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Evaluation of perioperative care and drivers of cost in geriatric thoracolumbar trauma

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A B S T R A C T

Introduction: As the population of elderly patients continues to rise, the number of these individuals presenting with thoracolumbar trauma is expected to increase.

Research question: To investigate thoracolumbar fusion outcomes for patients with vertebral fractures as stratified by decade. Secondarily, we examined the variability of cost across age groups by identifying drivers of cost of care.

Materials and methods: We queried the United States Nationwide Inpatient Sample(NIS) for adult patients undergoing spinal fusion for thoracolumbar fractures between 2012 and 2017. Patients were stratified by decade 60–69(sexagenarians), 70–79(septuagenarians) and 80–89(octogenarians). Bivariable analysis followed by multivariable regression was performed to assess independent predictors of length of stay(LOS), hospital cost, and discharge disposition.

Results: A total of 2767 patients were included, of which 46%(N = 1268) were sexagenarians, 36% septuagenarians and 18%(N = 502) octogenarians. Septuagenarians and octogenarians had shorter LOS compared to sexagenarians(ß = −0.88 days; p = 0.012) and(ß = -1.78; p < 0.001), respectively. LOS was reduced with posterior approach(-2.46 days[95% CI: 3.73–1.19]; p < 0.001), while Hispanic patients had longer LOS(+1.97 [95% CI: 0.81–3.13]; p < 0.001). Septuagenarians had lower total charges $12,185.70(p = 0.040), while the decrease in charges in octogenarians was more significant, with a decrease of $26,016.30(p < 0.001) as compared to sexagenarians. Posterior approach was associated with a decrease of $24,337.90 in total charges(p = 0.026). Septuagenarians and octogenarians had 1.72 higher odds(p < 0.001) and 4.16 higher odds(p < 0.001), respectively, of discharge to a skilled nursing facility.

Discussion and conclusions: Healthcare utilization in geriatric thoracolumbar trauma is complex. Cost reductions in the acute hospital setting may be offset by unaccounted costs after discharge. Further research into this phenomenon and observed racial/ethnic disparities must be pursued.

1. Introduction

Globally, the proportion of the elderly in the general population continues to rise, as it is estimated that 1 in 5 people will be 60 years or older by 2050. (United Nations Population) This has resulted in a significant increase in the rate of spine fusion surgeries by over 239% in patients over the age of 65 (Rajaee et al., 2012). These patients are at significantly higher risk of adverse surgical outcomes due to osteoporosis, comorbidity burden, frailty, gait abnormalities, and poorer nutritional status. All of these factors may continue to worsen with increasing age (Chan et al., 2021; George et al., 2021; Ondeck et al., 2018; Saleh et al., 2017). Among patients undergoing spinal surgery, the effects of advanced age remain controversial. Some studies dispute the traditionally presumed notion that older patients experience poorer outcomes, while others have demonstrated clear associations between patient age and postoperative morbidity and mortality (Saleh et al., 2017; Kuo et al., 2022; Oichi et al., 2019; Balabaud et al., 2015). Moreover, this risk may differ based on the preoperative diagnosis and

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complexity of spine surgery (Deyo et al., 2010).

Patients with thoracolumbar trauma represent a specific population where the adverse effects of advanced age on spinal fusion outcomes is of particular concern. Already, the rate of thoracic and lumbar vertebral fractures has increased by 47% over a recent 20-year span (Amin et al., 2014). A United States National Health and Nutrition Examination Survey demonstrated that a rising incidence of vertebral fractures occurs with age, with an overall prevalence of 11% in patients aged 70–79 years and 18% in those ≥80 years (Cosman et al., 2017). This risk is secondary to a decreased ability to withstand injury as a result of the physiologic aging process and osteoporosis. While surgeons may attempt to avoid multi-segment spinal surgery in the elderly to reduce morbidity, thoracolumbar fracture fixation often requires multi-level constructs thereby increasing operative risk (Balabaud et al., 2015).

Stratifying elderly patients by an age range may be more meaningful for preoperative decision making rather than using a specific single-age threshold. The purpose of this study was therefore to examine the patient profile of elderly patients presenting with a thoracolumbar fracture requiring operative intervention. We sought to examine the role that decade of life may play among patients aged 60–69 (sexagenarian), 70–79 (septuagenarian), and 80–89 (octogenarian) on thoracolumbar fusion perioperative outcomes. Secondarily, we aimed to characterize the variability of cost associated with thoracolumbar trauma while identifying drivers of cost of care in the geriatric population. This work may provide valuable information as the number of elderly patients presenting with vertebral fractures continues to rise.

2. Materials and methods

2.1. Data source

The current study utilized the United States Nationwide Inpatient Sample (NIS) database, a publicly available database sponsored by the Healthcare Cost and Utilization Project (HCUP). NIS is the most comprehensive all-payer hospital admission repository in the United States. It comprises health-care utilization data from over 1000 hospitals, capturing over 20% of annual hospitalizations in the United States. The database includes patient demographics, length of stay (LOS), total hospital charges, and a range of perioperative outcomes coded as diagnostic and procedural codes based on the International Classification of Diseases, Ninth Revision (ICD-9), and Tenth Revision (ICD-10). Given that the NIS database does not include patient and hospital identifiers, this study was considered exempt by the institutional review board (IRB).

2.2. Patient population

All adult patients over 18 years of age who underwent fusion for thoracolumbar vertebral fractures between the years 2012–2017 were included in our study. The identification of cases was done using codes validated in prior literature. Patients were first identified by ICD-9 (805.2, 806.2×, 805.4, 806.4) and ICD-10 (S22.0xxA, S32.0sxxA) diagnostic codes for thoracolumbar fractures. Patients who underwent non-elective anterior or posterior fusion for thoracolumbar fracture were then subsequently identified using specific ICD-9 (81.02, 81.04, 81.06, 81.03, 81.05, 81.07, 81.08), and ICD-10 (0RGsxy1, 0RGsxyJ, OSGsxyJ1) diagnostic codes for fusion (De Stefano et al., 2022). All patients received in hospital treatment for their surgery.

Patient demographics, surgical characteristics, perioperative outcomes, discharge destination, and total hospital charges were included in the analysis. Hospital characteristics were described based on type (non-teaching, teaching, and rural), size, and United States geographic region (Northeast, Midwest, South, and West). Total hospital charges were calculated by multiplying Diagnosis Related Group (DRG) codes with hospital-specific cost-to-charge ratios as determined by the Agency for Healthcare Research and Quality. The HCUP indices for the diagnosis-related groups were employed to adjust for variations in hospitalization severity. Hospitalization costs across years assessed were subsequently standardized to December 2017 US dollars, to account for inflation.

Patient injury severity was assessed using the Severity All Patient Refined Diagnosis Related Groups (APRDRG), Mortality APRDRG scales which represent a proxy for injury and mortality severity according to the following subclasses for mortality: (1) minor likelihood of dying, (2) moderate likelihood of dying, (3) major likelihood of dying, (4) extreme likelihood of dying. ADPRG severity of injury was defined as (1) minor loss of function (includes cases with no comorbidity or complications), (2) moderate loss of function, (3) major loss of function, (4) extreme loss of function.

2.3. Statistical analysis

Patients were categorized by age groupings. Descriptive statistics were reported as mean and standard deviation for continuous variables and count and percent for categorical variables. Parametric and nonparametric continuous variables were assessed using analysis of variance (ANOVA) or Kruskal Wallis testing, respectively. All categorical variables were compared using a Pearson chi-square analysis. Post-hoc pairwise testing was performed for between-group comparisons. Multivariable linear regression was then conducted accounting for the following independent covariates: age, race, approach, location of injury severity, mortality and expected payer. Dependent variables analyzed were length of stay (LOS), total hospital charges, and discharge disposition. The threshold for statistical significance was set at $P < 0.05$. All statistical analyses were conducted using RStudio (Version 1.2.5001).

3. Results

3.1. Patient demographics

A total of 2767 patients underwent non-elective fusion for thoracolumbar fractures from 2012 to 2017, with an average age of 71.5 years. Within this cohort, 46% (N = 1268) were sexagenarians (age 60–69), followed by 36% septuagenarians (age 70–79) and 18% (N = 502) octogenarians. The majority of patients were male (55.8%), with a higher proportion of males comprising the sexagenarian group compared to octogenarians (58.4% vs. 52.9%, $p = 0.062$). The majority of patients were White across all age groups (87.7%), with a decreased proportion of White patients who were sexagenarian (83.4%), compared to septuagenarians (85.6%, $p = 0.044$) and octogenarians (88.8%, $p = 0.016$). The proportion of Black, Hispanic, and Asian or Pacific Islander (API) categories showed little variation across age groups. Regarding median income quartile, there was a statistically significant difference between the youngest and oldest age groups ($p = 0.21$), with the oldest patients comprising a higher proportion in the highest income quartile (27.4%) compared to the youngest group (21.9%). There was a significant variation in the distribution of hospital regions where patients received care with the highest proportion receiving care in the South Atlantic region of the United States ($p = 0.002$) (Table 1).

3.2. Surgical characteristics

There was no statistically significant difference in the severity of APRDRG across the age groups ($p = 0.695$). However, significant differences were observed in mortality APRDRG levels, as octogenarians showing a higher proportion of patients in the highest mortality levels: 3 (octogenarians: 36.7% vs sexagenarians: 23.3%) and 4 (octogenarians: 19.0% vs. sexagenarians: 10.5%) ($p < 0.001$). The posterior approach was more frequently utilized regardless of age. However, the type of surgical approach differed significantly across age groups ($p < 0.001$), with the anterior approach being less frequently employed as age increased (sexagenarians: 6.94% vs. octogenarians: 2.55%, $p < 0.001$).

Table 1
Patient demographics and hospital characteristics for patients who underwent fusion for thoracolumbar fracture between 2012 and 2017.

	60–69 N = 1268	70–79 N = 997	80–89 N = 502	P-value	P-value 60–69 vs 70-79	P-value 60–69 vs 80-89	P-value 70–79 vs 80-89
Age	64.5 (2.85)	74.2 (2.86)	83.7 (2.66)				
Sex				**0.036**	0.062	0.062	0.681
Male	766 (58.4%)	552 (54.0%)	270 (52.9%)				
Female	545 (41.6%)	471 (46.0%)	240 (47.1%)				
Race				**0.007**	**0.044**	**0.016**	0.469
White	1022 (83.4%)	823 (85.6%)	427 (88.8%)				
Black	50 (4.08%)	21 (2.19%)	6 (1.25%)				
Hispanic	85 (6.94%)	61 (6.35%)	25 (5.20%)				
API	25 (2.04%)	30 (3.12%)	15 (3.12%)				
Median Income Quartile				**0.049**	0.936	**0.021**	0.058
0-25th percentile	328 (25.7%)	255 (25.4%)	107 (21.6%)				
26th to 50th percentile (median)	373 (29.2%)	287 (28.6%)	123 (24.8%)				
51st to 75th percentile	296 (23.2%)	241 (24.0%)	130 (26.2%)				
76th to 100th percentile	280 (21.9%)	222 (22.1%)	136 (27.4%)				
Hospital Region:				**0.002**	0.360	**0.003**	**0.005**
New England	43 (3.28%)	34 (3.32%)	31 (6.08%)				
Mid-Atlantic	171 (13.0%)	121 (11.8%)	87 (17.1%)				
East North Central	214 (16.3%)	180 (17.6%)	91 (17.8%)				
West North Central	117 (8.92%)	82 (8.02%)	42 (8.24%)				
South Atlantic	265 (20.2%)	240 (23.5%)	89 (17.5%)				
East South Central	107 (8.16%)	79 (7.72%)	31 (6.08%)				
West South Central	160 (12.2%)	98 (9.58%)	38 (7.45%)				
Mountain	108 (8.24%)	84 (8.21%)	35 (6.86%)				
Pacific	126 (9.61%)	105 (10.3%)	66 (12.9%)				

Abbreviations: API: Asian Pacific Islander.

The number of admitted diagnoses increased with age (sexagenarians: 14.6 vs octogenarians: 17.7, $p < 0.001$). Discharge destinations showed significant differences across all age groups ($p < 0.001$). As age increased, the proportion of patients discharged to skilled nursing facilities (SNF) increased (sexagenarians: 63.7% vs. octogenarians: 87.5%, $p < 0.001$), and the proportion of patients discharged to home decreased (sexagenarians: 12.6% vs. octogenarians: 3.97%, $p < 0.001$). The fracture location ($p = 0.072$), number of days from admission to surgery ($p = 0.204$), and the LOS ($p = 0.06$) were not significantly different between groups (Table 2).

3.3. Insurance status and payer

Total hospital charges for thoracolumbar fracture treatment differed

Table 2
Surgical characteristics for patients for patients who underwent fusion for thoracolumbar fracture between 2012 and 2017.

	60–69 N = 1268	70–79 N = 997	80–89 N = 502	P-value	P-value 60–69 vs 70-79	P-value 60–69 vs 80-89	P-value 70–79 vs 80-89
Severity APRDRG:				0.695			
1	13 (0.99%)	13 (1.27%)	4 (0.78%)				
2	53 (4.04%)	51 (4.99%)	18 (3.53%)				
3	989 (75.4%)	769 (75.2%)	378 (74.1%)				
4	256 (19.5%)	190 (18.6%)	110 (21.6%)				
Mortality APRDRG:				**<0.001**	**<0.001**	**<0.001**	**<0.001**
1	478 (36.5%)	199 (19.5%)	66 (12.9%)				
2	391 (29.8%)	377 (36.9%)	160 (31.4%)				
3	305 (23.3%)	295 (28.8%)	187 (36.7%)				
4	137 (10.5%)	152 (14.9%)	97 (19.0%)				
Approach:				**<0.001**	**0.012**	**0.001**	0.129
Anterior	91 (6.94%)	45 (4.40%)	13 (2.55%)				
Posterior	1220 (93.1%)	978 (95.6%)	497 (97.5%)				
Location:				0.072			
Thoracic	737 (56.2%)	625 (61.1%)	309 (60.6%)				
Lumbosacral	425 (32.4%)	312 (30.5%)	150 (29.4%)				
Thoraco-lumbar	149 (11.4%)	86 (8.41%)	51 (10.0%)				
# Admitted Diagnosis	14.6 (6.64)	16.6 (6.59)	17.7 (6.50)	**<0.001**	**<0.001**	**<0.001**	**0.009**
Days from Admission to Surgery	2.96 (3.61)	3.15 (3.46)	3.28 (3.35)	0.204			
Length of Stay	11.1 (9.64)	10.5 (6.78)	10.3 (5.83)	0.060			
Discharge Destination:				**<0.001**	**<0.001**	**<0.001**	**<0.001**
Routine	270 (20.6%)	94 (9.19%)	14 (2.75%)				
Transfer to Short Term Hospital	25 (1.91%)	16 (1.56%)	9 (1.76%)				
SNF	834 (63.7%)	796 (77.8%)	446 (87.5%)				
Home Health	165 (12.6%)	82 (8.02%)	20 (3.92%)				
AMA	1 (0.08%)	1 (0.10%)	0 (0.00%)				
Expired in Hospital	15 (1.15%)	34 (3.32%)	21 (4.12%)				
Death:	15 (1.15%)	34 (3.32%)	21 (4.12%)	**<0.001**	**0.001**	**0.001**	0.678

Abbreviations: APRDRG: All Patients Refined Diagnosis Related Groups, SNF: Skilled Nursing Facility, AMA: Against Medical Advice.

significantly across age groups and decreased with age (sexagenarians: $219,791 vs octogenarians: $193,207, p = 0.001). This trend remained consistent after adjusting for inflation (p = 0.001) Medicare was the predominant insurance type with its proportion increasing from 46.8% in sexagenarians to 86.8% in octogenarians (p < 0.001). In contrast, the proportion of patients with private insurance significantly decreased with age, from 36.7% among sexagenarians to 10.6% among octogenarians (p < 0.001) (Table 3).

3.4. Multivariable analysis: length of stay

On multivariable regression, septuagenarians and octogenarians patients had significantly shorter LOS (ß: 0.88 days; p = 0.012) and (ß: 1.78 days; p < 0.001) respectively. Compared to White patients, Hispanic patients had significantly longer LOS (ß: 1.97 days; p < 0.001). LOS was lower following posterior approach (ß: 2.46 days; p < 0.001) but increased with severity APRDRG (ß: 3.30 days; p < 0.001), mortality APRDRG (ß: 2.21 days; p < 0.001) and in self-payers (ß: 4.63; p < 0.001) (Table 4).

3.5. Multivariable analysis: total charges

Age had a significant impact on total charges with septuagenarians having lower total charges (ß: $12,185.70; p = 0.040), and octogenarians demonstrating a pronounced reduction in total charges (ß: $26,016.30; p < 0.001) as compared to sexagenarians. Hispanic patients incurred higher total costs (ß: $41,401.30; p-value <0.001) compared to their non-Hispanic counterparts. Surgical approach, specifically posterior approach, was associated with a decrease of $24,337.90 in total charges (p = 0.026) (Table 5).

3.6. Multivariable analysis: discharge destination

On multivariable analysis, septuagenarians and octogenarians had higher odds of discharge to SNF (odds ratio (OR): 1.72, p < 0.001 and OE: 4.16, p < 0.001, respectively) compared to sexagenarians. Hispanic (OR: 0.65, p = 0.024) and API patients (OR: 0.49, p = 0.015) were less likely to be transferred to a SNF compared to White patients. Increased severity (OR: 1.29, p = 0.045) and mortality risk (OR: 1.50, p < 0.001), as determined by APRDRG, were associated with a higher likelihood of transfer to SNF. When examining expected payer types, Medicare served as the reference category. Patients with Medicaid, private insurance, or self-pay were all significantly less likely to be transferred to SNF or require a transfer, with odds ratios of 0.44 (p = 0.005), 0.57 (p < 0.001), and 0.13 (p < 0.001), respectively. Patients classified under 'other' payer types also had reduced odds (OR: 0.57, p = 0.011) compared to Medicare patients (Table 6).

Table 4
Regression analysis for patients who underwent lumbar fusion for thoracolumbar fracture between 2012 and 2017 using length of stay as the dependent outcome.

Variable	Estimate	P-value	Lower 95	Upper 95
Age Group:				
60–69	Reference			
70–79	−0.88	**0.012**	−1.57	−0.20
80–89	−1.78	**<0.001**	−2.63	−0.93
Race:				
White	Reference			
Black	0.56	0.511	−1.12	2.25
Hispanic	1.97	**0.001**	0.81	3.13
API	0.004	0.996	−1.75	1.76
PosteriorApproach	−2.46	**<0.001**	−3.73	−1.19
Location:				
Thoracic	Reference			
Lumbosacral	−0.10	0.763	−0.75	0.55
Thoracolumbar	−0.51	0.302	−1.47	0.46
Severity APRDRG	3.30	**<0.001**	2.61	4.00
MortalityAPRDRG	2.21	**<0.001**	1.85	2.58
Expected Payer:				
Medicare	Reference			
Medicaid	0.85	0.378	−1.03	2.72
Private	0.21	0.573	−0.52	0.94
Self-Pay	4.63	**<0.001**	2.40	6.86
No Charge	0.32	0.939	−8.06	8.71
Other	1.01	0.136	−0.31	2.34

Abbreviations: APRDRG: All Patients Refined Diagnosis Related Groups, API: Asian Pacific Islander.

4. Discussion

With an expanding elderly population, the rate of patients undergoing fusion for thoracolumbar fractures is projected to rise, potentially resulting in significant healthcare expenditures (Neifert et al., 2020). Older populations have distinct disease etiology and clinical differences compared to their younger counterparts, which should be considered in the context of spinal trauma. Such patients are increasingly susceptible to inferior surgical outcomes given that elderly populations have degenerative spinal rigidity affecting biomechanics, worse healing, and a propensity for subsequent fractures (Ibrahim et al., 2020; Sunder et al., 2023). Advances in spinal fixation and medical care have broadened the safety profile and pool of candidates eligible for fusion, making it imperative to appreciate perioperative outcomes and drivers of costs pertaining to care (Wang et al., 2015). In the current analysis, we investigated the perioperative outcomes of patients undergoing fusion for thoracolumbar fractures, stratified by age. We found that patients aged 80–89 had significantly shorter LOS, staying almost two days less than their younger counterparts (60–69 years old). Consequently, older patients (80–89) had lower total hospital costs, saving over $26,000 compared to their younger counterparts (60–69 years old).

Table 3
Total charges and payer for patients who underwent lumbar fusion for thoracolumbar fracture between 2012 and 2017.

	60–69 N = 1311	70–79 N = 1023	80–89 N = 510	P-value	P-value 60–69 vs 70-79	P-value 60–69 vs 80-89	P-value 70–79 vs 80-89
Total Charges	$219,791 ($179,917)	$205,012 ($132,389)	$193,207 ($127,921)	**0.001**	0.050	**0.001**	0.254
Adjusted Total Charges[a]	$226,947 ($184,157)	$213,255 ($136,812)	$197,138 ($128,172)	**0.001**	0.066	**0.001**	0.165
Expected Payer:				**<0.001**	**<0.001**	**<0.001**	**0.047**
Medicare	613 (46.8%)	839 (82.1%)	442 (86.8%)				
Medicaid	64 (4.89%)	6 (0.59%)	2 (0.39%)				
Private	480 (36.7%)	140 (13.7%)	54 (10.6%)				
Self-Pay	36 (2.75%)	10 (0.98%)	0 (0.00%)				
No Charge	3 (0.23%)	0 (0.00%)	0 (0.00%)				
Other	113 (8.63%)	27 (2.64%)	11 (2.16%)				

Abbreviations: APRDRG: All Patients Refined Diagnosis Related Groups.
[a] Adjusted for inflation.

Table 5
Regression analysis for patients who underwent lumbar fusion for thoracolumbar fracture between 2012 and 2017 using total charge as the dependent outcome.

Variable	Estimate	P-value	Lower 95	Upper 95
Age Group:				
60–69	Reference			
70–79	$-12,185.70	**0.040**	$-23,796.77	$-5,74.64
80–89	$-26,016.30	**<0.001**	$-40,444.41	-$11,588.25
Race:				
White	Reference			
Black	$-2381.80	0.869	$-30,686.41	$25,922.78
Hispanic	$41,401.30	**<0.001**	$21,735.48	$61,067.20
API	$23,321.50	0.125	$-6460.65	$53,103.66
PosteriorApproach	$-24,337.90	**0.026**	$-4,5811.96	$-2863.78
Location:				
Thoracic	Reference			
Lumbosacral	$-13,575.10	**0.015**	$-24,532.62	$-2617.60
Thoracolumbar	$30,026.80	**<0.001**	$13,822.75	$46,230.92
Severity APRDRG	$26,469.80	**<0.001**	$14,562.18	$38,377.43
MortalityAPRDRG	$9484.10	**0.003**	$3226.60	$15,741.66
Length of Stay	$10,521.40	**<0.001**	$9870.06	$11,172.66
Expected Payer:				
Medicare	Reference			
Medicaid	$-11,294.40	0.484	$-42,884.96	$20,296.07
Private	$-889.40	0.887	$-13,186.70	$11,407.83
Self-Pay	$-23,340.30	0.225	$-61,025.17	$14,344.65
No Charge	$-36,120.60	0.615	$177,032.25	$104,791.00
Other	$-25,578.40	**0.025**	$-47,902.47	$-3254.27

Abbreviations: APRDRG: All Patients Refined Diagnosis Related Groups, API: Asian Pacific Islander.

Table 6
Regression analysis for patients who underwent lumbar fusion for thoracolumbar fracture between 2012 and 2017 using SNF/Transfer as the dependent outcome.

Variable	Estimate	P-value	Odds Ratio	Lower 95	Upper 95
Age Group:					
60–69	Reference				
70–79	0.55	**<0.001**	1.72	1.36	2.19
80–89	1.43	**<0.001**	4.16	2.85	6.25
Race:					
White	Reference				
Black	0.06	0.836	1.06	0.61	1.94
Hispanic	−0.44	**0.024**	0.65	0.44	0.95
API	−0.71	**0.015**	0.49	0.29	0.88
PosteriorApproach	0.19	0.372	1.21	0.79	1.83
Location:					
Thoracic	Reference				
Lumbosacral	0.12	0.280	1.13	0.90	1.42
Thoracolumbar	0.11	0.543	1.11	0.80	1.57
Severity APRDRG	0.25	**0.045**	1.29	1.004	1.65
MortalityAPRDRG	0.40	**<0.001**	1.50	1.31	1.71
Expected Payer:					
Medicare	Reference				
Medicaid	−0.82	**0.005**	0.44	0.25	0.79
Private	−0.57	**<0.001**	0.57	0.45	0.72
Self-Pay	−2.07	**<0.001**	0.13	0.06	0.25
Other	−0.56	**0.011**	0.57	0.38	0.89

Abbreviations: APRDRG: All Patients Refined Diagnosis Related Groups, API: Asian Pacific Islander.

Our results ultimately demonstrate a paradoxical association between advancing age and lower LOS amongst the oldest patients. We postulate that there is an element of selection bias to our results, in that patients aged 80–89 in our study were deemed physiologically healthy enough for a surgical intervention. Therefore, the overall health status of these patients may have facilitated their post-surgical recovery and allowed them to mobilize earlier with physical therapy. These factors taken as a whole may have contributed to their shorter hospital stays. We acknowledge that this proposition contrasts with existing trends in the literature citing increased surgical risk associated with advanced age (Tsujimoto et al., 2022; Arul et al., 2019). Despite this, there is a growing body of literature endorsing the use of frailty scores as a superior measure of risk stratification and true physiologic status compared to chronological age (Mehkri et al., 2023; Kessler et al., 2018; Sun et al., 2020; Dicpinigaitis et al., 2022).

Another major finding in our study was the fact that despite a decrease in LOS, octogenarians and septuagenarians were significantly more likely to be discharged to SNF. Therefore, the reduced LOS and subsequent cost savings within a higher-risk surgical group, specifically septuagenarians and octogenarians, is possibly linked to an increased likelihood of discharge to a SNF. As healthcare systems intensify efforts to reduce costs, there has been a concentrated effort to reduce LOS through measures such as early discharge planning, (Siddique et al., 2021) even in the advanced age patient. While their inpatient LOS is reduced, we postulate that their care burden may be redistributed towards SNFs and acute inpatient rehabilitation(IPR). In this way, their overall health costs are potentially not being decreased, but rather shifted to these rehabilitation facilities.

In an effort to reduce immediate costs associated with LOS, hospitals likely find that, due to Medicare coverage, septuagenarians and octogenarians are able to get easier acceptance into SNFs and IPR (Bowblis and Brunt, 2014). Indeed, our data reveals that inpatient stays of septuagenarians and octogenarians were associated with lower healthcare expenditures of $12,000 and $26,000 compared to sexagenarians. However, cost data from the literature demonstrates that discharge to a SNF for orthopaedic patients has been associated with higher long-term costs, even when factoring in comorbidities (Kaidi et al., 2021). This concern is highlighted by Werner et al., who demonstrate that total joint arthroplasty patients who are discharged to a SNF, as opposed to home, were more likely to develop severe post-discharge adverse events and unplanned readmissions (Werner et al., 2019). When considering this study alongside our own findings, such cost containment strategies may inadvertently result in increased postoperative complications in an effort to expedite discharge and reduce costs. These considerations are especially pertinent in an era of value-based healthcare models tied to reimbursement. Therefore, surgeons should be advised that while expedited discharges of elderly patients to SNF may yield short-term cost reductions, these measures have the potential to lead to adverse outcomes and increased costs to the healthcare system as a whole.

Surgical approach was also associated with LOS. Patients undergoing a posterior spinal fusion had a 2.5-day shorter LOS, resulting in cost savings of approximately $25,000. These findings mirror those of a recent comparison between anterior and posterior approaches in elective lumbar fusion that found that the posterior approach was associated with reduced LOS (3.59 vs 4.19 days) and decreased total hospital charges ($141,700 vs $211,015) (De Stefano et al., 2022). In line with these findings, Crawford et al., described that posterior, as opposed to anterior approaches, provides more efficient patient turnover, and significantly reduces healthcare costs (Crawford et al., 2021). Compared to anterior approaches, posterior approaches are also generally less invasive and less morbid from a patient recovery perspective. Not surprisingly, these patients would be expected to have longer lengths of stay.

Finally, another noteworthy finding in our study was the observation that Hispanic patients experienced significantly longer LOS and significantly higher total charges for their thoracolumbar fracture admissions. This highlights a potentially significant healthcare disparity in postoperative care, even when accounting for confounding variables. Moreover, this aligns with emerging literature regarding healthcare disparities in orthopaedics (Lad et al., 2013). Jain et al. found that Hispanic patients undergoing decompression for cauda equina syndrome had a LOS of 1.34 days longer than their White counterparts (Jain et al., 2018). Similarly, within the arthroplasty literature, a meta-analysis by Rudisill et al. demonstrated that Hispanic patients undergoing total joint arthroplasty had higher rates of complications

and prolonged LOS compared to White patients (Rudisill et al., 2023). These findings are supported by a survey of orthopaedic surgeons in which 12% noted that patients receive different healthcare quality based on race/ethnicity (Adelani and O'Connor, 2017). A recent study by Ryan et al. identified Hispanic ethnicity as an independent factor associated with delay in surgery for hip fracture (Ryan et al., 2015). This under-appreciated healthcare disparity, while certainly multifactorial, may be due to clinician bias in pain management, gaps in insurance coverage, and lower healthcare literacy in this population but requires further attention (Lee et al., 2019). Moreover, our findings are particularly important when constructing risk algorithms and personalized care plans for thoracolumbar trauma patients, given the observed disparities. Overall, these findings should raise awareness, but also serve as a foundation to reduce gaps in care as more efforts are needed to provide solutions to improve care for all thoracolumbar patients, irrespective of background.

We acknowledge several limitations that warrant discussion including the retrospective design and reliance on NIS data, which is confined to the United States and susceptible to coding and reporting errors. Due to limitations within the database, we were unable to report the relevant patient specific factors such as osteoporotic status, and number of levels fused which are important variables for comparison and therefore the findings of the current study must be interpreted with caution. Notably, the absence of details on the mechanism of injury (i.e. fragility fractures vs. high energy trauma) as indications for thoracolumbar fusion cannot be ignored. We are also unable to discuss the influence of socioeconomic factors on the decision to seek hospital care or the health seeking behavior of patients. While it is possible that individuals with without adequate insurance or lower income may be less inclined to seek hospital treatment, our study was not designed to directly assess severity of injury against health seeking behaviors. Additionally, we were unable to capture information regarding patients' pre-surgical living arrangements which is an important aspect when considering postoperative discharge disposition. We were also unable to determine the length of stay of patients at their SNF and IPR facilities. Further multicenter research examining the specific injury pattern, levels fused, and outcomes stratified by age are warranted.

5. Conclusions

Older patients undergoing fusion for thoracolumbar fractures had shorter LOS and reduced hospital cost. However, these patients had a higher likelihood of discharge to SNFs and acute inpatient rehabilitation. Additionally, our findings highlight a healthcare disparity in thoracolumbar trauma, as Hispanic patients experienced dramatically longer hospital stays and associated costs. The observations highlight the need for increased research to further understand drivers of cost associated with current perioperative care strategies and policy considerations among this vulnerable population. These findings guide ongoing initiatives to economize and lead efforts aimed at refining discharge decisions, ensuring the optimal balance between patient outcomes and cost efficiency within the evolving healthcare landscape. Surgeons should be advised of the overall health care cost of care when managing geriatric spinal trauma.

Availability of data and material

All relevant data are included in the manuscript draft, tables, and figures. The raw data are available upon reasonable request from the corresponding author.

Funding and data source

This research was conducted without any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. All data utilized in this study were sourced the National Inpatient Sample(NIS) database.

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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