ARTICLE

Race and socioeconomic disparity in treatment and outcome of traumatic cervical spinal cord injury with fracture: Nationwide Inpatient Sample database, 1998–2009

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Abstract

Study design A retrospective national administrative database study.

Objective Advances in treatment of traumatic cervical spinal cord injury with fracture (TCSCIF) have led to significant improvements in clinical outcomes; however, progress in healthcare is seldom ubiquitous across demographic groups. Therefore, we explored if disparities in treatment and outcome after TCSCIF exist across race and socioeconomic status.

Setting USA.

Methods We queried the Nationwide Inpatient Sample database from 1998 to 2009 for TCSCIF hospitalizations. Multivariate analysis was used to identify the correlation between socioeconomic status and race to injury, treatment type, and outcome.

Results There were 21,985 admissions for TCSCIF, 66.9% of whom had a favorable discharge disposition. In-hospital mortality rate was 12.5%. A total of 43.7% underwent surgery. Overall, surgery was associated with lower in-hospital mortality (OR 0.30, 95% CI 0.27–0.34, $p < 0.01$) and better discharge disposition (OR 0.68, 95% CI 0.62–0.74, $p < 0.01$) versus nonsurgical or no intervention. African-American (AA) race and low socioeconomic status (LSES) were significant predictors of lower odds to undergo surgery and unfavorable discharge disposition, respectively; potentially explained by a higher odds of increased New Injury Severity Score classification at presentation. Surgical and favorable discharge rates for LSES and non-Caucasian races, however, have been steadily improving over the study period.

Conclusions Despite trending improved outcomes after TCSCIF, LSES, or AA race were more likely to have worse outcomes compared to their counterparts. In addition, LSES, AA, and Hispanic groups were less likely to undergo surgical treatment, suggesting disparities in management and outcome effect.

Introduction

Understanding and reducing racial disparities in healthcare is a national priority [1]. It is well documented that such inequalities in healthcare exist even when adjusted for

severity of condition [2, 3]. Traumatic cervical spinal cord injury with fracture (TCSCIF), affects over 11,000 people every year across the USA from which patients acutely present with sensory, motor, and autonomic neurovascular deficits secondary to disruption of the cervical spinal cord [4–6]. In addition, with motor vehicle crashes being the leading cause of TCSCIF over the past 40 years for individuals younger than 45 years old, many of these patients suffer concomitant complex orthopedic, pulmonary, and cardiovascular trauma, necessitating rapid multidisciplinary medical management [7, 8].

There is a continuously growing body of preclinical and clinical data suggesting that decompressive surgery of the spinal cord after injury helps to prevent various secondary mechanisms of injury and helps to improve neurologic outcome [9–12]. In addition, there is a current trend in research

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and practice popularizing early (<24 h) to ultra-early (<8 h) surgical decompression and stabilization to regain motor and sensory function in all grades of TCSCIF, including complete injury [13–15]. With timely surgical decompression and stabilization of TCSCIF serving as a mainstay of treatment, inaccessibility to care could limit otherwise potentially recoverable neurologic decline [16, 17].

Advances in treatment of TCSCIF have led to significant improvements in overall clinical outcomes; however, progress in healthcare may not be ubiquitous across demographic groups. If a disparity in surgical treatment of populations exists for an acute traumatic condition, which has proven to benefit from timely intervention, it is the responsibility of healthcare systems to identify and help rectify barriers to optimal treatment. The purpose of this study was to identify potential inequalities in management and outcome for TCSCIF in at-risk populations by analyzing surgical intervention rates, functional outcome, and mortality across various racial and socioeconomic groups.

Methods

We surveyed the National Inpatient Sample (NIS) database from the Agency for Healthcare Research and Quality, Healthcare Cost and Utilization project. The NIS contains a cohort of hospitalization and discharge data from all hospitals participating in the Healthcare cost and Utilization Project; representing ~20% of all US nonfederal admissions (excluding rehabilitation and long-term acute care facilities). NIS delineates hospitals by region, location, teaching status, size, and ownership. We adhered to methods outlined by NIS protocol to account for these factors in our estimations of the total number of hospitalizations as well as our variables for the years 1998–2009. For further information regarding NIS, please see <http://www.hcup-us.ahrq.gov/nisoverview.jsp>.

We surveyed the NIS for teaching and nonteaching hospital admissions regarding cervical spine trauma from 1998 to 2009. To specifically identify hospitalizations in the NIS for cervical trauma where surgery may be indicated, we used the ICD-9 (International Classification of Disease, 9th Revision) diagnosis codes for TCSCIF (806.00–806.09). We excluded diagnosis code '952.0X' (cervical spinal cord injury without evidence of spinal bone fracture). All patients included therefore suffered a traumatic cervical spinal cord injury with associated cervical fracture and a resulting neurological injury.

The first analysis performed was to determine whether intervention type (surgical, nonsurgical, or none) was a predictor of discharge disposition for TCSCIF. This analysis was performed twice, once with discharge disposition as the outcome variable (favorable: home or inpatient rehabilitation

hospital, or unfavorable: death, hospice, skilled nursing facility, or long-term acute care hospital, years 1998–2009), and a second time with hospital mortality (died or survived) as the outcome variable. We included age, gender, admission year, hospital bed size, hospital region, and hospital case volume as covariates in all analyses.

The second analysis was to determine a potential association between degree of bodily injury and race or socioeconomic status, as a potential confounding factor for treatment occurrence and outcome. The New Injury Severity Score (NISS) found in NIS is not an equal-interval score variable because patients with 'maximal' damage to any body zone are given the maximal score of 75, so traditional comparison protocols between race and NISS, such as ANOVA could not be used. Instead, we classified NISS into four categories (minor severity, minor to moderate severity, moderate to major severity, and major severity) based on the quartiles of NISS observed in the dataset: $NISS < 13$ = minor, $12 < NISS < 17$ = minor/moderate, $16 < NISS < 26$ = moderate/major, and $NISS > 25$ = major. We then used ordinal logistic regression to determine whether race was a predictor of NISS category. In addition, chi-square test determined whether the socioeconomic status was associated with NISS category.

The third analysis was to explore any potential association between race or socioeconomic status and surgical intervention rates, discharge disposition, and hospital mortality for patients with TCSCIF. Generalized estimating equations (SAS Proc GENMOD) were used to determine whether race (Caucasian, African American, Hispanic, Asian/Pacific Islander, Native American, or Other) was a predictor of unfavorable outcomes for TCSCIF patients. The analysis was performed three times, with surgical intervention, discharge disposition (favorable or unfavorable), and hospital mortality as the outcome variable. The analysis was repeated for low socioeconomic status (LSES), defined by the NIS variable indicating the median income in the patient's ZIP code; with all patients in the lowest ZIP income classified as "low" and all others as "higher," substituted for race. We included age, gender, admission year, hospital bed size, hospital region, hospital case volume, and NISS as covariates in all analyses. Finally, we combined race and socioeconomic status into a single multivariate model (four groups: Caucasian/higher status, Caucasian/LSES, non-Caucasian/higher status, and non-Caucasian/LSES) to observe potential association between surgical intervention rates, discharge disposition, and hospital mortality for patients with TCSCIF.

The fourth analysis was to assess any change in trends with respect to surgical intervention, discharge disposition, and mortality rates in minority populations or LSES individuals over time. The proportion of Caucasian patients and the proportion of non-Caucasian patients with TCSCIF

who had surgical intervention (years 1988–2009), favorable outcomes (years 1998–2009), and mortality (years 1998–2009) were analyzed. Regression analysis was performed for these proportions on race category and year to determine whether race had an effect on the proportion of favorable outcomes. This analysis was repeated with socioeconomic status substituted for race. The SAS statistical software package (version 9.3, SAS Institute Inc., Car, NC, USA) was used to create generalized estimating equations and all linear regression models. All analyzed data can be found in the supplementary materials section.

Results

The NIS survey resulted in 21,985 admissions for TCSCIF. Patient and hospital characteristics are listed in Table 1. With respect to favorable outcome as a function of hospital intervention, 20,176 patients were queried (observations were not included if discharge disposition information was missing). Patients who received surgical intervention had higher odds of favorable discharge as patients who received no intervention (OR 1.60, 95% CI 1.46–1.84, $p < 0.01$). Patients who received nonsurgical intervention had lower odds of favorable discharge as patients who received surgical intervention (OR 0.52, 95% CI 0.42–0.64, $p < 0.01$). Patients who received surgical intervention had lower odds of death as patients who received no intervention (OR 0.30, 95% CI 0.27–0.34, $p < 0.01$), and the odds of survival for patients who received nonsurgical intervention were not significantly different from those who received no intervention ($p = 0.44$).

Effect of race and socioeconomic status on NISS

With respect to NISS, logistic regression indicated that race was a predictor of NISS category ($p = < 0.01$) for TCSCIF patients. African Americans (OR 1.20, 95% CI 1.13–1.34, $p < 0.01$), Hispanics (OR 1.40, 95% CI 1.28–1.56, $p < 0.01$), Asian/Pacific Islanders (OR 1.30, 95% CI 1.02–1.55, $p = 0.03$), Native Americans (OR 1.50, 95% CI 1.02–2.12, $p = 0.04$), and ‘Other Races’ (OR 1.40, 95% CI 1.13–1.64, $p < 0.01$) had higher odds of being in a higher cumulative NISS category compared to Caucasians. Chi-square analysis showed socioeconomic status was not significantly associated with NISS ($p = 0.24$). There were 20,832 observations with information concerning race and/or socioeconomic status.

Surgical intervention, favorable outcome, and mortality across race and socioeconomic status

Overall, race was a predictor of surgical intervention ($p = 0.04$) in TCSCIF patients. Both African American (OR 0.83,

Table 1 Patient and hospital demographics, by insurance status. Standard deviation (SD)

	Insured (<i>n</i> = 36,398)	Uninsured (<i>n</i> = 8,034)	<i>p</i> -value
Age, years (mean $\pm$ SD)	48.4 $\pm$ 22.6	39.0 $\pm$ 15.7	<0.01
Race			
Caucasian	18,112 (71.8%)	3397 (61.1%)	<0.01
Black	3867 (15.3%)	1136 (20.4%)	
Hispanic	1910 (7.6%)	735 (13.2%)	
Asian	615 (2.4%)	101 (1.8%)	
Native American	157 (0.6%)	43 (0.8%)	
Other	576 (2.3%)	149 (2.7%)	
Socioeconomic status			
Low	8787 (25.3%)	2357 (31.4%)	<0.01
Higher	26,000 (74.7%)	5154 (68.6%)	
Gender			
Female	10,017 (27.5%)	1315 (16.4%)	<0.01
Male	26,376 (72.5%)	6716 (83.6%)	
Hospital bed size			
Small	3112 (8.6%)	419 (5.2%)	<0.01
Medium	8428 (23.2%)	1863 (23.3%)	
Large	24,800 (68.2%)	5717 (71.5%)	
Hospital teaching status			
Nonteaching	13,613 (37.5%)	2990 (37.4%)	0.89
Teaching	22,727 (62.5%)	5009 (62.6%)	
Hospital region			
Northeast	6024 (16.5%)	830 (10.3%)	<0.01
Midwest	8751 (24.0%)	1597 (19.9%)	
South	12,815 (35.2%)	3710 (46.1%)	
West	8837 (24.3%)	1903 (23.7%)	
Annual hospital volume (mean $\pm$ SD)	22.2 $\pm$ 24.7	23.4 $\pm$ 22.8	<0.01
Injury Severity Score (mean $\pm$ SD)	21.7 $\pm$ 15.1	22.0 $\pm$ 14.9	0.11
In-hospital mortality			
Died	3236 (8.9%)	620 (7.8%)	<0.01
Survived	33,071 (91.1%)	7385 (92.3%)	
Discharge disposition 1 (1998–2009 only)			
Favorable	10,963 (71.3%)	2746 (83.0%)	<0.01
Unfavorable	4412 (28.7%)	561 (17.0%)	
Discharge disposition 2 (all years)			
Routine	3599 (48.6%)	11,416 (34.7%)	<0.01
Transfer to short-term hospital	593 (8.0%)	3020 (9.2%)	
Transfer to another type of facility	2272 (30.7%)	13,515 (41.1%)	
Home healthcare	299 (4.0%)	1808 (5.5%)	
Against medical advice	73 (1.0%)	159 (0.5%)	
Died	571 (7.7%)	2966 (9.0%)	
Discharged alive, destination unknown	0 (0%)	4 (0.01%)	
Admission source			
Transfer	4664 (14.9%)	677 (9.8%)	<0.01
Other	26,685 (85.1%)	6268 (90.2%)	

95% CI 0.73–0.94, $p < 0.01$) and Hispanic (OR 0.87, 95% CI 0.76–0.99, $p = 0.03$) TCSCIF patients had lower odds of receiving surgery versus nonsurgical or no intervention compared to Caucasians. There were 14,847 observations in

the dataset used for analysis; 6795 of those patients received a surgical intervention. LSES TCSCIF patients also had lower odds of receiving surgery versus nonsurgical or no intervention (OR 0.87, 95% CI 0.82–0.94, $p < 0.01$) or nonsurgical versus no intervention (OR 0.80, 95% CI 0.67–0.94, $p = 0.01$). There were 20,758 observations in the dataset used for analysis; 9073 of those patients received a surgical intervention.

Overall, minority race (African American, Hispanic, Asian/Pacific Islander, Native American, or ‘Other Races’) was not significantly different compared to Caucasians with respect to favorable discharge; however, African American TCSCIF patients had lower odds of favorable discharge (OR 0.80, 95% CI 0.72–0.89, $p < 0.01$). There were 13,079 observations in the dataset used for analysis; 4002 patients had favorable discharge and 3412 had routine discharge. When LSES was substituted for race in the TCSCIF population, this group had lower odds of favorable discharge (OR 0.87, 95% CI 0.77–0.98, $p = 0.02$) and routine discharge (OR 0.88, 95% CI 0.79–0.97, $p = 0.01$) compared to higher income status. There were 19,014 observations in the dataset used for analysis; 5492 of those patients had favorable discharge and 5469 had routine discharge. Race and socioeconomic status were not significant predictors of in-hospital mortality.

Our multivariate model that controlled for race and socioeconomic status demonstrated that higher status non-Caucasians had lower odds of receiving surgery than higher status Caucasians (OR 0.89, 95% CI 0.81–0.97, $p = 0.01$). LSES non-Caucasians had lower odds of receiving surgery than higher status Caucasians (OR 0.83, 95% CI 0.73–0.94, $p < 0.01$). Higher status non-Caucasians had lower odds of receiving surgery than LSES Caucasians (OR 0.87, 95% CI 0.77–0.99, $p = 0.03$). LSES non-Caucasians had lower odds of receiving surgery than LSES Caucasians (OR 0.82, 95% CI 0.71–0.94, $p = 0.01$). For favorable discharge status higher status non-Caucasians, LSES non-Caucasians, and LSES Caucasians all had lower odds of favorable discharge compared to higher status Caucasians (OR 0.83, 95% CI 0.73–0.95, $p = 0.01$ /OR 0.69, 95% CI 0.59–0.81, $p < 0.01$ /OR 0.75, 95% CI 0.66–0.85, $p < 0.01$), respectively. Finally combined race–status was not a significant predictor of in-hospital mortality.

Trends in surgical intervention, favorable outcome, and mortality over time for race and socioeconomic status

We calculated the proportion of Caucasian patients and the proportion of non-Caucasian patients all with TCSCIF who had surgical intervention (1988–2009), favorable outcomes (years 1998–2009), and mortality (years 1998–2009). These metrics were analyzed to determine any potentially

deviating trends. With respect to surgical intervention (see Fig. 1), rates were increasing for all races combined ($p < 0.01$ for effect of year). There was no difference in surgical intervention rate changes for Caucasians and non-Caucasians ($p = 0.47$), African-American patients and Caucasian patients ($p = 0.34$), Hispanic patients and Caucasian patients ($p = 0.19$), or lower and higher socioeconomic status patients ($p = 0.75$).

Figure 2 illustrates the trends in favorable discharge rate for various races and socioeconomic status compared to that of Caucasian patients and high-income classes, respectively. Favorable outcome rates were improving for all races ($p < 0.01$ for effect of year), improving for both African Americans and Caucasians ($p = 0.05$ for effect of year), but no evidence that they were improving more rapidly for one race versus the other ($p = 0.42$). In addition, favorable outcome rates improved for Hispanics ($p < 0.01$ for effect of year), and improved more rapidly for Hispanics than for Caucasians ($p = 0.02$). With respect to socioeconomic class, favorable outcome rates improved for all classes ($p = 0.03$ for effect of year), but not more rapidly for patients of higher status than for patients of LSES ($p = 0.48$). Finally with respect to mortality, outcomes were not significantly improving for all races combined ($p = 0.41$ for effect of year), or when compared between non-Caucasian patients and Caucasian patients ($p = 0.27$), African-American patients and Caucasian patients ($p = 0.07$), Hispanic patients and Caucasian patients ($p = 0.59$), and lower and higher socioeconomic status patients ($p = 0.19$).

Discussion

As the US healthcare system continues to strive for high-quality equal access treatment of all individuals, monitoring intervention rates as a function of race and socioeconomic status is critical. Not only does it provide a benchmark for current practices, but also identifies gaps in our widely varied healthcare landscape. The NIS appears to represent a key dataset with increasing utility in reporting trended patient interventions and outcomes on the basis of race and socioeconomic status. Further, the NIS is helpful in assessing pertinent associations between operative intervention and disposition for potentially susceptible demographic groups.

Data from the NIS database demonstrated that African Americans and LSES individuals suffering from TCSCIF had both lower odds of undergoing operative intervention and higher odds of unfavorable discharge disposition than their counterparts. In our multivariate model that controlled for race and socioeconomic status, race (but not socioeconomic status) was a factor in receiving surgery and both race and LSES impacted favorable discharge. There are

Fig. 1 Trends in surgical intervention rate from 1988–2009 for Caucasian patients and all non-Caucasian patients (graph **a**), African American patients (graph **b**), Hispanic patients (graph **c**), and high

versus LSES (graph **d**). Note, Caucasian patients and higher socioeconomic status are represented by the red line, other races and LSES by the blue line

multiple factors that could contribute to these observed differences. First, African Americans had greater odds of higher NISS than Caucasians. This raises the question of whether potentially other serious traumatic injuries within these populations negatively influence the possibility of undergoing surgical treatment. The etiology of traumatic spinal cord injury (TSCI) does exhibit variation between race. The third most common cause of TSCI in patients under 45 years old is gunshot wounds and accounts for 33% of injuries in African Americans, 14.6% in Hispanics, and only 3.0% in Caucasians from pooled data from the National Spinal Cord Injury Database and National Shriners Spinal Cord Injury Database [7, 18]. Future work to assess potential racial and/or socioeconomic differences in the etiology of TCSCIF merits further study.

Secondly, cultural differences with respect to trust in healthcare systems may influence patient and family decisions to seek intervention. This has been linked to lower rates of satisfaction with physicians and weakened

therapeutic alliance [19–23]. Multiple studies have documented, in both African American and Hispanic populations, an increased sense of physician distrust, concern for privacy, and worry of a potentially harmful experience in the hospital [24–26]. Finally, decreased access to healthcare in African American, Hispanic, and LSES individuals is a well-documented trend even within the last 5 years [27]. These factors, both individually and as a whole, may contribute to the decreased surgical intervention rates in at-risk populations.

The trends for operative intervention, and favorable discharge disposition for TCSCIF, are improving for non-Caucasian, African American, Hispanic, and low-income individuals over the study period. By 2009, surgical intervention rates had crossed (representing increased operative intervention rates than Caucasians) or consistently surpassed their benchmark comparison category, for at-risk races and socioeconomic levels, respectively. Favorable discharge rates were found to improve across the board as

Fig. 2 Trends in favorable discharge rate from 1998–2009 for Caucasian patients and all non-Caucasian patients (graph **a**), African-American patients (graph **b**), and Hispanic patients (graph **c**), and high

versus LSES (graph **d**). Note, Caucasian patients and LSES are represented by the red line, other races and higher socioeconomic status by the blue line

well. The rate of favorable discharges for Hispanic patients was outpacing its Caucasian benchmark. Mortality rates over the same time period observed were not statistically different between at-risk groups and their Caucasian or high socioeconomic counterpart.

Limitations of this study include its retrospective nature and the inherent potential for selection bias. The NIS does not provide clinical data with regard to certain patient factors and outcomes that may offer greater insight such as fracture type, neurologic and functional outcome, intensive care unit length of stay, or specific presenting neurological status. Secondly, we were unable to assess timing of surgical intervention, which could have significant implications for neurological recovery and discharge status. Thirdly, in performing the multivariate analysis combining race and socioeconomic status, 36% of the surgical intervention observations and 58% of the discharge observations were lost due to a lack of combined race/socioeconomic data. Finally, the relationship of NISS to overall clinical

status is unclear, therefore one cannot deduce the relationship of a higher NISS (with all racial groups assessed being higher than Caucasians) with the likelihood of surgical intervention, or favorable outcome.

The current US healthcare system is charged with providing equal access and quality care, irrespective of socioeconomic or racial factors. In the setting of TCSCIF, optimal implementation of appropriate surgical and medical management has been demonstrated to improve outcome, and therefore potential socioeconomic and racial disparities deserve further inquiry. This data may not only service as a benchmark for future comparison, but also encourage further investigation to underlying etiologies for race and socioeconomic disparities in care.

Data archiving

The data that supports the findings of this study are available from the NIS but restrictions apply to the availability of

these data, which were used under license for the current study, and so are not publically available. Data are however available from the authors upon reasonable request and with permission of the NIS.

Supplementary material

The University of Florida Biostatistical Consulting Laboratory performed analyses based on data from the NISdatabase. Report 1 includes raw hospital demographics tables. Reports 2 and 3 include multivariate analyses of TCSCIF patients of different socioeconomic status and race with respect to surgical intervention rates, discharge, and mortality. Report 4 includes the multivariate analyses of TCSCIF patients with race and economic status as covariates with respect to surgical intervention rates, discharge, and mortality.

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Author contributions ABD was the primary author of the article and responsible for amassing finished data summarising and compiling the completed manuscript. BR is the coprincipal investigator of the project, providing founding idea, and protocol for data discovery. He provided feedback on the report. DN contributed to extracting and analyzing NIS data, interpreting results, and creating summary tables and figures. SV contributed to interpretation of results and writing the article. DTL contributed to interpretation of results and writing the article. WCF contributed to interpretation of results and writing the article. BH contributed to the acquisition and interpretation of data and results for the article. DJH is the coprincipal investigator of the project, providing founding idea, and protocol for data discovery. He provided feedback on the report and was responsible for final proofing.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Statement of Ethics We certify that all applicable institutional and governmental regulations concerning the ethical use of clinical data were followed during the course of this research. This was in adherence with the University of Florida Institutional Review Board (IRB# 6272011).

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