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Low Socioeconomic Status Is Associated With Increased Complication Rates: Are Risk Adjustment Models Necessary in Cervical Spine Surgery?

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Abstract

Study Design: Retrospective cohort study.

Objectives: The objective of this study was to determine whether lower socioeconomic status was associated with increased resource utilization following anterior discectomy and fusion (ACDF).

Methods: The National Inpatient Sample database was queried for patients who underwent a primary, 1- to 2-level ACDF between 2005 and 2014. Trauma, malignancy, infection, and revision surgery were excluded. The top and bottom income quartiles were compared. Demographics, medical comorbidities, length of stay, complications, and hospital cost were compared between patients of top and bottom income quartiles.

Results: A total of 69 844 cases were included. The bottom income quartile had a similar mean hospital stay (2.04 vs 1.77 days, $P = .412$), more complications (2.45% vs 1.77%, $P < .001$), and a higher mortality rate (0.18% vs 0.11%, $P = .016$). Multivariate analysis revealed bottom income quartile was an independent risk factor for complications (odds ratio = 1.135, confidence interval = 1.02-1.26). Interestingly, the bottom income quartile experienced lower mean hospital costs ($17 041 vs $17 958, $P < .001$).

Conclusion: Patients in the lowest income group experienced more complications even after adjusting for comorbidities. Therefore, risk adjustment models, including socioeconomic status, may be necessary to avoid potential problems with access to orthopedic spine care for this patient population.

Keywords
ACDF, cervical, fusion, orthopedic

Introduction

Anterior cervical discectomy and fusion (ACDF) is one of the most common cervical spine surgeries with a conservative estimate of over 130 000 procedures performed annually in the United States.[1] While substantial evidence exists that ACDF is safe and cost-effective, current fee-for-service reimbursement modalities are thought to contribute to unsustainable health care expenditures in the United States.[2-4] Alternative payment methods such as the Centers for Medicare and Medicaid Services Bundled Payments for Care Improvement (BPCI) initiative have been shown to reduce costs while maintaining favorable outcomes for orthopedic surgeries.[5-7]

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However, evidence exists that some bundled payment models may unfairly penalize hospitals that take care of certain patient populations. Notably, advanced age, some comorbidities, and use of government insurance have been reported as independent risk factors for increased resource utilization for total joint arthroplasty (TJA).[8-10]

While BPCI have not yet been widely adopted for ACDF, there has recently been significant interest in the potential implications of the adoption of alternative payment methods in spine surgery.[11-15] A survey of predominantly academic-affiliated organizations employing over 110 spine surgeons found reservations and concerns, but an increased interest in the use of bundled payments for spine surgery reimbursement.[15] Clearly, in order for bundled payments to be effective in controlling cost for cervical spine surgery, proper risk stratification is necessary.

Spine surgeons may argue that ACDF is more heterogeneous compared to TJA. Therefore, care must be taken to ensure that alternative payment strategies adequately adjust for risk between different patient populations. Previous studies have indicated that 90-day total costs for ACDF surgery may vary significantly based on geographic region or individual surgeon.[16,17] While previous research has reported lower socioeconomic status as an independent risk factor for poor outcomes after TJA, its effect on cervical spine surgery is less clear.[18] As hospitals and surgeons consider adopting bundled payments in cervical spine surgery, factors that influence patient outcomes must be examined to ensure continued access to care for all patients. Few prior studies have directly examined the role of socioeconomic status on outcomes following ACDF. Our study aimed to retrospectively examine the effect of socioeconomic status on perioperative outcomes and resource utilization over a 10-year period using a large national database.

Materials and Methods

Our study utilized the Nationwide and National Inpatient Sample (NIS), Healthcare Cost and Utilization Project, Agency for Healthcare Research and Quality.[19] The NIS comprises a 20% representative sample of all inpatient discharges from community hospitals in the United States (excluding long-term acute care and rehabilitation hospitals). Data from patients with all insurance types including private, Medicare, and Medicaid is captured in the NIS. We utilized the NIS between the years 2005 and 2014 based on the availability of the database at our institution. Since the NIS is composed of publicly available deidentified patient information no institutional review board approval was required.

The *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) procedure codes 81.02 and 80.51 were used to identify patients who underwent primary 1- to 2-level ACDF. Patients with a primary diagnosis of infection, malignancy, or trauma were excluded. Additionally, patients who underwent additional orthopedic procedures during the same hospital stay were not included in our analysis. Specific methodology and exclusion criteria used to identify patients undergoing ACDF can be found in the Supplemental Appendix (available in the online version of the article). Patients in the top and bottom quartiles of income were placed into high- and low-income groups. Patients in the middle 2 income quartiles were excluded. The NIS records patient income quartile based on the median income of their ZIP code. A description of these methods and income quartile cutoffs can be found online in the description of the NIS data elements.[20] Demographic characteristics of patients were abstracted from the database.

Rates of complications and mortality were recorded. ICD-9-CM diagnosis codes were used to identify perioperative complications. Complications included deep vein thrombosis, pulmonary embolism, respiratory complication, neurologic complication including dural root tears, acute renal failure, stroke, myocardial infarction, intraoperative hemorrhage, and wound complications. Specific ICD-9-CM diagnosis codes used to identify complications are listed in the Supplemental Appendix (available in the online version of the article).

Resource utilization was accessed through analysis of length of stay (LOS) and hospital costs. Hospital costs were calculated using hospital-specific cost-to-charge ratios provided by the NIS. All dollar amounts were adjusted to reflect 2017 levels of inflation using the consumer price index for medical care from the Bureau of Labor Statistics. Extended LOS and high-end hospital costs were defined as the top 10 percentiles for the sample (4 days and $27 333). Hospital cost and LOS for each group were compared using the Mann-Whitney *U* test. Univariate analysis was performed to assess differences in the rates of demographic characteristics and comorbidities between the high- and low-income cohorts. Multivariate analysis was utilized to compare the risks experiencing complications, extended LOS, and high-end hospital costs. Calculations were performed using IBM SPSS Statistics for Macintosh, Version 23.0. Statistical significance was interpreted as a P value of <.05.

Results

After exclusion criteria were applied, we identified 35 111patients from the bottom income quartile and 34 733 patients from the top income quartile who underwent ACDF between 2005 and 2014. The mean age of patients in the low-income group was 52.7 years compared to 51.8 years in the high-income group ($P < .001$). Patients in the low-income group were more commonly black or Hispanic and less commonly white (Table 1). Elective procedures were slightly more common for the high-income group (90.2% vs 86.3%, $P < .001$). Compared to the high-income group, lower income patients had higher rates of comorbid conditions. Demographic characteristics and rates of comorbidities of the 2 groups are outlined in Table 1.

Complications occurred in 2.45% of patients in the low-income group and 1.77% of the high-income group ($P < .001$). Rates of acute renal failure, bleeding complications, and respiratory complications occurred more frequently low-income patients following ACDF (Table 2). The rates of neurological complications did not differ between the groups. Rates of specific complications are listed in Table 2. Mortality

Table 1. Characteristics and Rates of Comorbidities for Patients Undergoing ACDF in High- and Low-Income Groups.

	Low Income (n = 35 111), >$40 000	High Income (n = 34 733), >$66 000	P
Year			P < .001
2005-2007	10 738	11 492	
2008-2011	14 458	14 782	
2012-2014	9915	8459	
Age			P < .001
<45	8935	9679	
45-52	9668	10 115	
53-60	7390	7142	
>60	9117	7794	
Sex			P < .001
Male	16 611	16 898	
Female	18 499	17 835	
Race			P < .001
White	21 935 (73.5%)	24 696 (85.3%)	
Black	4581 (15.4%)	1371 (4.7%)	
Hispanic	2163 (7.3%)	1256 (4.3%)	
Other	1151 (3.9%)	1644 (5.7%)	
Hospital region			P < .001
Northeast	3646	7483	
Midwest	5962	7343	
South	21 393	10 304	
West	4110	9603	
Procedure type			P < .001
Elective	30 220 (86.3%)	31 286 (90.2%)	
Nonelective	4814	3,391	
Comorbidities			
Obesity	3247 (9.2%)	2795 (8.0%)	P < .001
Diabetes	6247 (17.8%)	3818 (11.0%)	P < .001
Chronic renal failure	491 (1.4%)	363 (1.0%)	P < .001
Hypertension	15 816 (45.0%)	12 083 (34.8%)	P < .001
CHF	517 (1.5%)	227 (0.7%)	P < .001
COPD	5970 (17.0%)	4081 (11.7%)	P < .001
Anemia	996 (2.8%)	837 (2.4%)	P < .001

Abbreviations: ACDF, anterior discectomy and fusion; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease.

Table 2. Rates of Adverse Outcomes.

Outcome	Low Income (n = 35 111), >$40 000	High Income (n = 34 733), >$66 000	P
Extended LOS	5402 (15.4%)	4471 (12.9%)	P < .001
High-end hospital cost	2962 (8.8%)	3505 (10.4%)	P < .001
Any complication	860 (2.45%)	614 (1.77%)	P < .001
Mortality	64 (0.18%)	39 (0.11%)	P = .016
DVT	44	35	P = .335
PE	32	24	P = .303
Bleeding complication	175	117	P = .001
Wound complication	17	15	P = .747
Respiratory complication	358	207	P < .001
Acute renal failure	181	100	P < .001
Cardiac complication	73	81	P = .476
Neurologic complication	125	123	P = .967

Abbreviations: LOS, length of stay; DVT, deep vein thrombosis; PE, pulmonary embolism.

Table 3. Adjusted Risks of Individual Perioperative Complications.

	Bleeding Complication, OR (95% CI)	Respiratory Complication, OR (95% CI)	Acute Renal Failure, OR (95% CI)
Socioeconomic status			
Low income	1.345 (1.038-1.741)	1.222 (1.026-1.454)	1.250 (0.960-1.628)
High income	—	—	—

Abbreviations: OR, odds ratio; CI, confidence interval.

following ACDF was significantly more common for low-income patients compared to the high-income group (0.18% vs 0.11%, $P = .016$). Multivariate analysis revealed that low income was an independent risk factor for experiencing a perioperative complication (odds ratio = 1.167, confidence interval = 1.027-1.326). Additionally, multivariate analysis demonstrated that low income was an independent risk factor for respiratory complications but not for acute renal failure or bleeding complications (Table 3). After adjusting for differences in demographic factors and comorbidities there was no difference between the high- and low-income cohorts with regard to mortality following ACDF (Table 4).

The mean LOS was 1.77 days for the high-income group compared to 2.04 for low-income patients ($P = .412$). An extended LOS of 3 or greater was more common in the low-income group (15.4% vs 12.9%, $P < .001$). Notably, inpatient hospital costs were greater for the high-income cohort compared to the low-income group ($17 958 vs $17 041, $P < .001$). High-end hospital costs also occurred more frequently in the high-income group (Table 5). After accounting for differences in baseline characteristics between the groups, there was no difference in the risk of extended LOS between the cohorts. Multivariate analysis revealed that patients in the low-income group were less likely to experience high-end hospital costs following ACDF compared to high-income patients (odds ratio = 0.753, confidence interval = 0.705-0.804).

Discussion

ACDF is one of the most common spinal surgeries and has been suggested as a target for health care spending reduction through value-based payment methods. Bundled payments, a proposed alternative payment model, which seeks to control costs by grouping all associated expenses for an episode of care over 90 days into a single reimbursement payment, have shown mixed results for orthopedic surgeries.[5,7,21-23]

Our study examined the impact of socioeconomic status on outcomes and resource utilization following ACDF. The NIS allowed the creation of a large sample size to compare outcomes between low- and high-income patients. Low socioeconomic status patients in our sample were more likely to experience a perioperative complication even after adjusting differences in baseline patient characteristics. This is consistent

with previous studies that have reported that private insurance type, a surrogate for higher socioeconomic status, is predictive of lower rates of complications in spinal surgery.[24,25] While rates of mortality were greater for the lower-income quartile, after adjusting for differences in comorbidities between the groups this difference became nonstatistically significant. This results contrasts findings by Alosh et al that mortality following anterior cervical spine surgery was much more likely for those with Medicaid insurance.[26] However, Medicaid insurance is not a perfect marker for all patients with low socioeconomic status because it does not include uninsured patients.

Our investigations into the impact of low socioeconomic status on resource utilization produced mixed results. Average hospital LOS was similar for the low- and high-income quartiles. These results are likely consistent with previous spine research that found only a very modest relationship between socioeconomic status and LOS following ACDF.[11] Interestingly, the high-income quartile was actually significantly more likely to experience high-end hospital costs. In a study of 1 year of the NIS, Kalakoti et al reported similar findings with regard to cost and income level.[11] While BPCI have been shown to

Table 4. Hospital Costs and LOS Following ACDF.

	Low Income, >$40 000	High Income, >$66 000	*P* (K Test)
Length of stay			$P = .412$
Mean ± SD	2.04 ± 3.82	1.77 ± 2.66	
Median	1.00	1.00	
Mean rank	34 975	34 870	
Hospital cost			$P < .001$
Mean ± SD	$17 041 ± 13 164	$17 958 ± 11 609	
Median	$14 558	$15 739	
Mean rank	31 960	35 083	

Abbreviations: ACDF, anterior discectomy and fusion; LOS, length of stay.

Table 5. Adjusted Risks of Perioperative Outcomes and Increased Resource Utilization.

	Complication, OR (95% CI)	Mortality, OR (95% CI)	Extended LOS, OR (95% CI)	High-End Cost, OR (95% CI)
Socioeconomic status				
Low income	1.167 (1.027-1.326)	1.321 (0.807-2.163)	1.028 (0.971-1.088)	0.753 (0.705-0.804)
High income	—	—	—	—
Race				
White	—	—	—	—
Black	1.198 (0.927-1.549)	0.970 (0.374-2.513)	1.409 (1.255-1.582)	1.662 (1.495-1.848)
Hispanic	1.286 (1.071-1.502)	0.493 (0.226-1.075)	2.511 (2.328-2.707)	1.791 (1.652-1.942)
Other	1.205 (0.963-1.508)	0.714 (0.276-1.848)	1.831 (1.661-2.019)	1.385 (1.252-1.532)
Sex				
Male	1.587 (1.429-1.764)	1.950 (1.208-3.147)	0.973 (0.923-1.025)	1.246 (1.174-1.322)
Female	—	—	—	—
Procedure type				
Nonelective	4.207 (3.723-4.754)	15.262 (9.202-25.311)	10.782 (10.161-11.442)	4.850 (4.530-5.191)
Elective	—	—	—	—
Hospital region				
Northeast	0.746 (0.617-0.901)	1.206 (0.587-2.478)	0.773 (0.714-0.836)	0.328 (0.300-0.360)
Midwest	0.839 (0.690-1.020)	1.010 (0.461-2.213)	0.564 (0.514-0.619)	0.336 (0.304-0.372)
South	0.682 (0.583-0.797)	0.852 (0.452-1.606)	0.471 (0.439-0.506)	0.282 (0.262-0.304)
West	—	—	—	—
Year				
2005-2007	0.624 (0.533-0.730)	1.518 (0.852-2.706)	1.149 (1.072-1.230)	0.857 (0.791-0.927)
2008-2011	0.660 (0.580-0.752)	1.148 (0.677-1.946)	0.972 (0.913-1.034)	0.899 (0.839-0.963)
2012-2014	—	—	—	—
Age				
<45	0.453 (0.377-0.543)	0.141 (0.061-0.324)	0.595 (0.550-0.643)	0.675 (0.617-0.737)
45-52	0.530 (0.450-0.623)	0.044 (0.011-0.185)	0.589 (0.548-0.634)	0.735 (0.677-0.799)
53-60	0.656 (0.562-0.767)	0.404 (0.226-0.725)	0.733 (0.681-0.789)	0.871 (0.802-0.947)
>60	—	—	—	—
Comorbidities				
Obesity	1.359 (1.144-1.616)	1.126 (0.545-1.608)	1.295 (1.191-1.409)	1.195 (1.084-1.318)
Diabetes	1.160 (1.004-1.340)	1.365 (0.823-2.265)	1.311 (1.222-1.406)	1.143 (1.052-1.241)
Chronic renal failure	2.398 (1.879-3.061)	2.052 (0.971-4.339)	1.784 (1.485-2.142)	1.490 (1.222-1.816)
Hypertension	1.137 (0.997-1.295)	0.841 (0.510-1.387)	1.216 (1.147-1.288)	1.054 (0.987-1.127)
CHF	3.351 (2.617-4.290)	4.245 (2.249-8.014)	3.219 (2.665-3.888)	2.335 (1.907-2.860)
COPD	1.424 (1.233-1.644)	1.055 (0.596-1.869)	1.334 (1.244-1.431)	1.198 (1.103-1.300)
Anemia	3.174 (2.622-3.843)	2.118 (1.093-4.105)	3.272 (2.893-3.701)	2.456 (2.148-2.808)

Abbreviations: OR, odds ratio; CI, confidence interval; LOS, length of stay; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease.

reduce costs in arthroplasty, access to care for certain populations and other unintended consequences remain concerns.[5,10,23] Martin et al found that for lumbar fusion, BPCI implementation did not lead to significant cost reduction for participating hospitals and that there was a trend toward procedures being performed more frequently at high-volume centers. It has been suggested that the increase in procedure frequency is the result of hospitals trying to offset losses incurred from inclusion of higher risk patients in BPCI.[23] Furthermore, Ugiliweneza et al found that even among similar patient sharing Diagnosis Related Groups codes, cost of care varied widely for 30-, 60-, and 90-day episodes of care.[27] While BPCI increased to combat inappropriate financial incentives in fee-for-service reimbursement, new unintended financial consequences should be closely monitored. Without appropriate risk adjustment, these at-risk populations may face access to care issues.

Our study has a number of limitations, many of which are inherent to the design of the NIS. Notably, while most bundled payments models include all costs incurred within a 90-day period, our study only looked at resource utilization in the immediate perioperative period. However, prior studies have demonstrated that the majority of costs from 90-day bundles arise from the initial hospitalization. One study found that 95% of costs in 90-day expenditures arose from in-hospital expenses.[27] Additionally, socioeconomic status was modeled utilizing median income of a patient's ZIP code. Therefore, individual patients may have been grouped incorrectly. However, previously published studies have utilized this method for assessing the role of socioeconomic status.[28,29] Using a large administrative database also introduces the possibility of coding inaccuracies. Overall despite limitations, the NIS is commonly utilized by researchers because it allows the creation of large sample sizes and can guide further prospective studies.

Our study adds to the body of research suggesting that a variety of factors including socioeconomic status should be considered when creating risk adjustment models for bundled payments in cervical spine surgery. As bundled payments are implemented for cervical spine surgeries, the impact of these alternative payment interventions on outcomes and procedure volume should be studied closely, especially for hospitals that serve a large number of patients from low income backgrounds.

In conclusion, low-income patients undergoing ACDF were more likely to experience a perioperative complication compared to patients in the high-income group. Without risk adjustment in these proposed alternative payment models, these patient populations may face access to care difficulties.

Declaration of Conflicting Interests

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Supplemental Material

The supplemental material is available in the online version of the article.

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