare the risk of death by race in level I and II trauma hospitals for patients with moderate to severe TBI, controlling for observable potential confounders. Our stratified results provide evidence of variability in outcomes between level I and II trauma hospitals. We found Blacks, Hispanics, and Asians to have poorer outcomes in level II trauma hospitals compared to Whites with similar injuries treated in similar hospitals. In level I hospitals, the results were not significant, although the elevated odds ratios for Hispanics and Asians approached statistical significance. These findings were robust after controlling for key patient, injury and hospital characteristics including injury severity, injury type (i.e., blunt vs. penetrating), injury intent, admission Glasgow Coma Score and systolic blood pressure, and others.

Wong and colleagues concluded that a few conditions account for most of the mortality disparity in the United States and that trauma in particular accounts for much of the disparity between African Americans and Whites.[67] Research on TBI outcome disparities has received little attention in the literature, although Bazarian reported racial and ethnic disparities in emergency department care for patients with mild TBI.[68] In another study of emergency care disparities, Pope and colleagues found that nonwhite patients were more likely to have been mistakenly discharged from the emergency department with a missed diagnosis of acute cardiac ischemia.[69] Evidence also suggests that African Americans are less

likely to receive non-emergent surgical treatment such as renal transplantation and knee arthroplasty[70,71] and less likely to receive diagnostic and treatment services for acute low back pain.[72] Our findings suggest the need for more focused research into the underlying causes for TBI outcome disparities.

There are several limitations to our study. First, while we believe that our model adequately adjusts for patient and hospital characteristics, we cannot rule out the possibility of unmeasured covariates that could further distinguish the treatment groups. Second, we relied on Abbreviated Injury Scale codes to control for TBI. Misclassification of TBI severity is possible due to incomplete or inaccurate injury coding. However, we were unable to identify any studies indicating systematic miscoding of injuries by race. Second, coding of race and ethnicity from patient charts and medical records offers the potential for misclassification. Hispanic ethnicity is included in the NTDB as a race category. It is unclear how multiracial individuals (e.g., Hispanic Blacks) were coded within the data. Also, nearly 10% of records in the NTDB were missing race as some hospitals provide little or no race data on their patients. To the extent that miscoding of race/ethnicity was present in our data, the resulting measurement error would tend to bias the results toward the null, a conservative bias.

We also used receipt of blood transfusion as a surrogate for hemodynamic instability as the NTDB includes only one systolic blood pressure measurement at admission to the emergency department. We did not know the extent of transfusions (i.e., number of units received) or the time course of transfusions (i.e., in the emergency room, in the operating room, or in the intensive care unit or ward setting). We were also not able to identify patients who were unsuitable for receiving rehabilitation services, although adjusting for TBI severity in our model should help to moderate this factor. Our analysis also does not include patients who were transferred out of the emergency department to another acute care facility as the NTDB includes only patients who were admitted to the hospital.

This study demonstrates the presence of racial disparities in both the mortality and rehabilitation discharge pattern of hospitalized persons with TBI. Our finding of greater disparity in level II hospitals compared to level I hospitals is concerning and offers some motivation for further research. Level II hospitals tend to be community hospitals with care provided by physicians operating in private or group practices. More research is needed to identify the underlying causes of these disparities, including potential provider bias. Promoting the use of established clinical practice guidelines and focusing educational efforts towards reducing variability of care may also help to reduce racial disparities in this population.

Table 3.1. Patient, injury and hospital characteristics by discharge status

	Discharged Alive No. (%) (n=56,195)	Died in Hospital No. (%) (n=15,478)	p Value
Female	16,956 (30.2)	4,473 (28.9)	.006
Age, mean (sd)	38.8 (22.9)	45.8 (24.9)	<.001
Race			
White	36081 (64.2)	9396 (60.7)	<.001
Black	6550 (11.7)	2003 (12.9)	<.001
Hispanic	6038 (10.7)	1953 (12.6)	<.001
Native American/Alaskan	403 (0.7)	85 (0.6)	.02
Asian/Pacific Islander	993 (1.8)	374 (2.4)	<.001
Other	1100 (2.0)	259 (1.7)	.02
Unknown	5030 (9.0)	1408 (9.1)	.58
Primary payer			
Medicare	5225 (9.3)	2354 (15.2)	<.001
Medicaid	6181 (11.0)	1105 (7.3)	<.001
Other insurance	24079 (42.9)	5223 (33.7)	<.001
Self-pay	6781 (12.0)	2948 (19.4)	<.001
Missing payer	13995 (24.9)	3782 (24.4)	.23
Co morbidities			
Cirrhosis	91 (0.2)	66 (0.4)	<.001
Chronic drug abuse	357 (0.6)	52 (0.3)	<.001
Diabetes	1115 (2.0)	356 (2.3)	.008
Cardiac/AMI/Heart Disease	6574 (11.7)	2823 (18.5)	<.001
Psychiatric	578 (1.0)	106 (0.7)	<.001
Seizures	252 (0.5)	47 (0.3)	.009
COPD	488 (0.9)	141 (0.9)	.485
Coagulopathy or hemophilia	285 (0.5)	149 (1.0)	<.001
Injury Type			
Blunt	54400 (96.8)	12980 (83.9)	<.001
Penetrating	1697 (3.0)	2474 (16.0)	<.001
Other (e.g., drowning, suffocation)	98 (0.2)	24 (0.2)	.593
Injury Intent			
Unintentional	48847 (86.9)	11987 (77.5)	<.001
Suicide/attempted suicide	453 (0.8)	1180 (7.6)	<.001
Assault	5057 (9.0)	1618 (10.5)	<.001
Undetermined	1838 (3.3)	693 (4.5)	<.001

Table 3.1. Patient, injury and hospital characteristics by discharge status (continued)

	Discharged Alive No. (%) (n=56,195)	Died in Hospital No. (%) (n=15,478)	p Value
Injury Severity Score (mean)	23.5	32.1	<.001
Maximum TBI injury scale			
AIS 4	24997 (44.5)	2371 (15.3)	<.001
AIS 5	8435 (15.0)	10931 (70.6)	<.001
Glasgow Coma Score in ED			
3	8267 (14.7)	9407 (60.8)	<.001
4-7	4539 (8.1)	1957 (12.6)	<.001
8-11	4160 (7.4)	868 (5.6)	<.001
12-14	10426 (18.6)	1166 (7.5)	<.001
15	23515 (41.9)	1125 (7.3)	<.001
Unknown	4558 (8.1)	896 (5.8)	<.001
Spinal cord injury diagnosis	1975 (3.5)	645 (4.2)	<.001
Hypotension in ED (Systolic BP<90 mmHG)	2204 (3.9)	3708 (24.0)	<.001
Blood products received	3304 (5.9)	1793 (11.6)	<.001
Hospital teaching status			
Community teaching	15738 (28.0)	4372 (28.3)	.556
University teaching	33408 (59.5)	9282 (60.0)	.24
Non-teaching	3207 (5.7)	923 (6.0)	.23
Unknown	3,842 (6.8)	901 (5.8)	<.001
Hospital type			
Public	28653 (51.0)	8178 (52.8)	<.001
Private	23609 (42.0)	6307 (40.8)	.005
Unknown	3933 (7.0)	993 (6.4)	.009
Transferred in from another hospital	15578 (27.7)	3436 (22.2)	<.001
Mean TBI Volume (annual)	566.2	562.7	.274
Trauma Designation			
Level 1	39114 (69.6)	10661 (68.9)	.084
Level 2	17081 (30.4)	4817 (31.1)	.084

Table 3.2. Patient, injury and hospital characteristics by race

Characteristic	White No. (%) (n=45764)	Black No. (%) (n=8963)	Hispanic No. (%) (n=8575)	Asian No. (%) (n=1500)	Native American No. (%) (n=514)	Other No. (%) (n=1436)
Female	15462 (32.5)	2223* (24.8)	1716* (20.0)	557* (37.1)	120* (23.3)	405* (28.2)
Age (mean)	42.6	34.7*	31.9*	43.5	32.3*	34.9*
Died	9405 (19.8)	2006* (22.4)	1954* (22.8)	374* (24.9)	85 (16.5)	259 (18.0)
Discharge to Rehabilitation	9847 (20.7)	1423* (15.9)	1277* (14.9)	233* (15.5)	88* (17.1)	191* (13.3)
Primary payer						
Medicare	6237 (13.1)	574* (6.4)	293* (3.4)	191 (12.7)	13* (2.5)	70* (4.9)
Medicaid	3861 (8.1)	1469* (16.4)	1361* (15.9)	194* (12.9)	84* (16.3)	152* (10.6)
Self-pay	5066 (10.6)	1726* (19.3)	2309* (26.9)	268* (17.9)	61 (11.9)	169 (11.8)
Other payer	21423 (45.0)	2652* (29.6)	3188* (37.2)	591* (39.4)	190* (37.0)	474* (33.0)
Injury Severity Score (mean)	25.3	25.3	25.8*	25.9*	24.2*	25.2
Penetrating injury	1787 (3.8)	1272* (14.2)	869* (10.1)	73 (4.9)	25 (4.9)	67 (4.7)
Glasgow Coma Score in ED (mean)	10.4	9.9*	9.6*	10.0*	9.8*	10.5
Level II hospital	16346 (34.3)	1446* (16.1)	2508* (29.2)	487 (32.5)	150* (29.2)	349* (24.3)

*Significantly different from White ($p<.05$).

Table 3.3. Adjusted factors associated with death in patients with moderate to severe traumatic brain injury

	Level I Hospitals		Level II Hospitals	
Risk Factor	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
Age	1.02 (1.02, 1.03)	<.001	1.03 (1.02, 1.04)	<.001
Female	1.08 (0.99, 1.18)	.071	0.91 (0.81, 1.02)	.090
Race				
White	1.0 (reference)		1.0 (reference)	
Black	1.14 (0.94, 1.38)	.173	1.32 (1.06, 1.64)	.012
Hispanic	1.37 (0.98, 1.91)	.064	1.24 (0.98, 1.57)	.068
Asian	1.41 (0.99, 1.99)	.053	1.47 (1.11, 1.96)	.008
Native American	0.87 (0.53, 1.43)	.578	0.50 (0.18, 1.38)	.178
Other	0.97 (0.71, 1.31)	.819	1.13 (0.73, 1.74)	.586
Missing	0.91 (0.65, 1.27)	.573	1.06 (0.84, 1.35)	.607
Glasgow Coma Scale				
3	20.22 (14.3, 28.5)	<.001	26.53 (19.03, 37.00)	<.001
4-7	7.87 (5.98, 10.34)	<.001	8.59 (6.31, 11.70)	<.001
8-11	3.71 (2.92, 4.74)	<.001	3.68 (2.78, 4.87)	<.001
12-14	1.90 (1.57, 2.30)	<.001	2.00 (1.61, 2.47)	<.001
Missing	3.47 (2.60, 4.61)	<.001	2.65 (1.71, 4.10)	<.001
15	1.0 (reference)		1.0 (reference)	
Anatomic profile				
Component A	1.34 (1.26, 1.43)	<.001	1.26 (1.19, 1.33)	<.001
Component B	1.06 (1.02, 1.11)	.003	1.07 (1.03, 1.11)	<.001
Component C	1.03 (0.99, 1.08)	.104	1.04 (0.99, 1.09)	.160
Component D	0.73 (0.68, 0.78)	<.001	0.74 (0.69, 0.79)	<.001
Penetrating injury	4.46 (3.44, 5.79)	<.001	2.85 (2.00, 4.06)	<.001
Spinal cord injury	1.10 (0.88, 1.36)	.410	0.74 (0.53, 1.04)	.081
Hypotension	6.08 (5.02, 7.35)	<.001	6.17 (4.91, 7.75)	<.001
Blood products	2.00 (1.60, 2.50)	<.001	1.87 (1.41, 2.48)	<.001
Payer				
Commercial & other	1.0 (reference)			
Medicare	1.50 (1.25, 1.79)	<.001	1.09 (0.87, 1.36)	.447
Self-pay	2.07 (1.68, 2.56)	<.001	1.39 (1.08, 1.79)	.010
Medicaid	0.76 (0.61, 0.94)	.011	0.69 (0.52, 0.94)	.017
Missing	1.16 (0.86, 1.58)	.332	1.19 (0.88, 1.60)	.257

Table 3.3. Adjusted factors associated with death in patients with moderate to severe traumatic brain injury (continued)

Risk Factor	Level I Hospitals OR (95% CI)	*P* Value	Level II Hospitals OR (95% CI)	*P* Value
Intent				
Unintentional	1.0 (reference)		1.0 (reference)	
Self-inflicted	1.23 (0.90, 1.70)	.194	2.59 (1.57, 4.27)	<.001
Interpersonal	0.59 (0.50, 0.69)	<.001	0.78 (0.60, 1.02)	.065
Undetermined	1.34 (0.95, 1.88)	.094	1.28 (0.96, 1.70)	.095
Volume				
<300	0.95 (0.72, 1.26)	.744	0.82 (0.66, 1.01)	.067
300-600	1.20 (0.94, 1.53)	.143	0.83 (0.64, 1.07)	.152
>600	1.0 (reference)		1.0 (reference)	
Co-morbidities				
Heart Disease	1.27 (1.02, 1.58)	.033	0.95 (0.75, 1.19)	.651
COPD	0.87 (0.62, 1.22)	.417	1.43 (0.84, 2.45)	.188
Diabetes	1.26 (0.87, 1.81)	.217	0.88 (0.68, 1.13)	.306

Table 3.4. Adjusted factors associated with discharge to a rehabilitation center for survivors with severe traumatic brain injury

	Level I Hospitals		Level II Hospitals	
Risk Factor	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
Age	1.00 (0.99, 1.00)	.393	1.00 (0.99, 1.00)	.428
Female	0.96 (0.83, 1.11)	.551	0.97 (0.83, 1.13)	.689
Race				
White	1.0 (reference)		1.0 (reference)	
Black	0.66 (0.51, 0.86)	.002	0.60 (0.40, 0.91)	.015
Hispanic	0.73 (0.50, 1.05)	.091	0.63 (0.43, 0.93)	.020
Asian	0.79 (0.48, 1.32)	.370	0.95 (0.59, 1.52)	.828
Native American	0.55 (0.30, 1.02)	.057	1.45 (0.54, 3.91)	.459
Other	0.89 (0.52, 1.50)	.654	0.52 (0.25, 1.09)	.085
Missing	0.36 (0.20, 0.65)	.001	0.08 (0.03, 0.24)	<.001
Glasgow Coma Scale				
3	4.14 (3.03, 5.64)	<.001	4.82 (3.53, 6.59)	<.001
4-7	4.32 (3.13, 5.97)	<.001	5.25 (3.73, 7.40)	<.001
8-11	2.89 (2.07, 4.02)	<.001	2.94 (2.03, 4.26)	<.001
12-14	1.75 (1.32, 2.32)	<.001	1.62 (1.19, 2.22)	.002
Missing	2.67 (1.78, 4.01)	<.001	1.35 (0.75, 2.42)	.312
15	1.0 (reference)		1.0 (reference)	
Spinal cord injury	2.83 (1.77, 4.53)	<.001	2.42 (1.29, 4.57)	.006
Payer				
Commercial and other	1.0 (reference)		1.0 (reference)	
Medicare	0.68 (0.45, 1.03)	.070	0.60 (0.37, 0.98)	.041
Self-pay	0.79 (0.57, 1.10)	.164	0.44 (0.26, 0.75)	.003
Medicaid	0.71 (0.57, 0.90)	.004	0.59 (0.41, 0.84)	.004
Missing	0.92 (0.62, 1.37)	.693	1.02 (0.70, 1.51)	.891
Length of stay	1.01 (1.00, 1.01)	.065	1.00 (1.00, 1.01)	.668

Chapter 4: Hospital Characteristics and Rural Trauma Outcomes

Summary

People living in rural areas suffer higher per capita death rates than urban dwellers for all injuries, and rural residents are 50% more likely to die from trauma than urban residents. Yet, the role played by organized trauma systems in rural settings has received relatively little attention.

We tested two hypotheses: trauma patients are more likely to expire in rural hospitals without trauma designation than in similar designated hospitals, and admitted patients are more likely to be transferred after admission from non-designated hospitals than from designated hospitals.

We conducted a retrospective cohort study using data from the National Inpatient Sample (NIS) for years 1998-2003. Multivariable logistic regression was used to control for patient and hospital characteristics with stratification by hospital volume (<500 discharges per year, 500-1500 discharges per year). Included in the analyses were all patients who were hospitalized with a moderate to major traumatic (non-iatrogenic) injury in nonfederal short-stay rural hospitals with annual discharges of 1500 or fewer patients (N=9,590). Our main outcome measures were in-hospital death and transfer to another acute care facility after initial admission.

A total of 333 patients (3.5%) died in-hospital. After adjusting for patient, injury and hospital characteristics, in-hospital death was more likely among patients treated at non-designated hospitals with less than 500 discharges per year (OR, 2.35, 95% CI 1.25-4.41) than among patients treated at similar trauma-designated hospitals. Patients were also more likely to be transferred after admission to a non-designated hospital, although this finding was significant only in the larger volume hospitals with discharges of 500-1500 per year (OR 1.41,

95% CI 1.08-1.83). The increased in-hospital mortality rate in non-designated hospitals deserves attention. Expanding trauma designation to include more rural hospitals may lead to improved outcomes. Implementing transfer requirements for non-designated hospitals may reduce delays in definitive care for injured patients in rural settings.

Introduction

There is a general perception that trauma victims cared for in rural areas experience greater morbidity and mortality than their urban counterparts – a perception supported by a number of published observations. For example, people living in rural areas suffer a higher per capita death rate than urban dwellers for all types of injuries.[73,74] Rural residents are 50% more likely to die from trauma than urban residents.[75,76] Motor vehicle crashes are the leading cause of mortality for both urban and rural trauma victims, although the rural motor-vehicle fatality rate is 31.4 per 100,000 compared to metropolitan areas with a rate of 13.2 per 100,000.[77] Furthermore, the frequency of traumatic injury may be greater in rural areas. For example, drowning, falls, farm-related and occupational injury rates are also higher in rural areas compared to urban areas. Residents of remote, rural counties also tend to have higher rates of traumatic brain injury (fatal and non-fatal) than urban residents.[78]

The geography of rural areas (e.g., inclement weather, difficult terrain) and the occurrence of unwitnessed injury create unique challenges for trauma care. Long transport times, rudimentary training of prehospital personnel, fewer available physicians, and limited exposure to trauma patients are also cited as reasons for poor outcomes for rural trauma patients.[79] A reliance on volunteer EMS providers and the general public's tendency to privately transport family members to local hospitals may also add to the challenges of rural trauma care. Additional hospital-based factors cited as significant contributors to the excess mortality in rural areas include limited diagnostic capabilities and delayed or incomplete

surgical capabilities.[80,81,82,83] Several studies have documented that many rural trauma deaths are preventable, with evidence that a high rate of inappropriate emergency department care related to airway and chest injury management is a major contributor to preventable rural trauma deaths.[84,85,86] Typically, trauma designation requirements address training for emergency department personnel in the resuscitation and stabilization of trauma patients through such courses as Advanced Trauma Life Support.

Lower expectations may exist in rural communities with regard to trauma care. Esposito reported that because rural communities typically believe in the adequacy of their medical care system, there has been little emphasis on the development of organized trauma systems in rural areas[87]. MacKenzie and colleagues also identified the need to define the appropriate role for level 3, level 4 and level 5 trauma centers in these areas, as well as the benefits and possible disadvantages of inclusive systems of trauma care in which all hospitals are categorized at some level of trauma designation.[88] Time delays can negatively affect patient outcomes, and inclusive systems may lead to longer time to receive definitive care.[89,90] Despite the two-fold greater rate of trauma mortality in rural communities than in urban areas, the role played by trauma systems in the rural setting has received relatively little attention, and is limited to studies focusing on one or two level 3 hospitals in a regional trauma system or a single state system.[91,92] Significant financial and personnel costs are associated with developing and maintaining a rural trauma system, and thus it is essential to determine the benefits associated with rural hospital participation in trauma systems so that policy-makers can better address system design and implementation to assure optimal trauma care while avoiding over-designation of trauma services and the accompanying duplication of effort.

This study uses administrative data to assess the effects of trauma-designation level on mortality outcomes in rural areas and the likelihood of patient transfer to another acute care facility after initial admission to a rural hospital. The results of the study should be useful in

promoting and informing a policy debate about the utility of trauma-designation systems for improving rural quality of trauma care.

Design and Methods

Data source

Discharge administrative data from the 1998-2003 National Inpatient Sample of the Healthcare Cost and Utilization Project, sponsored by the Agency for Healthcare Quality and Research, were used for this study. The NIS is provided by public and private statewide data organizations as part of a federal-state-private collaboration.[93] The NIS data are collected and compiled in a uniform format from a national sample of more than 1000 hospitals annually. Each data year includes all hospital discharges from the participating hospitals, representing about 7 million hospitalizations per year. The sampling frame includes discharges from non-federal, short-term general and specialty hospitals (excluding rehabilitation hospitals and hospital units of institutions, such as prisons, mental institutions and developmental centers) in the United States. Federal hospitals (Veterans Administration, Department of Defense, and Indian Health Service hospitals) are not included in the NIS. Data were obtained from the HCUP Central Distributor, with approval from the institutional review board at the University of Washington.

The NIS data include demographic information (e.g., age, gender), admission type and source, diagnostic and procedure codes, payer source and total charges, length of stay and discharge disposition. A NIS hospital data file with facility characteristics (e.g., hospital location, ownership, bed size, urban/rural, geographic region, and teaching status) can be linked to the patient core data. The NIS does not contain physiologic or laboratory patient data.

Eligibility

For this study, the population of interest was victims of traumatic injury cared for in small hospitals in the rural setting. As such, eligibility was limited to patients discharged from hospitals that were identified as rural in the NIS (i.e., hospitals located in non-metropolitan statistical areas). Patients were also required to have been hospitalized with an *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD9-CM) code for any injury (800-904.9, 910-959.9) in any of up to 15 diagnoses on the discharge record. We excluded late effects of injury (ICD9-CM 905-909.9). We also excluded patients with minor injuries only as indicated by an Injury Severity Score of less than 9. Hospitals from 11 states not providing hospital identifiers to allow for determination of trauma designation were excluded. As our focus was on small, rural hospitals, we excluded large volume hospitals, defined as having annual discharges of greater than 1500 patients – the median volume of hospitals with level IV trauma designation in the sample.

Dependent variables

We identified patients who died from the uniform coding of hospital disposition. We created a binary indicator variable for 'died', coded '1' for 'died in hospital' and '0' for 'discharged alive'. Similarly, we identified patients who were transferred to another acute care facility after initial admission at the rural hospital from the uniform disposition. A binary indicator variable was created for 'transferred patient' and coded 1 if discharge disposition was transfer to another acute care facility and 0 for all other dispositions excluding death, such as to home or to a skilled nursing facility.

Independent variables

Hospital trauma designation level is not identified in the NIS dataset. To identify trauma designation level, we used data from the American Trauma Society's national trauma

service inventory. The American Trauma Society surveyed all hospitals nationwide to ascertain trauma designation levels. These data include the American Hospital Association's hospital identification number for each facility that allowed linking to the NIS hospital file. We created a binary indicator variable for hospitals without trauma designation, coded 1 if no designation and 0 if designated at level III-V. No level I or II hospitals were included as all had more than 1500 annual hospital discharges.

Control and confounding variables

We selected control and confounding variables *a priori* for the multivariable analytic models and confirmed importance based on the presence of significant bivariate associations when comparing variables by hospital type (trauma designated vs. not trauma designated) or status (lived vs. died). Indicator variables were created for payer groupings (Medicare, Medicaid, self-pay, commercial/private payer, other payer, missing payer), teaching hospital, and received-in-transfer patient. We defined a control variable for the presence of potentially 'damage control surgery' (i.e., emergency, life-saving surgery performed to merely stabilize a critically injured patient's vital signs, and not intended as definitive surgery for the underlying injury) based on relevant ICD9-CM procedure codes[94]. Because the NIS does not include vital signs such as systolic blood pressure, we included receiving a blood transfusion as a surrogate for hypotension using an indicator variable for receipt of blood products (ICD9-CM procedure 99.0). We also created an indicator variable for penetrating injury based on the presence of an External Cause of Injury (E-code) for firearms, knives, or cuts. An injury severity score (ISS) was calculated for each record using the ICDMAP-90 software.[95] The ISS is widely accepted as a valid measure of injury severity and is used as a control variable in this analysis.[96,97] Other control variables included patient-specific variables such as age, gender and race. We categorized age into four groups (0-54 years, 55-74, 75-84, >=85 years) to reflect the relatively older population receiving care in smaller, rural hospitals.

The NIS hospital file includes an identification of hospital location (urban or rural) based on the metropolitan statistical area (MSA) designation assigned to each hospital. The binary field is coded as either urban or rural, and we restricted our study to rural based on this classification. As the smallest geographic identifiers available in the NIS data are hospital ZIP codes, we obtained additional geographic precision by including the Rural Urban Commuting Area (RUCA) ZIP code approximation.[98] The RUCA system is a ten-tiered classification system based population size and commuting relationships and ranges from urbanized (continuously built up areas of 50,000 or more) to isolated rural with population of less than 2500. As many data sets will not support analysis using a ten-tiered classification system as in RUCA, we opted for the four-tiered consolidation of RUCA codes developed by Schueller.[99] This approach consolidates RUCA codes into four classes: 1) urban core areas, 2) suburban areas, 3) large town areas and 4) small town and isolated rural areas. We included the 4-tiered RUCA variable in our multivariable analyses to reduce confounding and potentially increase precision.

Data Analysis

Univariate and bivariate analyses were completed using t-tests for continuous variables and chi-square tests for categorical variables. To identify significant associations between patient and hospital factors (including trauma designation) and in-hospital death, we used logistic regression with death as the dependent variable and the independent and control variables described above. We adjusted for clustering on hospital identifier to account for correlation of individual outcomes within hospitals using the cluster option in Stata 9.1 (College Station, Texas). Explanatory variables are presented as odds ratios, with p-values and confidence intervals. We also examined odds of transfer to another acute care facility among survivors using multivariable clustered logistic regression.

Evidence on the relationship between trauma center volume and outcomes has been mixed and mainly focused on level 1 and 2 trauma centers located primarily in urban settings.[100,101,102,103] No studies were identified on the relationship between volume and trauma outcomes in rural hospitals. As volume may serve as a proxy for hospital size (e.g., beds) and capabilities (available resources and technology), we stratified our analysis by hospital volume. We examined separately hospitals with annual discharges of less than 500 and those with discharges of between 500 and 1500 patients per year.

Results

Overall

We identified a total of 9,590 hospitalizations with injuries among small, rural hospitals. There were 333 in-hospital deaths representing 3.5% of injury hospitalizations. We identified 1176 (12.3%) patients who were initially admitted to a rural hospital, but subsequently transferred to another acute care facility.

Age, Gender, Payer, and Injury Characteristics

Table 4.1 presents the relative frequencies of patient and hospital characteristics and their relationships with trauma designation. Patients receiving care in hospitals with trauma designation were older than those cared for at non-designated hospitals (mean age 75.2 years vs. 72.8 years, $p<.001$). We observed similar distributions by gender across hospital designation, with a greater proportion of women than men discharged from both designated and non-designated hospitals. Patients were more likely to be Medicare recipients in designated hospitals, although this may be explained by age. We observed a small difference in the proportion of patients receiving Medicaid (3.3% at non-designated hospitals vs. 1.7% at designated hospitals, $p<.001$). We did not observe a significant difference in injury severity by hospital designation. Patients received in transfer from another acute care facility were more

common among designated trauma hospitals than among hospitals without designation (7.8% vs. 3.8%, p<.001), as expected with participation in organized trauma systems. Patients in non-designated hospitals were slightly more likely to receive blood products in hospital (10.5% vs. 8.9%, p=.014). Penetrating trauma was rare in this sample, representing less than 0.5% of cases. As such, we excluded penetrating trauma from the multivariable analyses.

Hospital characteristics

Table 4.2 presents the relative frequencies of hospital characteristics and their bivariate relationships with trauma designation versus no designation. Trauma hospitals were more likely to be located in the Midwest and West regions, whereas non-designated hospitals were more likely to be located in the Northeast or South. Limiting our sample to hospitals with annual discharges of 1500 or fewer and to states providing hospital identifiers may have influenced the observable differences across regions, and thus we controlled for region in the multivariable analyses. Trauma hospitals were more likely to be classified as small town/isolated rural than non-designated hospitals (86.7% vs. 80.7%, p<.001), and a greater proportion of patients received care at trauma hospitals with fewer than 500 discharges per year than at non-designated hospitals with similar volume (21.3% vs. 14.4%, p<.001).

Multivariable Logistic Regression

Table 4.3 presents the adjusted results of a stratified logistic regression model evaluating the odds of in-hospital death based on patient and hospital risk factors identified in Tables 4.1 and 4.2. While initially included as a potential confounder, payer status was removed from the mortality model because its effect on the model was insignificant and the effect size of the variable of interest (trauma designation) was unchanged.

In the lowest volume hospitals (fewer than 500 total discharges per year), patients were more likely to die in non-designated hospitals than in trauma designated hospitals (OR 2.35, 95% CI 1.25-4.41, p=.008). We observed an increased risk of death in males, in older

patients, and in patients with more severe injuries. In the higher volume hospitals (500-1500 discharges per year), lack of trauma designation was not associated with an increased risk of in-hospital death. However, similar to the lowest volume hospitals, we did observe an increased risk of death in males, in older patients, and in patients with more severe injuries. Irrespective of volume, race was not associated with risk of death in non-designated or designated hospitals. The fit of the logistic regressions modeling in-hospital mortality was good, with a *p*-value for the Hosmer-Lemeshow tests of 0.36 and 0.85 respectively. We also conducted several sensitivity analyses including a restricted analysis of small town hospitals only (i.e., hospitals with coded as '4' for small town rural in the RUCA 4-tier classification scheme) and an analysis of adults only rather than the inclusive model of patients of all ages. In both cases, our results were robust with regard to magnitude and significance of the predictors of interest.

We next compared factors associated with transfer to another acute care facility after initial admission at a rural hospital. Table 4.4 presents the adjusted results of a stratified logistic regression modeling the odds of transfer out among survivors based on patient and hospital risk factors identified in Tables 4.1 and 4.2. In the lowest volume hospitals, we did not observe an association between trauma designation and odds of transfer after admission. However, in the higher volume hospitals, hospitals without trauma designation were more likely to transfer patients after admission (OR 1.41, 95% CI 1.08-1.83, p=.011). Women were less likely to be transferred after admission, whereas patients with more severe injuries were more likely to receive a transfer. Race was not associated with likelihood of transfer in either the low or high volume hospitals. We did observe that Medicaid patients in the lowest volume hospitals were significantly more likely to be transferred than patients with other payers (OR 4.60, 95% CI 2.16-9.80, p<.001). No significant payer difference was observed in the larger volume hospitals.

Discussion

While studies have demonstrated the effectiveness of trauma-center care on mortality in patients hospitalized in large, urban hospitals[104], little is known about the effect of trauma designation on the care provided to patients in small, rural hospitals. To our knowledge, this is the first study to compare the risk of in-hospital death and delayed transfer between rural hospitals with trauma designation and similar hospitals without designation, controlling for observable patient, injury and hospital characteristics. We observed an increased risk of death for patients treated at the smallest non-designated rural hospitals compared to similarly sized and located trauma-designated hospitals. This finding was robust after controlling for many patient and hospital characteristics. However, in the larger volume hospitals with 500 or more annual discharges, we did not observe a difference in mortality.

We hypothesized that trauma hospitals would be better positioned to identify patients needing a higher level of care prior to admission, and thus would be less likely to transfer patients after an initial admission. In the smallest hospitals, we did not observe a difference in likelihood of transfer after admission. However, in the larger volume hospitals, non-designated hospitals were more likely to transfer patients after admission. In our study, we were unable to determine factors influencing the decision to admit vs. transfer a patient from the emergency department, although the presence of trauma protocols and procedures associated with designation may be influential. It appears that the increased mortality observed in small, non-designated hospitals (compared to designated hospitals) may disappear in larger non-designated hospitals, where patient transfers are more likely after admission (compared to designated hospitals). These findings may offer support for the benefit of trauma system utilization in the rural setting.

There are several limitations to our study. First, we cannot rule out the potential for omitted variable bias due to unobserved covariates that might distinguish the group of patients receiving care at non-designated hospitals from those cared for at trauma hospitals. While we believe that our model adequately adjusts for patient and hospital characteristics, we cannot rule out the possibility of unmeasured covariates that could further distinguish the treatment groups. Second, we lacked physiologic data, such as systolic blood pressure that could have further improved our ability to adjust for injury severity. Third, we relied on mapping of ICD9-CM diagnostic codes to determine injury severity, rather than the preferred, but unavailable, direct coding of injuries using the Abbreviate Injury Scale[105]. We also used blood transfusion as a surrogate for hypotension and blood loss, but we do not know the extent of transfusions (i.e., number of units received) or the time course of transfusions (i.e., in the emergency room, in the operating room, or in the intensive care unit or ward setting). We also performed a sensitivity analysis including 'damage-control surgery' in the models; the results were comparable to the original model with no significant differences. Fourth, we did not have prehospital data (e.g., weather restrictions for transport, receiving hospital diversion status, scene vital signs, etc.) or hospital data (e.g., census status, physician or other staffing availability, operating room availability) that potentially could have identified other important factors that could impact transfer decisions.

Lastly, we cannot rule out the possibility of selection bias in this sample, with seriously injured patients potentially being transported more often to designated trauma facilities. However, if this bias does exist in these data, we expect that the direction would be towards the null. In addition, the injury severity of patients was not different between the two hospitals groups (Table 4.1). We also cannot rule out the possibility that the most seriously injured patients were too unstable to be transported to a designated hospital in which case it might be expected that a higher rate of death would be found. We believe that controlling for

rurality, hospital volume, injury severity and receipt of blood products should mitigate this potential.

The clinical decision at the initial hospital to admit or transfer an injured patient may depend on the training and experience of the emergency department provider and the available hospital resources and capabilities. In the smallest, rural hospitals, medical care in emergency departments may be supervised primarily by nurse practitioners, physician assistants or family practice physicians, rather than by emergency medicine physicians or surgeons, as commonly occurs in urban areas. We were unable to identify the actual level of training of the decision-maker (i.e., emergency medicine physician, nurse practitioner, physician assistant). Also, we cannot rule out differences in care that may be attributable to hospital personnel, such as the presence and availability of general surgeons, or to hospital resources, such as an intensive care unit or redundancy in blood product availability – all of which may impact care and outcomes of the injured patient.

This study provides evidence in support of trauma designation for rural hospitals. While previous studies have been limited to large, urban hospitals, this study is the first to document the benefit of trauma designation to small, rural hospitals. The increased in-hospital mortality rate in non-designated hospitals deserves attention. Opportunities for quality improvement as well as potential policy intervention should be pursued as one step towards reducing preventable trauma mortality in rural communities. The development of transfer guidelines and/or requirements for non-designated hospitals should also be considered to reduce delays in reaching definitive care for the injured rural patient.

Table 4.1. Patient and injury characteristics of rural trauma hospitalizations by hospital designation

	Hospitals without trauma Designation No.(%) (n=6,159)	Hospitals with trauma designation No.(%) (n=3,431)	P-value
Female	3950 (64.1)	2248 (65.6)	.165
Age (mean)	72.8 years	75.2 years	<.001
0-54 y	1114 (18.1)	495 (14.4)	
55-74 y	1121 (18.2)	553 (16.1)	
75-84 y	1793 (29.1)	1049 (30.6)	
>=85 y	2130 (34.6)	1334 (38.9)	
Race			
White	3396 (55.1)	2252 (65.6)	<.001
Black	58 (0.9)	3 (0.1)	<.001
Hispanic	45 (0.7)	26 (0.8)	.882
Asian/Pacific Islander	15 (0.2)	5 (0.2)	.314
Native American	41 (0.7)	1 (<0.1)	<.001
Other	39 (0.6)	7 (0.2)	<.001
Unknown	2565 (41.7)	1137 (33.1)	<.001
Primary payer			
Medicare	4370 (71.0)	2602 (75.8)	<.001
Medicaid	206 (3.3)	58 (1.7)	<.001
Commercial/HMO/private	1147 (18.6)	568 (16.6)	.011
Self-pay	242 (3.9)	115 (3.4)	.152
Other payer	182 (3.0)	87 (2.5)	.233
Injury Severity Score			
Mean	10.2	10.1	.054
9-15	5666 (92.0)	3212 (93.6)	
16-24	418 (6.8)	180 (5.3)	
25-75	85 (1.4)	45 (1.3)	
Penetrating injury	31 (0.5)	7 (0.2)	.025
Transferred in from another acute care facility	233 (3.8)	266 (7.8)	<.001
Received blood products	646 (10.5)	306 (8.9)	.014
In-hospital death	209 (3.4)	124 (3.6)	.596
Transferred after initial Admission	814 (13.2)	362 (10.6)	<.001

Table 4.2. Hospital characteristics of rural trauma hospitalizations by designation

	No Trauma Designation No. (%) (n=6159)	Trauma Designation No.(%) (n=3431)	P-value
Hospital region			<.001
Northeast	729 (11.8)	11 (0.3)	
Midwest	2940 (47.7)	2088 (60.9)	
South	1420 (23.1)	18 (0.5)	
West	1070 (17.4)	1314 (38.3)	
Rural-urban classification			<.001
Rural, urban fringe	131 (2.1)	94 (2.7)	
Large town	1056 (17.2)	362 (10.6)	
Small town/isolated rural	4972 (80.7)	2975 (86.7)	
Total hospital discharges per year			
Mean	958.3	890.6	<.001
<500	889 (14.4)	732 (21.3)	
500-999	2141 (34.8)	1230 (35.9)	
1000-1500	3129 (50.8)	1469 (42.8)	
Hospital size			<.001
Small	3120 (50.7)	1289 (37.6)	
Medium	2435 (39.5)	1699 (49.5)	
Large	604 (9.8)	443 (12.9)	

Table 4.3. Predictors of in-hospital death for individuals with moderate to severe blunt traumatic injury using clustered logistic regression

Risk Factor	Hospitals with <500 Discharges per year† OR (95% CI)	*P* Value	Hospitals with 500-1500 discharges per year†† OR (95% CI)	*P* Value
No trauma designation	2.35 (1.25-4.41)	.008	0.90 (0.69-1.18)	.442
Age (y)	1.08 (1.05-1.10)	<.001	1.06 (1.05-1.08)	<.001
Female	0.47 (0.26-0.87)	.016	0.49 (0.39-0.62)	<.001
Injury severity score				
9-15	1.0 (reference)		1.0 (reference)	
16-24	1.64 (0.45-5.91)	.453	3.41 (2.31-5.02)	<.001
25-75	11.38 (2.39-54.19)	.002	12.79 (6.14-26.65)	<.001
Blood products received	1.12 (0.30-4.12)	. 864	1.50 (1.08-2.07)	.015
Transferred in from another hospital	2.24 (0.93-5.40)	.073	1.49 (0.98-2.25)	.06
Race/ethnicity				
White	1.0 (reference)		1.0 (reference)	
All other races/ethnicity	1.85 (0.51-6.76)	.351	0.86 (0.33-2.25)	.765
Missing race	0.53 (0.25-1.15)	.107	0.93 (0.70-1.24)	.63
Rural/Urban 4-tier code	0.97 (0.47-2.01)	.930	0.93 (0.70-1.23)	.613

†c=.80, Hosmer-Lemeshow test = 8.8 (*P*=.36). OR indicates odds ratio; CI, confidence interval.
††c=.74, Hosmer-Lemeshow test = 4.1 (*P*=.85)

Table 4.4. Transfer out after admission using Clustered Logistic Regression

Risk Factor	Hospitals with <500 Discharges per year† OR (95% CI)	*P* Value	Hospitals with 500-1500 discharges per year†† OR (95% CI)	*P* Value
No trauma designation	1.25 (0.80-1.94)	.333	1.41 (1.08-1.83)	.011
Age (y)	1.01 (1.00-1.02)	.042	1.00 (1.00-1.01)	.541
Female	0.59 (0.43-0.81)	.001	0.69 (0.59-0.81)	<.001
Injury severity score				
9-15	1.0 (reference)		1.0 (reference)	
16-24	1.48 (0.80-2.75)	.209	1.99 (1.52-2.62)	<.001
25-75	2.18 (0.83-5.79)	.115	2.28 (1.26-4.13)	.006
Blood products received	0.95 (0.44-2.06)	. 896	0.56 (0.40-0.78)	.001
Transferred in from another hospital	0.43 (0.24-0.77)	.005	0.72 (0.47-1.09)	.119
Race/ethnicity				
White	1.0 (reference)		1.0 (reference)	
All other races/ethnicity	1.18 (0.47-2.95)	.721	0.97 (0.64-1.45)	.872
Missing race	0.73 (0.47-1.12)	.153	1.02 (0.79-1.31)	.901
Primary payer				
Medicare	1.0 (reference)		1.0 (reference)	
Medicaid	4.60 (2.16-9.80)	<.001	1.23 (0.76-1.99)	.403
Self-pay/charity	0.82 (0.35-1.95)	.656	0.63 (0.38-1.03)	.065
Private pay/commercial	1.15 (0.67-1.98)	.609	0.81 (0.60-1.10)	.177
Other payer	0.96 (0.27-3.46)	.948	1.09 (0.70-1.71)	.705
Missing	1.37 (0.13-14.15)	.794	dropped	
Rural/Urban 4-tier code	1.11 (0.79-1.54)	.546	1.35 (0.99-1.83)	.055

†c=..62, Hosmer-Lemeshow test = 7.9 (*P*=.44). OR indicates odds ratio; CI, confidence interval.
††c=.61, Hosmer-Lemeshow test = 14.44 (*P*=.07)

Chapter 5: Conclusion

This research yielded a number of important findings. First, children with splenic injuries who received care at general hospitals were much more likely to undergo splenectomy than similar children who received care at children's hospitals. To reduce potentially unnecessary splenectomies in children, policymakers should consider options such as 1) the adoption of clinical practice guidelines for the management of pediatric splenic injuries, 2) the provision of continuing medical education in the area of pediatric splenic injury management, 3) the development of transfer agreements and protocols to assure that pediatric spleen patients are referred to children's hospitals, and 4) the conducting of chart reviews of pediatric splenic injury cases to facilitate quality improvement and assure adherence to guidelines and optimal practice.

In addition, for children with suspected abdominal injuries, destination procedures should be considered to allow ambulances to bypass a general hospital in favor of a children's hospital. Strategies to promote spleen-conserving practice should also be considered that include differential payer reimbursement for hospitals that demonstrate best practices. Alternatively, conservative non-operative management could receive an enhanced payment to provide an incentive for spleen-conserving practices rather than splenectomy. The finding of an association between hospital profit status and care management raises some concern in light of a nationwide trend towards hospital conversion from not-for-profit to for-profit ownership. This research may be useful to state legislators and/or insurance commissioners in their decision-making process of approving or denying hospital conversion requests.

Chapter 3 included findings of an association between race and TBI outcomes, with a noticeable disparity between people of color and Caucasians in the risk of in-hospital death and the likelihood of receiving post-acute rehabilitation services. The disparity appears greater

in level II trauma services than in level I hospitals, although it is unclear whether this is due to a greater reliance on neurosurgeons operating in private practice at level II hospitals, compared to level I models that rely more on neurosurgical residents. Policymakers should consider implementing targeted quality improvement initiatives address these disparities. In addition, peer-review of TBI charts should be conducted to identify the underlying causes of these disparities as well as to further focus efforts for quality improvement. Although provider bias and/or institutional racism may or may not be central to these disparities, the evidence clearly supports the need for strategies to address these disparities. The implementation of clinical practice guidelines for the care and management of TBI may also be an appropriate step toward assuring equal access to optimal care.

The chapter 4 findings documented a positive association between trauma designation and rural trauma hospital outcomes. Inclusive trauma systems have the potential to positively impact upon trauma outcomes by providing early resuscitation and stabilization of the trauma patient, while minimizing delays in transfer. This study provides evidence to policymakers in support of the value of trauma designation for rural hospitals.

This research adds to the knowledge of trauma systems effectiveness. Policy-makers can use the results of this research to support legislation aimed at including rural hospitals in new trauma systems, improving existing trauma systems or preserving mature systems that provide rural trauma care. High turnover in rural hospitals results in the need for substantial technical assistance to be provided by state trauma oversight agencies. Justifying the value of rural hospital participation in trauma systems is important to assuring ongoing state support for this assistance. Similarly, rural hospital administrators may use this evidence to support their decisions to participate in state trauma systems. For states without trauma systems, this research provides evidence in support of authorizing state trauma systems legislation.

The decision to include or exclude rural level 3-5 hospitals has significant economic and political implications for local communities. Significant costs are associated with operating a trauma service, including equipment, training and personnel. Enticing community physicians to join a trauma system or to remain participants in a trauma system requires good evidence of benefit. By determining the benefit of rural hospital trauma designation, this research should prove useful to hospital administrators and health policy-makers in their efforts to assure the provision of rural trauma services.

The 1966 white paper on injury, *Accidental death and disability: The neglected disease of modern society*, set the stage for early trauma system development.[106] Yet, despite significant efforts to implement trauma systems in the United States, one-third of states do not have organized trauma systems. States with trauma systems are struggling to balance the political realities of competing interest groups with the vision of assuring optimal resources for the injured patient.

REFERENCES

[1] National Center for Health Statistics

[2] National Academy of Sciences (1966). *Accidental death and disability: The neglected disease of modern society.* Washington, DC.

[3] Rutledge R, Fakhry SM, Meyer A, Sheldon GF, Baker C. An analysis of the association of trauma centers with per capita county trauma death rates. *Ann Surg* 1993;218:512-524.

[4] Stewart TC, Lane PL, Stefanits T. An evaluation of outcomes before and after trauma center designation using Trauma and Injury Severity Score analysis. *J Trauma.* 1995;39:1036-1040.

[5] Shackford SR, Mackersie RC, Hoyt DB, et al. Impact of a trauma system on outcome of severely injured patients. *Arch Surg.* 1987;122:523-527.

[6] Cales RH. Trauma mortality in Orange County: the effects of the implementation of a regional trauma system. *Ann Emerg Med.* 1984;13:1-10.

[7] Mann NC, Mullins RJ, MacKenzie EJ, Jurkovich GJ, Mock CN. Systematic review of published evidence regarding trauma system effectiveness. *J Trauma.* 1999;47(3)Supplement:S25-S33.

[8] Mullins RJ and Mann NC. Population-based research assessing the effectiveness of trauma systems. *J Trauma.* 1999;47(3):S-59-S66.

[9] Mackenzie EJ. Review of evidence regarding trauma system effectiveness resulting from panel studies. *J Trauma.* 1999;47(3)S34-S41.

[10] American College of Surgeons (1999): *Resources for the Optimal Care of the Injured Patient.* Chicago, IL.

[11] Rivara FP, Cummings P, Koepsell TD, Grossman DC, Maier RV (Eds.): Injury Control: A Guide to Research and Program Evaluation, chapter 16 (Stiell IG), p 217-235, Cambridge University Press, Cambridge UK, 2001.

[12] Sacco RL, Boden-Albala B, Gan R, et al. Stroke incidence among white, black and Hispanic residents of an urban community: the Northern Manhatten Stroke Study. *Am J Epidemiol* 1998;147:259-68.

[13] Robinson N, Lloyd CE, Stevens LK. Social deprivation and mortality in adults with diabetes mellitus. *Diabet Med* 1998;15:205-12.

[14] Wong MD, Shapiro MF, Boscardin WJ, Ettner SL. Contribution of major diseases to disparities in mortality. *N Engl J Med* 2002;347(20):1585-92.

[15] Edwards MJ, Gamel JW, Vaughan WP, Wrightson WR. Infiltrating ductal carcinoma of the breast: the survival impact of race. *J Clin Oncol* 1998;16:2693-9.

[16] Alexander M, Grumbach K, Remy L, Rowell R, Massie BM. Congestive heart failure hospitalizations and survival in California: patterns according to race/ethnicity. *Am Heart J* 1999;137:919-27.

[17] Nathans AB, Jurkovich GJ, Maier RV, et al. Relationship between trauma center volume and outcomes. *JAMA* 2001;285(9):1164-1171.

[18] Margulies DR, Cryer HG, McArthur DL, Lee SS, Bongard FS, Fleming AW. Patient volume per surgeon does not predict survival in adult level I trauma centers. *J Trauma* 2001;50(4):597-603.

[19] Glance LG, Osler TM, Dick A, Mukamel D. The relationship between trauma center outcome and volume in the National Trauma Data Bank. *J Trauma* 2004;56(3):682-690.

[20] London JA, Battistella FD. Is there a relationship between trauma center volume and mortality? *J Trauma* 2003;54(1):16-25.

[21] Gandjour A, Bannenberg A, Lauterbach KW. Threshold volumes associated with higher survival in health care: A systematic review. *Medical Care* 2003;41(10):1129-41.

[22] Douglas EJ and Simpson JS. The conservative management of splenic trauma. *J Pediatr Surg.* 1971; 6:565-570.

[23] Morse MA and Garcia VF. Selective non-operative management of pediatric blunt splenic trauma: risk for missed associated injuries. *J Pediatr Surg.* 1994; 29(1):23-27.

[24] Coburn MC, Pfeifer J, DeLuca FG. Nonoperative management of splenic and hepatic trauma in the multiply injured pediatric and adolescent patient. *Arch Surg.* 1995; 130(3):332-338.

[25] Cornwell EE. The role of nonoperative management of the injured spleen. *J Nat Med Assoc.*1993; 85(4):297-299.

[26] Eastern Association for the Surgery of Trauma (EAST), Guidelines for the Management of Liver and Spleen Injuries. Access via internet at www.east.org.

[27] Bain IM and Kirby RM. 10 year experience of splenic injury: an increasing place for conservative management after blunt trauma. *Injury.* 1998;29(3):177-182.

[28] HCUPnet interactive website, AHRQ. National estimates from the 2000 KIDS inpatient database.

[29] Myers JG, Dent DL, Stewart RM, et al. Blunt splenic injuries: dedicated trauma surgeons can achieve a high rate of nonoperative success in patients of all ages. *J of Trauma.* 2000;48(5):801-806.

[30] Lynch AM and Kapila R. Overwhelming postsplenectomy infection. *Infect Dis Clin North Am.* 1996;10:693-707.

[31] Singer D. Post-splenectomy sepsis. In: Rosenberge HS and Bolander RP (eds) Perspectives in Pediatric Pathology, 1973, Vol 1, Chicago Year Book, Medical Publishers, pp. 285-311.

[32] Deodar HA, Marshall RJ, Barnes JN. Increased risk of sepsis after splenectomy. *British Medical Journal.* 1993;307:1408-1409.

[33] Beytout J, Tournilhac O, Laurichesse H. Asplenia and hyposplenism. *Presse Med.* 2003;32(suppl):S5-9.

[34] Waghorn DJ. Overwhelming infection in Asplenic patients: current best practice preventive measures are not being followed. *J Clin Pathol.* 2001;54:214-218.

[35] Bain IM and Kirby RM. 10 year experience of splenic injury: an increasing place for conservative management after blunt trauma. *Injury.* 1998;29(3):177-182.

[36] Mooney DP, Forbes PW. Variation in the management of pediatric splenic injuries in New England. *J of Trauma.* 2004;56(2):328-333.

[37] Champion HR, Copes WS, Sacco WJ, et al. The major trauma outcome study: establishing national norms for trauma care. *J of Trauma.* 1990;30(11):1356-1365.

[38] Piontek FA, Coscia R, Marselle CS, Korn RL, Zarling EJ. The impact of American College of Surgeons verification on trauma outcomes. *J of Trauma.* 2003;54(6):1041-1047.

[39] Weinberg JA, McKinley K, Petersen SR, et al. Trauma laparotomy in a rural setting before transfer to a regional center: does it save lives? *J of Trauma.* 2003;54(5):823-828.

[40] Devereaux PJ, Heels-Ansdell D, Lacchetti C, et al. Payment for care at private for-profit and private not-for-profit hospitals: a systematic review and meta-analysis. *CMAJ.* 2004;170(12):1817-1824.

[41] Sloan FA, Trogdon JG, Curtis LH, Schulman KA. Does the ownership of the admitting hospital make a difference? Outcomes and process of care of Medicare beneficiaries admitted with acute myocardial infarction. *Med Care.* 2003;41(10):1193-205.

[42] Healthcare Cost and Utilization Project (HCUP). Kids' Inpatient Database (KID), 2000 (CD-ROMs). Rockville, MD: Agency for Healthcare Research and Quality; 2000.

[43] Examples of hospital units of institutions include hospital wards of prisons, mental institutions and developmental centers.

[44] ICDMAP-90 Injury Severity Coding Software, Johns Hopkins University and Tri-Analytics, Inc., Baltimore, MD, 1997.

[45] American College of Surgeon's Committee on Trauma. Resources for Optimal Care of the Injured Patient, 1999, Chicago, IL 1998.

[46] Feliciano DV, Moore EE, Mattox KI (Eds) 1996: Trauma, 3rd edition, pp 55-56, Appleton and Lange, Stamford, CT.

[47] Potoka DA, Schall LC, Ford HR. Risk factors for splenectomy in children with blunt splenic trauma. *J of Ped Surg 2002*;37(3):294-299.

[48] Mooney DP, Forbes PW. Variation in the management of pediatric splenic injuries in New England. *J of Trauma* 2004;56(2):328-333.

[49] Cuellar AE and Gertler PJ. Trends in hospital consolidation: the formation of local systems. *Health Affairs* 2003;22(6):77-87.

[50] Horning B. Triad's new market strategy: a threat to community hospitals. *States Health* 2004;12(1):1-10.

[51] Eastern Association for the Surgery of Trauma, Clinical Practice Guidelines. Accessed via internet at east.org, May, 2004.

[52] Centers for Disease Control and Prevention (CDC), National Center for Injury Prevention and Control. Traumatic Brain Injury in the United States: A Report to Congress. Atlanta, GA, 1999.

[53] Thurman D, Alverson C, Dunn K, Guerrero J, Sniezek J. Traumatic brain injury in the United States: a public health perspective. *J Head Trauma Rehab* 1999;14(6):602-15.

[54] Centers for Disease Control and Prevention (CDC), National Center for Injury Prevention and Control. Injury fact book 2001-2002. Atlanta, GA 2001.

[55] Thurman D, Alverson C, Dunn K, Guerrero J, Sniezek J. Traumatic brain injury in the United States: a public health perspective. *J Head Trauma Rehab* 1999;14(6):602-15.

[56] Washington Trauma Registry, 2003 data.

[57] Institute of Medicine. *Unequal treatment: What healthcare providers need to know about racial and ethnic disparities in healthcare.* National Academy of Sciences, March 2002.

[58] American College of Surgeons, National Trauma Data Bank 2005 Fact Sheet, accessed via internet on December 14, 2005, http://www.facs.org/trauma/ntdbfaq.html

[59] Langlois JA, Rutland-Brown W, Thomas KE. *Traumatic Brain Injury in the United States: Emergency Department Visits, Hospitalizations, and Deaths.* Atlanta (GA): Centers for Disease Control and Prevention, National Center for Injury Prevention and Control; 2004.

[60] ICDMAP-90 Injury Severity Coding Software, Johns Hopkins University and Tri-Analytics, Inc., Baltimore, MD, 1997.

[61] Copes WS, Champion HR, Sacco WJ, Lawnick MM, Gann DS, Gennarelli T, MacKenzie E, Schwaitzberg S. Progress in characterizing anatomic injury. *J Trauma* 1990;30(10):1200-1207.

[62] Sacco WJ, MacKenzie EJ, Champion HR, Davis EG, Buckman RF. Comparison of alternative methods for assessing injury severity based on anatomic descriptors. *J Trauma* 1999;47(3):441-446.

[63] Stephenson SC, Langley JD, Civil ID. Comparing measures of injury severity for use with large databases. *J Trauma* 2002;53(2):326-332.

[64] Feliciano DV, Moore EE, Mattox KL (Eds.). Trauma, 3rd Edition. Appleton and Lange, Stamford, CT, 1996, p56-57.

[65] Rutland-Brown W, Wallace LJD, Faul MD, Langlois JA. Traumatic brain injury hospitalizations among American Indians/Alaska Natives. *J Head Trauma Rehabil* 2005;20(3):205-214.

[66] Burnett DM, Kolakowsky-Hayner, MA, Slater D, Stringer A, Bushnik T, Zafonte R, Cifu DX. Ethnographic analysis of traumatic brain injury patients in the National Model Systems Database. *Arch Phys Med Rehabil* 2003;84(Feb):263-267.

[67] Wong MD, Shapiro MF, Boscardin WJ, Ettner SL. Contribution of major diseases to disparities in mortality. *N Engl J Med* 2002;347(20):1585-1592.

[68] Bazarian JJ, Pope C, McClung J, Cheng YT, Flesher W. Ethnic and racial disparities in emergency department care for mild traumatic brain injury. *Acad Emerg Med* 2003;10(11):1209-1217.

[69] Pope JH, Aufderheide TP, Ruthazer R, Woolard RH, Feldman JA, Beshansky JR, Griffith JL, Selker HP. Missed diagnoses of acute cardiac ischemia in the emergency department. *N Engl J Med* 2000;342(16):1163-1170.

[70] Churak JM. Racial and ethnic disparities in renal transplantation. *J Nat Med Assoc* 2005;97(2):153-160.

[71] Jones A, Kwoh CK, Kelley ME, Ibrahim SA. Racial disparity in knee arthroplasty utilization in the Veterans Health Administration. Arthritis Case & Research 2005;53(6):979-981.

[72] Carey TS and Garrett JM. The relation of race to outcomes and the use of health care services for acute low back pain. *Spine* 2003;28(4):390-394.

[73] Baker SP, O'Neil B, Ginsburg MJ, Li G. Overview of Injury Mortalty: The Injury Fact Book. 2nd ed. New York, NY: Oxford University Press Inc. 1992.

[74] Baker SP, Whitfield RA, O'Neil B. Geographic variations in mortality from motor vehicle crashes. *N Eng J Med* 1987;316:1384-87.

[75] Rogers FB, Shackford SR, Olser TM, Vane DW, Davis JH. Rural trauma: the challenge for the next decade. *J Trauma* 1999;47:802-821.

[76] Grossman DC, Hart LG, Rivara FP, Maier RV, Rosenblatt R. From roadside to bedside: the regionalization of trauma care in a remote rural county. *J Trauma* 1995;38:14-21.

[77] National Center for Health Statistics. *Health, United States, 1996-1997 and Injury Chartbook.* Centers for Disease Control and Prevention, Hyattsville, MD, 1997.

[78] Gabella B, Hoffman RE, Marine WW, Stallones L. Urban and rural traumatic brain injuries in Colorado. *Annals of Epidemiology* 1997;7(3):207-212.

[79] Flowe KM, Cunningham PR, Foil B. Rural trauma systems in evolution. *Surg Annu* 1995;27:29-39.

[80] Henderson A, Coyne D, Wall D, et al. A survery of interhospital transfer of head-injured patients with inadequately treated life-threatening extracranial injuries. *Aust NZ J Surg* 1992;62:759-762.

[81] Nayduch D, Moylan J, Snyder BL, et al. American College of Surgeons trauma quality indicators: an analysis of outcome in a statewide trauma registry. *J Trauma* 1994;37:565-575.

[82] Esposito TJ, Maier RV, Rivara FP, et al. The impact of variation in trauma care times: urban vs. rural. *Prehosp Disaster Med* 1995;10:161-167.

[83] Norwood S, Fernandez L, England J. The early effects of implementing American College of Surgeons level II criteria on transfer and survival rates at a rurally based community hospital. *J Trauma* 1995;39:240-245.

[84] Esposito TJ, Sanddal ND, Hansen JD, Reynolds S. Analysis of preventable trauma deaths and inappropriate trauma care in a rural state. *J Trauma* 1995;39(5):955-962.

[85] Certo T, Rogers FB, Pilcher DB. Review of fatally injured patients in a rural state: 5 year followup. *J Trauma* 1983;23:559-565.

[86] Wenneker WW, Murray DH, Ledwich T. Improved trauma care in a rural hospital after establishing a level II trauma center. *Am J Surg* 1990;160:655-658.

[87] Ibid - Esposito et al. 1995.

[88] MacKenzie EJ, Hoyt DB, Sacra JC, et al. National Inventory of Hospital Trauma Centers. *JAMA* 2003;289(12): 1515-1522.

[89] Ibid - Mann, et al. 2001.

[90] Sampalis JS, Denis R, Frechette P, Brown R, Fleiszer D, Mulder D. Direct transport to tertiary trauma centers versus transfer from lower level facilities. *J Trauma* 1997;43:288-295.

[91] Mann NC, Mullins RJ, Hedges JR, Rowland D, Arthur M, Zechnich AD. Mortality among seriously injured patients treated in remote rural trauma centers before and after implementation of a statewide trauma system. *Medical Care* 2001;39(7):643-653.

[92] Richardson JD, Cross T, Lee D, et al. Impact of level III verification on trauma admissions and transfer: comparisons of two rural hospitals. *J Trauma* 1997;42(3):498-503.

[93] Healthcare Cost and Utilization Project (HCUP). National Inpatient Sample (NIS), 2003 (CD-ROMs). Rockville, MD: Agency for Healthcare Research and Quality; 2005.

[94] ICD9-CM procedure codes identified as 'damage control surgery' included: 38.3(6,7), 39.3, 39.3(1,2), 41.2, 41.43, 41.5, 44.49, 44.61, 45.01, 45.4, 45.6(1,3), 45.7, 45.7(1-6,9), 45.8, 45.9, 46.7, 46.7(1,3,5,9), 50.22, 50.3, 50.6, 50.6(1,9), 50.9, 52.5, 54.11, 55.4, 55.5, 55.51.

[95] ICDMAP-90 Injury Severity Coding Software, Johns Hopkins University and Tri-Analytics, Inc., Baltimore, MD, 1997.

[96] American College of Surgeon's Committee on Trauma. Resources for Optimal Care of the Injured Patient, 1999, Chicago, IL 1998.

[97] Feliciano DV, Moore EE, Mattox Kl (Eds) 1996: Trauma, 3rd edition, pp 55-56, Appleton and Lange, Stamford, CT.

[98] University of Washington, WWAMI Rural Health Research Center. RUCA ZIP Code Approximation Method.

[99] Schueller V. Guidelines for using rural-urban classification systems for public health assessment. Washington State Department of Health, Office of Community and Rural Health, Olympia, WA 2001.

[100] Nathans AB, Jurkovich GJ, Maier RV, et al. Relationship between trauma center volume and outcomes. *JAMA* 2001;285(9):1164-1171.

[101] Margulies DR, Cryer HG, McArthur DL, Lee SS, Bongard FS, Fleming AW. Patient volume per surgeon does not predict survival in adult level I trauma centers. *J Trauma* 2001;50(4):597-603.

[102] Glance LG, Osler TM, Dick A, Mukamel D. The relationship between trauma center outcome and volume in the National Trauma Data Bank. *J Trauma* 2004;56(3):682-690.

[103] London JA, Battistella FD. Is there a relationship between trauma center volume and mortality? *J Trauma* 2003;54(1):16-25.

[104] MacKenzie EJ, Rivara FP, Jurkovich GJ, Nathens AB, Frey KP, Egleston MP, Salkever DS, Scharfstein DO. A national evaluation of the effect of trauma-center care on mortality. *N Engl J Med* 2006;354(4):366-378.

[105] Association for the Advancement of Automotive Medicine. The Abbreviated Injury Scale, 1990 Revision, Update 98. Des Plaines, IL, 1998.

[106] National Academy of Sciences (1966). *Accidental death and disability: The neglected disease of modern society.* Washington, DC.

CURRICULUM VITAE

STEPHEN M. BOWMAN

Education

Baccalaureate Degree:	University of Washington, Seattle Bachelor of Arts, Philosophy, 1986
Masters Degree:	University of Washington, Seattle Masters in Health Administration, 1988
Administrative Residency:	Mayo Clinic, Rochester, Minnesota, 1987
Doctoral Candidate	University of Washington, Seattle, Fall, 2004 Health Services Research Area of emphasis: Evaluative sciences Expected completion of degree: Spring, 2006

Professional Experience

2000-Present	Epidemiologist Office of Emergency Medical Services and Trauma System, Washington State Department of Health Olympia, Washington
1998-2000	Manager, Trauma Designation, Registry & Quality Improvement, Office of Emergency Medical Services and Trauma System, Washington State Department of Health, Olympia, Washington
1997-1998	Acting Director, Chronic Disease Prevention and Risk Reduction Programs, Office of Community Wellness and Prevention, Washington State Department of Health Olympia, Washington
1996-1998	Director, Tobacco Prevention Programs, Department of Health Community & Family Health Division, Washington State Department of Health
1993-1996	Manager, Youth Tobacco Prevention Program Community & Family Health Division Washington State Department of Health

1992 -- 1993:	Manager, Disabilities Prevention Program Community and Family Health Division Washington State Department of Health,
1988 -- 1992:	Deputy Director for Planning & Evaluation 1990-1992 Planning and Evaluation Analyst 1988-1990; California State Council on Developmental Disabilities Sacramento, California.
1985 -- 1988:	Assistant to the Administrator (part-time) Clinical Training Unit Child Development and Mental Retardation Center University of Washington, Seattle, Washington.
1984 -- 1985:	Program Assistant (part-time) Regional Epilepsy Center, Harborview Medical Center, Seattle, Washington.

Awards and Honors

Quentin-Burdick Interdisciplinary Health Award, University of Washington, School of Nursing, 2004

Official Resolution: California State Council on Developmental Disabilities, August, 1992.

Special Recognition Award 1992: Epilepsy Society of Los Angeles and Orange Counties, 1992.

Exceptional Service Award: Epilepsy Society of San Diego County, 1992.

Professional Activities

Member, Washington State Institutional Review Board, January 2002 -
Member, Academy Health
Grant reviewer, National Medical Research Council, Singapore Ministry of Health, 2005 -
Grant reviewer, Administration on Developmental Disabilities, Department of Health and Human Services, 1992-1994

Bibliography

1. Bowman SM, Martin DP, Sharar SR, Zimmerman FJ. Racial disparities in outcomes of persons with moderate to severe traumatic brain injury. Submitted for publication (New England Journal of Medicine).

2. Bowman SM, Zimmerman FJ, Sharar SR, Baker MW, Martin DP. Hospital characteristics associated with rural trauma outcomes. Submitted for publication (JAMA).

3. Bowman SM, Zimmerman FJ, Christakis DA, Sharar SR, Martin DP. Hospital characteristics associated with the management of pediatric splenic injuries. *JAMA*. 2005;294:2611-2717.

4. Bowman SM. Trauma in Washington State: A report of the first 10 years, 1995-2004. Health Systems and Quality Assurance Division, Department of Health, March 2006.

5. Bowman S.: Emergency Cardiovascular Disease in Washington State, A State of the State, Health Systems and Quality Assurance Division, Department of Health, November 15, 2002.

6. Bowman S.: Survey reveals variability of emergency care for heart disease and stroke in Washington State. In EpiTrends, A Monthly Bulletin of Epidemiology and Public Health in Washington State, November 2001.

7. Bowman, S.: Epinephrine and Analphylaxis: Report to the Legislature, Health Systems and Quality Assurance Division, Department of Health, December, 1999.

8. Bowman, S.: Minors' Access to Tobacco: Report to the Legislature, Community and Family Health Division, Department of Health, Olympia, Washington: February, 1995.

9. Bowman, S.: A Plan for the Prevention of Disabilities in Washington State, Disability Prevention Program, Department of Health, Olympia, Washington: December, 1993.

10. Bowman, S.: California Epilepsy/Seizure Disorders Needs Assessment Report, California State Government Publication, Sacramento, California: August, 1992.

11. Bowman, S.: 1991 Annual Report, California State Council on Developmental Disabilities, Sacramento, California: January, 1992.

12. Bowman, S.: 1992-1994 Developmental Disabilities State Plan, California State Government Publication, Sacramento, California: August, 1991.

13. Bowman, S.: 1990 Annual Report, California State Council on Developmental Disabilities, Sacramento, California: January, 1991.

14. Evans, M. & Bowman, S.: Update 1990: Innovations in Family Support, California State Government Publication, Sacramento, California: June, 1990.

15. Bowman, S. & Evans, M.: Prader-Willi Syndrome: Report to the Legislature, California State Government Publication (Legislatively Mandated Report), Sacramento, California, April, 1990.

16. Evans, M. & Bowman, S.: Destination 2000: California's 1990 Report on Services to People with Developmental Disabilities, a federally mandated report to Congress, California State Government Publication, Sacramento, California: January, 1990.

17. Evans, M. & Bowman, S.: 1990-1991 Developmental Disabilities State Plan, California State Government Publication, Sacramento, California: August, 1989.

Presentations, Conferences and Symposiums

"Epidemiology of Traumatic Death." Invited presentation at the Airlift Northwest Annual Conference, October 14, 2005.

"Hospital characteristics associated with current best practices in the management of pediatric splenic injuries." Poster presentation, Annual Research Meeting, Academy Health, Boston, MA, June 2005.

"North Central Region Trauma Conference: The State of Affairs for Trauma." Invited presentation on trauma system utilization, transfers, diversions and outcomes. Wenatchee, Washington, June 2005.

"2005 Northwest Region Trauma QI Conference." Invited speaker, Port Orchard, Washington, May 2005.

"The Changing Practice of Stroke Care." Invited presentation on the burden of stroke care and the state of emergency stroke care in Washington State, Swedish Medical Center, Seattle, Washington, May 2005.

"Washington State Health Information Management Association Annual Conference." Invited presentation on trauma system effectiveness and the use of Washington Trauma Registry data for quality improvement, Wenatchee, Washington, April 2005.

"Northwest Region Quality Improvement Conference." Invited speaker, Port Orchard, Washington, June 2004.

"25th Annual EMS Conference" Invited presentation on using trauma registry data to assess injury outcomes, Spokane, Washington August 1999.

"4th Annual Tobacco Use Prevention Summer Institute." Invited presentation on community-based approaches to tobacco prevention, Albuquerque, New Mexico, July, 1998.

"Make Tobacco History: Power Through Community Action." Invited presentation to the Oregon State Tobacco Conference, December 1, 1995.

"The Second Annual Washington State Joint Conference on Health." Presentation: Tobacco Use: A Pediatric Epidemic. Yakima, Washington, September 19, 1995.

"23rd Annual Educational Conference: Washington State Environmental Health Association." Presentation: Local Health Departments take on the Tobacco Giants. Vancouver, Washington, April 27, 1995.

"Sixth Annual Conference on Abuse and Persons with Disabilities." Presentation: Abuse as a Cause of Disability: Surveillance and Assessment. Burbank, California, June, 1993.

"The Fourteenth Annual Symposium of the Committee on Sexuality Advocating for People with Developmental Disabilities." Presentations: 1) Opening keynote panel on legal and administrative issues surrounding privacy in group homes; and 2) Primary consumer satisfaction: Concerns on Life, Relationships and Health. Napa, California: March 1-2, 1990.

"Serving the Developmentally Disabled Elderly: A Training Conference for Case Managers and Program Directors." Los Angeles, California: October 24, 1990.

"California Sharing: Serving Older Persons with Developmental Disabilities." Presentation: Future trends and policy issues. San Diego, California: June 11, 1991.

"Community Capacity Building: Maximizing Access to Community." The 1991 Annual Planner's Conference, National Association of Developmental Disabilities Councils. Atlantic City, New Jersey: September 11-15, 1991.

"Fifth Annual Conference on Abuse of Persons with Developmental Disabilities." Riverside, California: November 22, 1991.

"Sixth Annual National Conference on Abuse and Disabilities." Burbank, California: June 18, 1993. Presentation: Abuse Causes Disability.

Teaching History

University of Washington, Health Services 592H, Doctoral Seminar, Spring 2006.

Trauma Registry Advanced Training in Analysis and Report, 1998 to present (100% responsibility.) This one-day class is taught 10 times per year in locations across Washington. The audience consists of trauma registrars and trauma nurse coordinators.

Additional Experience and Skills

Quentin N. Burdick Trainee in Rural Interdisciplinary Healthcare, School of Nursing, University of Washington, 2004-05.

Association for the Advancement of Automotive Medicine, Abbreviated Injury Scale Coding Certification

Legislation: Testified to state legislative committees on various issues pertaining to people with developmental disabilities; prepared legislative bill analyses and testimony for key state leaders; and monitored and tracked legislation pertaining to health and disability issues.

Group facilitation: Facilitated numerous committees and task forces in the development of long-range policy and strategic plans.

Summer Institute on Public Health Practice, University of Washington, 1993

Media: Interviewed on various newscasts as a tobacco prevention and control expert. These include segments on the Jim Lehr News Hour, National Public Radio (via local affiliate), KOMO television, and KIRO news radio.

Experience with Group Process

Fall, 1989: Conducted four public hearings in Los Angeles, San Diego, Oakland, and Sacramento to receive input for the federally mandated 1990 report.

Winter, 1991: Conducted eight public hearings in Los Angeles (2), San Diego, Irvine, Oakland, Sacramento, Fresno and Manteca to receive input for the 1992-1994 Developmental Disabilities State Plan.

Spring, 1992: Conducted seven public hearings in Los Angeles, San Diego, Bakersfield, San Francisco (2), Fresno and Modesto to receive consumer input for the State-Wide Epilepsy/Seizure Disorders Needs Assessment Report.

2000 to present: Provide facilitation, data support and analysis for the Governor's EMS and Trauma Steering Committee and the eight regional quality improvement committees across Washington State.