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In-Hospital Mortality Trends After Surgery for Traumatic Thoracolumbar Injury: A National Inpatient Sample Database Study

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In-hospital mortality trends after surgery for traumatic thoracolumbar injury: A national inpatient sample database study

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ABSTRACT

Introduction: Given the increasing incidence of traumatic thoracolumbar injuries in recent years, studies have sought to investigate potential risk factors for outcomes in these patients.

Research question: The aim of this study was to investigate trends and risk factors for in-hospital mortality after fusion for traumatic thoracolumbar injury.

Materials and methods: Patients undergoing thoracolumbar fusion after traumatic injury were queried from the National Inpatient Sample (NIS) from 2012 to 2017. Analysis was performed to identify risk factors for inpatient mortality after surgery.

Results: Patients in 2017 were on average older (51.0 vs. 48.5, $P = 0.004$), had more admitting diagnoses (15.5 vs. 10.7, $p < 0.001$), were less likely to be White (75.8% vs. 81.2%, $p = 0.006$), were from a ZIP code with a higher median income quartile (Quartile 1: 31.4% vs. 28.6%, $p = 0.011$), and were more likely to have Medicare as a primary payer (22.9% vs. 30.1%, $p < 0.001$). Bivariate analysis of demographics and surgical characteristics demonstrated that patients in the in-hospital mortality group ($n = 90$) were older (70.2 vs. 49.6, $p < 0.001$), more likely to be male (74.4% vs. 62.8%, $p = 0.031$), had a great number of admitted diagnoses (21.3 vs. 12.7, $p < 0.001$), and were more likely to be insured by Medicare (70.0% vs. 27.0%, $p < 0.001$). Multivariate regression analysis found age (OR 1.06, $p < 0.001$) and Black race (OR 3.71, $p = 0.007$) were independently associated with in-hospital mortality.

Conclusion: Our study of nationwide, traumatic thoracolumbar fusion procedures from 2012 to 2017 in the NIS database found older, black patients were at increased risk for in-hospital mortality after surgery.

1. Introduction

Traumatic thoracolumbar injuries have been increasing in developed countries, including the United States (Doud et al., 2015; Beschloss et al., 2022). These injuries disproportionately affect elderly patients—a trend reflective of the aging population and an increase in low-energy traumatic fractures of the thoracolumbar spine (Zileli et al., 2021; Jansson et al., 2010; Jain et al., 2015). Though these injuries may often be treated with nonoperative management, thoracolumbar fusion procedures have become increasingly common in this patient population and are necessary when instability or progressive neurological deficits are present (Kha et al., 2018). Although surgical techniques and outcomes continue to improve for patients who suffer these injuries, performing surgery in an aging population still poses significant risk. A recent study of patients that underwent surgery after thoracolumbar trauma found a 30-day readmission rate of 5.1%, with half of these patients being readmitted for a complication related to their surgery (Camacho et al., 2023). Another recent study by Beschloss et al. found inpatient mortality had increased from 1.9% to 2.5% in a national database cohort of patients with vertebral fracture from 1993 to 2015, further highlighting challenges that surround successful management of traumatic spine injuries (Beschloss et al., 2022).

Given the increasing incidence of these injuries and persistent surgical risk, recent studies have sought to investigate potential risk factors for outcomes such as complications, readmissions, resource utilization and mortality in these patients. Multiple studies have identified medical

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risk factors associated with mortality after spine surgery such as kidney disease, age, and male sex (Kim et al., 2022; Kobayashi et al., 2023; Kushioka et al., 2020; ElNemer et al., 2023). With respect to demographic risk factors, Corso et al. observed higher reoperation risk in Black patients with Medicare compared to White, commercially-insured patients after surgical treatment for cauda equina syndrome (Corso et al., 2023). The authors also found higher risk of mortality in patients with Medicaid compared to commercially-insured patients. Disadvantaged patients as measured by the Area Deprivation Index (ADI), a neighborhood-level socioeconomic measure, have been associated with prolonged length of stay and 90-day resource utilization following lumbar surgery (Hagan et al., 2022; Gordon et al., 2023). A recent database study of patients undergoing anterior cervical discectomy and fusion (ACDF) from 2005 to 2014 found patients from ZIP codes with the lowest median incomes experienced more complications after surgery, even after controlling for comorbidities (Lieber et al., 2020).

Though socioeconomic risk factors for complications, readmissions, and resource utilization have been well-studied in the literature, few studies have identified socioeconomic factors that may be associated with mortality in the traumatic spine population. Therefore, the aim of this study was to investigate trends in in-hospital mortality after fusion for traumatic thoracolumbar injury and to identify potential risk factors that may exist in this population.

2. Methods

2.1. Patient identification

Data was obtained from the National Inpatient Sample (NIS) (HCUP-US NIS Overview), a Healthcare and Utilization Project (HCUP) nationwide database that contains a 20% sample of inpatient admissions data from a subset of participating hospitals in the United States, from 2012 to 2017. From 2012 to 2015 Q3, patients undergoing primary, non-elective, thoracolumbar fusion were identified using the ICD-9 procedure codes 81.04, 81.05, 81.06, 81.07, and 81.08. From 2015 Q4 -2017, patients undergoing primary, non-elective, thoracolumbar fusion were identified using over 300 ICD-10 procedure codes (Appendix A). To identify suspected traumatic injury, patients were also screened for thoracolumbar fracture diagnoses codes. From 2012 to 2015 Q3, patients with ICD 9 codes 805.2, 805.3, 805.4, 805.5, 806.2, 806.3, 806.4, and 806.5 were selected. From 2015 Q4-2017, patients with ICD 10 codes S22.0, S24.0, S32.0, and S34.0 were included.

2.2. Database data

The NIS database provided numerous patient descriptors that were used for final analysis (NIS Description of Data Elements). Factors that were included for this study included: age, sex, race, surgical approach, surgery location, hospital region, Severity All Patients Refined Diagnosis Related Groups (APR DRG), Mortality APR DRG, # of admitted diagnoses, days from admission to surgery, length of stay (LOS), discharge destination, in-hospital mortality, ZIP code median income quartile, total charges, and expected payer (Medicare, Medicaid, Private Insurance, Uninsured, Other and Missing). Medicare is federal health insurance for people 65 or older and Medicaid is a joint state and federal program that insures low-income and resource restricted individuals (Division (DCD)). Severity APR-DRG is stratified by 3M Health Information Systems based on the base APR-DRG as follows: 1 = minor loss of function, 2 = moderate loss of function, 3 = major loss of function, 4 = extreme loss of function. Mortality APR-DRG is stratified in a similar manner where 1 = minor likelihood of dying, 2 = moderate likelihood of dying, 3 = major likelihood of dying, 4 = extreme likelihood of dying. Total charges were adjusted for inflation, using 2017 as the year of reference. Opioid use was collected using ICD-9 (304.0, 304.7, 305.5) and ICD-10 (F11.1–9) codes. Marijuana use/abuse was found using ICD-9 (304.3, 305.2) and ICD-10 (F12.1–9) codes.

2.3. Statistical analysis

Descriptive patient statistics were reported for demographics, surgical characteristics, and inpatient measures. Differences in categorical patient factors were compared using Fisher's exact or Pearson Chi-square tests. Differences in continuous data were compared using Mann-Whitney U and independent T-tests. Multivariate regression analysis was performed to identify patient factors that were independently associated with in-patient mortality. All analyses were performed in RStudio (Version 4.0.2, RStudio Inc., Boston, MA, USA).

3. Results

Query of the NIS database from 2012 to 2017 identified 8188 patients that underwent thoracolumbar fusion for traumatic vertebral fracture. Bivariate analysis of subjects by year found that patients in 2017 were on average older (51.0 vs. 48.5, $P = 0.004$), had more admitting diagnoses (15.5 vs. 10.7, $p < 0.001$), were less likely to be White (75.8% vs. 81.2%, $p = 0.006$), were from a ZIP code with a higher median income quartile (Quartile 1: 31.4% vs. 28.6%, $p = 0.011$), and were more likely to have Medicare as a primary payer (22.9% vs. 30.1%, $p < 0.001$). Patients in 2017 also were less likely to have a mortality APR-DRG classification of minor likelihood of dying (50.2% vs. 39.8%, $p < 0.001$) when compared to patients from 2012. There were no significant changes in proportion of patients that were male (63.2% vs. 62.3%, $p = 0.330$), had a history of opioid use/abuse (1.40% vs. 2.64%, $p = 0.155$), or had a history of marijuana use/abuse (2.73% vs. 3.67%, $p = 0.131$) (Table 1).

Bivariate analysis of surgical characteristics by year demonstrated that patients in 2017 received surgery sooner (2.29 vs. 2.67 days after admission, $p = 0.009$) and had a shorter length of stay (LOS) (9.76 vs. 11.2 days, $p < 0.001$) on average than patients treated in 2012. In 2017, a posterior approach was more commonly utilized (94.9% vs. 90.2%, $p < 0.001$). Additionally, patients were not routinely discharged home as frequently as they were in 2012 (41.2% vs. 34.7%, $p < 0.001$). Total charges per patient were greater in 2017 compared to 2012 ($227,415 vs. $204,071, $p < 0.001$). In-hospital mortality rates were not significantly different from 2012 to 2017 (0.93% vs. 1.55%, $p = 0.186$) (Table 2).

90 patients (1.10%) expired in the hospital during their surgical admission. Bivariate analysis of demographics and surgical characteristics demonstrated that patients in the in-hospital mortality group were older (70.2 vs. 49.6, $p < 0.001$), more likely to be male (74.4% vs. 62.8%, $p = 0.031$), had more admission diagnoses (21.3 vs. 12.7, $p < 0.001$), and were more likely to be on Medicare (70.0% vs. 27.0%, $p < 0.001$). Patients in the mortality group were also associated with the "extreme loss of function" Severity APR-DRG (85.6% vs. 16.9%, $p < 0.001$) and the "extreme likelihood of dying" Mortality APR-DRG (76.7% vs. 8.40%, $p < 0.001$). Total hospital charges were also significantly greater in the mortality group when compared to the no mortality group ($216,308 vs. $290,562, $p < 0.001$). There were no significant differences in race, hospital region, opioid or marijuana use/abuse, median ZIP income quartile, days from admission to surgery, or length of stay between the two groups (Table 3).

Multivariate regression analysis was also performed to identify independent predictors of in-hospital mortality. Increasing age (OR 1.06, $p < 0.001$), increasing Mortality APR-DRG (OR 3.47, $p < 0.001$), Severity APR-DRG (OR 5.48, $p < 0.001$), and Black race (OR 3.86, $p = 0.006$) were all statistically significant predictors of in-hospital mortality. Year of operation and ZIP code median income quartile were not found to have a statistically significant association with in-hospital mortality (Table 4).

4. Discussion

As the incidence of traumatic thoracolumbar injuries continues to

Table 1
Patient demographics by year.

	2012	2013	2014	2015	2016	2017	P Value
Age	48.5 (19.3)	48.9 (20.4)	49.4 (19.9)	50.9 (19.8)	50.1 (20.5)	51.0 (20.7)	**0.004***
Sex:							0.330
Male	811 (63.2%)	799 (61.7%)	874 (61.8%)	504 (65.7%)	1081 (64.3%)	1087 (62.3%)	
Female	473 (36.8%)	496 (38.3%)	540 (38.2%)	263 (34.3%)	601 (35.7%)	658 (37.7%)	
Race:							**0.006***
White	978 (81.2%)	914 (77.6%)	1050 (79.9%)	555 (80.1%)	1219 (77.2%)	1250 (75.8%)	
Black	56 (4.65%)	60 (5.09%)	80 (6.09%)	41 (5.92%)	97 (6.14%)	93 (5.64%)	
Hispanic	112 (9.29%)	121 (10.3%)	105 (7.99%)	59 (8.51%)	145 (9.18%)	190 (11.5%)	
API	16 (1.33%)	22 (1.87%)	27 (2.05%)	13 (1.88%)	47 (2.98%)	54 (3.28%)	
Native American	5 (0.41%)	15 (1.27%)	11 (0.84%)	6 (0.87%)	13 (0.82%)	17 (1.03%)	
Other	38 (3.15%)	46 (3.90%)	41 (3.12%)	19 (2.74%)	58 (3.67%)	44 (2.67%)	
Hospital Region:							**<0.001***
New England	44 (3.43%)	44 (3.40%)	36 (2.55%)	55 (7.17%)	43 (2.55%)	61 (3.50%)	
Mid-Atlantic	144 (11.2%)	123 (9.50%)	175 (12.4%)	151 (19.7%)	181 (10.8%)	179 (10.3%)	
East North Central	192 (15.0%)	201 (15.5%)	199 (14.1%)	229 (29.9%)	230 (13.7%)	249 (14.3%)	
West North Central	109 (8.49%)	119 (9.19%)	134 (9.48%)	85 (11.1%)	131 (7.78%)	158 (9.05%)	
South Atlantic	268 (20.9%)	284 (21.9%)	299 (21.1%)	68 (8.87%)	373 (22.2%)	365 (20.9%)	
East South Central	155 (12.1%)	117 (9.03%)	141 (9.97%)	45 (5.87%)	143 (8.50%)	134 (7.68%)	
West South Central	170 (13.2%)	194 (15.0%)	178 (12.6%)	46 (6.00%)	212 (12.6%)	202 (11.6%)	
Mountain	125 (9.74%)	110 (8.49%)	137 (9.69%)	32 (4.17%)	141 (8.38%)	158 (9.05%)	
Pacific	77 (6.00%)	103 (7.95%)	115 (8.13%)	56 (7.30%)	229 (13.6%)	239 (13.7%)	
Severity APRDRG:							0.098
1 (Minor Loss of Function)	13 (1.01%)	6 (0.46%)	7 (0.50%)	6 (0.78%)	21 (1.25%)	22 (1.26%)	
2 (Moderate Loss of Function)	63 (4.91%)	59 (4.56%)	55 (3.89%)	20 (2.61%)	54 (3.21%)	64 (3.67%)	
3 (Major Loss of Function)	974 (75.9%)	999 (77.1%)	1109 (78.4%)	600 (78.2%)	1319 (78.4%)	1350 (77.4%)	
4 (Extreme Loss of Function)	234 (18.2%)	231 (17.8%)	243 (17.2%)	141 (18.4%)	289 (17.2%)	309 (17.7%)	
Mortality APRDRG:							**<0.001***
1 (Minor Likelihood of Dying)	645 (50.2%)	608 (46.9%)	663 (46.9%)	322 (42.0%)	665 (39.5%)	695 (39.8%)	
2 (Moderate Likelihood of Dying)	336 (26.2%)	339 (26.2%)	362 (25.6%)	213 (27.8%)	472 (28.0%)	497 (28.5%)	
3 (Major Likelihood of Dying)	209 (16.3%)	248 (19.2%)	284 (20.1%)	161 (21.0%)	364 (21.6%)	356 (20.4%)	
4 (Extreme Likelihood of Dying)	94 (7.32%)	100 (7.72%)	105 (7.43%)	71 (9.26%)	182 (10.8%)	197 (11.3%)	
Number of Admitted Diagnoses	10.7 (6.37)	11.4 (6.17)	11.6 (6.58)	13.1 (7.20)	13.6 (6.97)	15.5 (7.07)	**<0.001***
ZIP Median Income Quartile:							**0.011***
1 (Lowest)	388 (31.4%)	362 (28.5%)	391 (28.6%)	174 (23.2%)	460 (28.1%)	490 (28.6%)	
2	343 (27.8%)	376 (29.7%)	398 (29.1%)	203 (27.0%)	439 (26.9%)	479 (28.0%)	
3	269 (21.8%)	302 (23.8%)	310 (22.7%)	215 (28.6%)	411 (25.1%)	389 (22.7%)	
4 (Highest)	234 (19.0%)	228 (18.0%)	267 (19.5%)	159 (21.2%)	325 (19.9%)	353 (20.6%)	
Opioid Use Abuse:	18 (1.40%)	23 (1.78%)	22 (1.56%)	13 (1.69%)	32 (1.90%)	46 (2.64%)	0.155
Marijuana Use Abuse:	35 (2.73%)	41 (3.17%)	33 (2.33%)	27 (3.52%)	66 (3.92%)	64 (3.67%)	0.131
Expected Payer:							**<0.001***
Medicare	292 (22.9%)	356 (27.6%)	373 (26.4%)	219 (28.6%)	477 (28.4%)	524 (30.1%)	
Medicaid	139 (10.9%)	132 (10.2%)	189 (13.4%)	112 (14.6%)	261 (15.5%)	269 (15.5%)	
Private	582 (45.6%)	516 (39.9%)	598 (42.3%)	317 (41.4%)	639 (38.1%)	685 (39.4%)	
Self-Pay	136 (10.7%)	129 (9.98%)	104 (7.36%)	38 (4.97%)	128 (7.62%)	104 (5.98%)	
No Charge	6 (0.47%)	13 (1.01%)	7 (0.50%)	5 (0.65%)	3 (0.18%)	7 (0.40%)	
Other	121 (9.48%)	146 (11.3%)	142 (10.0%)	74 (9.67%)	171 (10.2%)	151 (8.68%)	

*denotes statistical significance with $p < 0.05$; *Abbreviations:* API – Asian/Pacific Islander, APRDRG – All Patient Refined Diagnosis Related Groups.

Table 2
Surgical characteristics by year.

	2012	2013	2014	2015	2016	2017	P Value
Days from Admission to Surgery	2.67 (3.33)	2.55 (3.65)	2.51 (3.75)	2.42 (2.84)	2.30 (2.76)	2.29 (2.69)	**0.009***
Approach:							**<0.001***
Anterior	126 (9.81%)	100 (7.72%)	91 (6.44%)	46 (6.00%)	103 (6.12%)	89 (5.10%)	
Posterior	1158 (90.2%)	1195 (92.3%)	1323 (93.6%)	721 (94.0%)	1580 (93.9%)	1655 (94.9%)	
Length of Stay	11.2 (12.2)	10.9 (9.71)	10.5 (8.43)	9.93 (6.86)	10.4 (10.3)	9.76 (8.08)	**<0.001***
Discharge Destination:							**<0.001***
Routine	529 (41.2%)	488 (37.7%)	484 (34.2%)	222 (28.9%)	561 (33.4%)	606 (34.7%)	
Transfer to Short Term Hospital	31 (2.41%)	17 (1.31%)	27 (1.91%)	13 (1.69%)	35 (2.08%)	17 (0.97%)	
SNF	582 (45.3%)	660 (51.0%)	743 (52.5%)	441 (57.5%)	875 (52.1%)	887 (50.9%)	
Home Health	126 (9.81%)	113 (8.73%)	150 (10.6%)	79 (10.3%)	190 (11.3%)	204 (11.7%)	
AMA	3 (0.23%)	2 (0.15%)	1 (0.07%)	1 (0.13%)	4 (0.24%)	3 (0.17%)	
In Hospital Mortality:	12 (0.93%)	15 (1.16%)	9 (0.64%)	11 (1.43%)	16 (0.95%)	27 (1.55%)	0.186
Total Charges	$204,071 ($171,745)	$210,004 ($165,528)	$209,902 ($165,468)	$206,478 ($156,875)	$232,716 ($181,124)	$227,415 ($162,001)	**<0.001***

*denotes statistical significance with $p < 0.05$; *Abbreviations*: SNF – Skilled Nursing Facility, AMA – against medical advice.

Table 3
Bivariate analysis of demographics and in-hospital mortality.

	No Mortality	Mortality	P Value
	N = *8095*	*N* = *90*	
Age	49.6 (20.1)	70.2 (15.2)	**<0.001***
Sex:			**0.031***
Male	5086 (62.8%)	67 (74.4%)	
Female	3008 (37.2%)	23 (25.6%)	
Race:			0.151
White	5893 (78.3%)	72 (85.7%)	
Black	420 (5.58%)	7 (8.33%)	
Hispanic	730 (9.69%)	2 (2.38%)	
API	176 (2.34%)	1 (1.19%)	
Native American	67 (0.89%)	0 (0.00%)	
Other	244 (3.24%)	2 (2.38%)	
Hospital Region:			0.098
New England	275 (3.40%)	7 (7.78%)	
Mid-Atlantic	938 (11.6%)	15 (16.7%)	
East North Central	1285 (15.9%)	15 (16.7%)	
West North Central	726 (8.97%)	9 (10.0%)	
South Atlantic	1645 (20.3%)	12 (13.3%)	
East South Central	725 (8.96%)	10 (11.1%)	
West South Central	996 (12.3%)	6 (6.67%)	
Mountain	698 (8.62%)	5 (5.56%)	
Pacific	807 (9.97%)	11 (12.2%)	
Severity APRDRG:			**<0.001***
1 (Minor Loss of Function)	75 (0.93%)	0 (0.00%)	
2 (Moderate Loss of Function)	314 (3.88%)	1 (1.11%)	
3 (Major Loss of Function)	6336 (78.3%)	12 (13.3%)	
4 (Extreme Loss of Function)	1370 (16.9%)	77 (85.6%)	
Mortality APRDRG:			**<0.001***
1 (Minor Likelihood of Dying)	3593 (44.4%)	3 (3.33%)	
2 (Moderate Likelihood of Dying)	2218 (27.4%)	0 (0.00%)	
3 (Major Likelihood of Dying)	1604 (19.8%)	18 (20.0%)	
4 (Extreme Likelihood of Dying)	680 (8.40%)	69 (76.7%)	
Opioid Use Abuse:	153 (1.89%)	1 (1.11%)	1.000
Marijuana Use Abuse:	265 (3.27%)	1 (1.11%)	0.372
ZIP Median Income Quartile:			0.441
1 (Lowest)	2234 (28.4%)	31 (35.2%)	
2	2216 (28.1%)	21 (23.9%)	
3	1873 (23.8%)	22 (25.0%)	
4 (Highest)	1551 (19.7%)	14 (15.9%)	
Number of Admitted Diagnoses	12.7 (6.91)	21.3 (5.72)	**<0.001***
Expected Payer:			**<0.001***
Medicare	2178 (27.0%)	63 (70.0%)	
Medicaid	1097 (13.6%)	5 (5.56%)	
Private	3317 (41.1%)	18 (20.0%)	
Self-Pay	638 (7.90%)	1 (1.11%)	
No Charge	41 (0.51%)	0 (0.00%)	
Other	801 (9.92%)	3 (3.33%)	
Approach:			0.502
Anterior	550 (6.80%)	4 (4.44%)	
Posterior	7544 (93.2%)	86 (95.6%)	
Days from Admission to Surgery	2.44 (3.18)	2.78 (3.35)	0.345
Length of Stay	10.4 (9.53)	12.0 (8.74)	0.092
Total Charges	$216,308 ($168,459)	$290,562 ($171,405)	**<0.001***

*denotes statistical significance with $p < 0.05$; *Abbreviations:* API – Asian Pacific Islander, APRDRG – All Patient Refined Diagnosis Related Group.

rise, identifying risk factors for poor outcomes in these patients has become a major priority. Short-term outcomes after surgery such as complications, readmissions, and revisions are commonly viewed as important metrics in determining the overall success of patients who undergo surgery after these injuries. Awareness and consideration of social determinants of health, and their impact on these outcomes, has been brought to the forefront of academic medicine in recent years, with various indices incorporating factors such as average socioeconomic status, housing and transportation, education status, and employment status to create community-level socioeconomic stratifications (Kind et al., 2014; Glance; Kesler). These factors are especially important when considering our finding of significantly increased total charges in patients that expire in the hospital, a finding likely representative of these patients' medical complexities (Tanenbaum et al., 2016). After investigation of individual and community-level socioeconomic factors utilizing the NIS database from 2012 to 2017, our study observed no significant increase in mortality over that time, but did find an association between in-hospital mortality and patient's age and race after thoracolumbar fusion.

Trends in mortality among admitted spine patients vary between injury mechanisms and management. Jain et al. conducted a comprehensive assessment of in-hospital mortality after acute spinal cord injury from 1993 to 2012 and found an increase in mortality from 6.6% to 7.5% (Jain et al., 2015). This increase may, in part, be associated with an increase in surgical cases, particularly in the elderly population. Another study of the NIS database from 2005 to 2014 observed increased in-hospital mortality in patients >65 years of age that suffered a spinal cord injury, regardless of lesion site in the spine (Gao et al., 2020). Our study aligns with the recent literature, observing an increase in the average age of patient undergoing thoracolumbar fusion after traumatic injury from 2012 to 2017, and identifying age as an independent predictor of in-hospital mortality after surgery. Notably, there was no significant increase in mortality from 2012 to 2017, even with an increasingly aging patient cohort. Improvement in days from admission to surgery across the same time period may be one factor that has helped mitigate the risks of surgery in these patients, as multiple studies have observed fewer in-hospital complications and lower rates of in-hospital mortality with quicker time to surgery (Ruddell et al., 2021; Bellabarba et al., 2010; Barkay et al., 2023).

Recent literature presents mixed evidence regarding associations between patient demographic and socioeconomic factors and mortality after spine surgery. In a recent database study, Engler et al. found Black patients experienced more readmissions and complications, even when controlling for the patient's social vulnerability index (SVI)—a community-level socioeconomic index (Engler et al., 2023). However, 90-day mortality rates were fully explained by controlling for demographic factors, such as age, sex, and Charlson Comorbidity Index (CCI). Another study in the metastatic spine disease population similarly found no associations between race, SVI, insurance status, or modified Bauer Score (a validated prognostication model for metastatic spine disease) and survival after spine surgery (De la Garza Ramos et al., 2023). Conversely, Schoenfeld et al. observed increased odds (2.1 OR) of in-hospital mortality in black patients after spine trauma, even when controlling for other mortality risk factors such as Glasgow Coma Scale (GSC), injury severity score (ISS), and length of stay (Schoenfeld et al., 2013). Multiple studies have also found increased risk of mortality in Black patients after spine surgery, with one meta-analysis calculating a 55% higher risk of mortality after spine surgery compared to White patients (Khan et al., 2022; Akosman et al., 2023; Alosh et al., 2009). Our findings align with these studies, as Black patients were independently associated with increased in-hospital mortality rates when compared to White patients. Increased mortality rates in Black patients after trauma has been shown repeatedly in the literature, with previous studies citing implicit bias as a potential contributor to these inequities (Henry et al., 2023; Bailey et al., 2017; Scott et al., 2013). Although race has a unique significance in America, multiple studies have highlighted race as a risk factor for poor outcomes globally, both in the medical and surgical fields (Siddiq et al., 2023; Bakhtiari, 2022; Vitalis et al., 2021). Future research is necessary to further identify and investigate these healthcare disparities in spinal trauma, both in North America and globally.

Table 4
Regression analysis of in-hospital mortality.

	In Hospital Mortality			In Hospital Mortality		
Predictors	*Odds Ratios*	*CI*	*p-value*	*Odds Ratios*	*CI*	*p-value*
Age	1.06	1.04–1.08	**<0.001**	1.06	1.04–1.08	**<0.001**
Mortality APRDRG	3.47	2.10–6.00	**<0.001**	3.47	2.10–6.00	**<0.001**
Black	3.71	1.31–9.13	**0.007**	3.86	1.35–9.55	**0.006**
Hispanic	0.41	0.07–1.40	0.230	0.40	0.06–1.38	0.219
API	0.48	0.03–2.54	0.488	0.51	0.03–2.72	0.526
ZIP MI Quartile 1	Ref	Ref	Ref	Ref	Ref	Ref
ZIP MI Quartile 2	0.60	0.31–1.12	0.114	0.59	0.31–1.11	0.105
ZIP MI Quartile 3	0.95	0.50–1.78	0.880	0.97	0.51–1.82	0.922
ZIP MI Quartile 4	0.67	0.32–1.34	0.267	0.67	0.32–1.35	0.271
Number of Admission Diagnoses	1.02	0.98–1.07	0.305	1.02	0.98–1.07	0.323
Severity APRDRG	5.46	2.46–13.02	**<0.001**	5.48	2.47–13.12	**<0.001**
2012	Ref	Ref	Ref	Ref	Ref	Ref
2013				1.11	0.47–2.61	0.818
2014				0.68	0.26–1.75	0.434
2015				1.31	0.51–3.28	0.562
2016				0.71	0.31–1.66	0.424
2017				0.99	0.46–2.24	0.988

*denotes statistical significance with $p < 0.05$; *Abbreviations:* API – Asian Pacific Islander, APRDRG – All Patient Refined Diagnosis Related Group, ZIP MI – ZIP code median income.

The lack of a significant association of ZIP code median income quartile also suggests that community-level socioeconomic metrics may not provide prognostic utility in risk assessment of in-patient mortality after thoracolumbar fusion. Though ZIP code median income does not fully capture a person's community-level socioeconomic and psychosocial health, it can serve as a reasonable corollary in a nationwide database study. A recent study of mortality after surgery for metastatic spine disease found that mortality was not associated with two different community-level indices—social deprivation index (SDI) and area deprivation index (ADI) (Piña et al., 2023). Instead, insurance status and palliative care consultation were found to be associated with mortality in these patients. Community-level indices like SDI and ADI have also been investigated in relation to other outcomes after surgery, including readmissions, reoperations, and patient-reported outcome measures. Lambrechts et al. observed no association between distressed community index (DCI) quintile and PROMs after anterior cervical discectomy and fusion (ACDF) (Lambrechts et al., 2022). Another study found a similar lack of association between DCI and PROMs after elective lumbar fusion (Siegel et al., 2023). Though this study cannot assess PROMs due to the nature of the NIS database, these findings suggest that community-level indices such as DCI, ADI, and SVI may not adequately capture the disparities that exist in these communities.

This study is not without its limitations. The NIS database generates a sample of 20% of annual admissions from participating national hospitals; however, any outcome or complication encountered outside of the hospital admission is not reported. Therefore, it is not possible to draw conclusions about short-term outcomes such as readmissions, complications, and reoperations. Additionally, any inaccuracies in reported diagnoses codes or procedure codes associated with the admission cannot be validated. Changes in the International Classification of Diseases (ICD) from ICD-9 to ICD-10 during 2015 also posed challenges in querying the database; however, an extensive search of both classification systems was conducted to identify the appropriate codes to include in our query. Finally, ZIP code median income quartile is not as comprehensive as other validated community-level socioeconomic indices that include additional factors such as housing status, education status, and employment rates. It has been used in this study as an approximation to a patient's community-level health as other indices are not able to be calculated from the provided NIS data.

5. Conclusions

Our study of nationwide, traumatic thoracolumbar fusion procedures from 2012 to 2017 in the NIS database found older, black patients were at increased risk for in-hospital mortality; however, it is important to note that only 90 in-hospital mortalities were reported during this time and seven of these patients were black. We additionally observed no association between ZIP code median income and in-hospital mortality, highlighting a potential lack of prognostic utility in community-level socioeconomic measures in relation to mortality. As the awareness of healthcare disparities grows, future research focusing on racial and socioeconomic inequities should continue to critically evaluate their impact on spinal trauma surgical outcomes. Improving the prognostic value of current socioeconomic indices may help enhance care delivery to this patient population and beyond.

Conflicts of interest and source of funding

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. ICD 10 Codes for Primary Thoracolumbar Fusion

ICD 10	0RG1070, 0RG1071, 0RG107J, 0RG10A0, 0RG10AJ, 0RG10J0, 0RG10J1, 0RG10JJ, 0RG10K0, 0RG10K1, 0RG10KJ, 0RG1370, 0RG1371, 0RG137J, 0RG13A0, 0RG13AJ, 0RG13J0, 0RG13J1, 0RG13JJ, 0RG13K0, 0RG13K1, 0RG13KJ, 0RG1470, 0RG1471, 0RG147J, 0RG14A0, 0RG14AJ, 0RG14J0, 0RG14J1, 0RG14JJ, 0RG14K0, 0RG14K1, 0RG14KJ, 0RG2070, 0RG2071, 0RG207J, 0RG20A0, 0RG20AJ, 0RG20J0, 0RG20J1, 0RG20JJ, 0RG20K0, 0RG20K1, 0RG20KJ, 0RG2370, 0RG2371, 0RG237J, 0RG23A0, 0RG23AJ, 0RG23J0, 0RG23J1, 0RG23JJ, 0RG23K0, 0RG23K1, 0RG23KJ, 0RG2470, 0RG2471, 0RG247J, 0RG24A0, 0RG24AJ, 0RG24J0, 0RG24J1, 0RG24JJ, 0RG24K0, 0RG24K1, 0RG24KJ, 0RG4070, 0RG4071, 0RG407J, 0RG40A0, 0RG40AJ, 0RG40J0, 0RG40J1, 0RG40JJ, 0RG40K0, 0RG40K1, 0RG40KJ, 0RG4370, 0RG4371, 0RG437J, 0RG43A0, 0RG43AJ, 0RG43J0, 0RG43J1, 0RG43JJ, 0RG43K0, 0RG43K1, 0RG43KJ, 0RG4470, 0RG4471, 0RG447J, 0RG44A0, 0RG44AJ, 0RG44J0, 0RG44J1, 0RG44JJ, 0RG44K0, 0RG44K1, 0RG44KJ, 0RG6070, 0RG6071, 0RG607J, 0RG60A0, 0RG60AJ, 0RG60J0, 0RG60J1, 0RG60JJ, 0RG60K0, 0RG60K1, 0RG60KJ, 0RG6370, 0RG6371, 0RG637J, 0RG63A0, 0RG63AJ, 0RG63J0, 0RG63J1, 0RG63JJ, 0RG63K0, 0RG63K1, 0RG63KJ, 0RG6470, 0RG6471, 0RG647J, 0RG64A0, 0RG64AJ, 0RG64J0, 0RG64J1, 0RG64JJ, 0RG64K0, 0RG64K1, 0RG64KJ, 0RG7070, 0RG7071, 0RG707J, 0RG70A0, 0RG70AJ, 0RG70J0, 0RG70J1, 0RG70JJ, 0RG70K0, 0RG70K1, 0RG70KJ, 0RG7370, 0RG7371, 0RG737J, 0RG73A0, 0RG73AJ, 0RG73J0, 0RG73J1, 0RG73JJ, 0RG73K0, 0RG73K1, 0RG73KJ, 0RG7470, 0RG7471, 0RG747J, 0RG74A0, 0RG74AJ, 0RG74J0, 0RG74J1, 0RG74JJ, 0RG74K0, 0RG74K1, 0RG74KJ, 0RG8070, 0RG8071, 0RG807J, 0RG80A0, 0RG80AJ, 0RG80J0, 0RG80J1, 0RG80JJ, 0RG80K0, 0RG80K1, 0RG80KJ, 0RG8370, 0RG8371, 0RG837J, 0RG83A0, 0RG83AJ, 0RG83J0, 0RG83J1, 0RG83JJ, 0RG83K0, 0RG83K1, 0RG83KJ, 0RG8470, 0RG8471, 0RG847J, 0RG84A0, 0RG84AJ, 0RG84J0, 0RG84J1, 0RG84JJ, 0RG84K0, 0RG84K1, 0RG84KJ, 0RGA070, 0RGA071, 0RGA07J, 0RGA0A0, 0RGA0AJ, 0RGA0J0, 0RGA0J1, 0RGA0JJ, 0RGA0K0, 0RGA0K1, 0RGA0KJ, 0RGA370, 0RGA371, 0RGA37J, 0RGA3A0, 0RGA3AJ, 0RGA3J0, 0RGA3J1, 0RGA3JJ, 0RGA3K0, 0RGA3K1, 0RGA3KJ, 0RGA470, 0RGA471, 0RGA47J, 0RGA4A0, 0RGA4AJ, 0RGA4J0, 0RGA4J1, 0RGA4JJ, 0RGA4K0, 0RGA4K1, 0RGA4KJ, 0SG0070, 0SG0071, 0SG007J, 0SG00A0, 0SG00AJ, 0SG00J0, 0SG00J1, 0SG00JJ, 0SG00K0, 0SG00K1, 0SG00KJ, 0SG0370, 0SG0371, 0SG037J, 0SG03A0, 0SG03AJ, 0SG03J0, 0SG03J1, 0SG03JJ, 0SG03K0, 0SG03K1, 0SG03KJ, 0SG0470, 0SG0471, 0SG047J, 0SG04A0, 0SG04AJ, 0SG04J0, 0SG04J1, 0SG04JJ, 0SG04K0, 0SG04K1, 0SG04KJ, 0SG1070, 0SG1071, 0SG107J, 0SG10A0, 0SG10AJ, 0SG10J0, 0SG10J1, 0SG10JJ, 0SG10K0, 0SG10K1, 0SG10KJ, 0SG1370, 0SG1371, 0SG137J, 0SG13A0, 0SG13AJ, 0SG13J0, 0SG13J1, 0SG13JJ, 0SG13K0, 0SG13K1, 0SG13KJ, 0SG1470, 0SG1471, 0SG147J, 0SG14A0, 0SG14AJ, 0SG14J0, 0SG14J1, 0SG14JJ, 0SG14K0, 0SG14K1, 0SG14KJ, 0SG3070, 0SG3071, 0SG307J, 0SG30A0, 0SG30AJ, 0SG30J0, 0SG30J1, 0SG30JJ, 0SG30K0, 0SG30K1, 0SG30KJ, 0SG3370, 0SG3371, 0SG337J, 0SG33A0, 0SG33AJ, 0SG33J0, 0SG33J1, 0SG33JJ, 0SG33K0, 0SG33K1, 0SG33KJ, 0SG3470, 0SG3471, 0SG347J, 0SG34A0, 0SG34AJ, 0SG34J0, 0SG34J1, 0SG34JJ, 0SG34K0, 0SG34K1, 0SG34KJ

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