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Spine Surgeon Treatment Variability: The Impact on Costs

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Abstract

Study Design: Cross-sectional analysis.

Objectives: Given the lack of strong evidence/guidelines on appropriate treatment for lumbar spine disease, substantial variability exists among surgical treatments utilized, which is associated with differences in costs to treat a given pathology. Our goal was to investigate the variability in costs among spine surgeons nationally for the same pathology in similar patients.

Methods: Four hundred forty-five spine surgeons completed a survey of clinical and radiographic case scenarios on patients with recurrent lumbar disc herniation, low back pain, and spondylolisthesis. Those surveyed were asked to provide various details including their geographical location, specialty, and fellowship training. Treatment options included no surgery, anterior lumbar interbody fusion, posterolateral fusion, and transforaminal/posterior lumbar interbody fusion. Costs were estimated via Medicare national payment amounts.

Results: For recurrent lumbar disc herniation, no difference in costs existed for patients undergoing their first revision microdiscectomy. However, for patients undergoing another microdiscectomy, surgeons who operated <100 times/year had significantly lower costs than those who operated >200 times/year ($P < .001$) and those with 5-15 years of experience had significantly higher costs than those with >15 years ($P < .001$). For the treatment of low back pain, academic surgeons kept costs about 55% lower than private practice surgeons ($P < .001$). In the treatment of spondylolisthesis, there was significant treatment variability without significant differences in costs.

Conclusions: Significant variability in surgical treatment paradigms exists for different pathologies. Understanding why variability in treatment selection exists in similar clinical contexts across practices is important to ensure the most cost-effective delivery of care among spine surgeons.

Keywords

disc herniation, lumbar interbody fusion, degenerative disc disease

Introduction

Substantial variability exists among spine surgeons in treating patients with common lumbar pathologies including low back pain, disc herniation, and spondylolisthesis.[1-9] This variability is posited to be due to a relative absence of evidence-based guidelines, financial incentives, different specialty and training backgrounds, and different practice cultures based on geographical region and practice setting (eg, academic vs private practices). In the current era of value-based health care, there is increased scrutiny regarding surgical decision making and resource utilization, particularly with regard to cost-effective treatments.

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Between 1992 and 2003, Weinstein et al[9] found that Medicare spending for all inpatient back surgery more than doubled, and lumbar fusion, specifically, increased 500% from $75 million to $482 million, representing both increased volume and increased costs, and nearly half of total Medicare spending on spine surgery. Variability in operative approaches is a major driver of these costs. This variation stems, in part, from residency training[1] and continues throughout practice based on specialty, operative volume, practice duration, and geographic region.[2-9]

The present study is a cost analysis based on the results of a national survey of US spine surgeons looking at surgical treatment patterns for common spinal pathologies.[2,6] We investigate the variability in costs based on demographic groups of the spine surgeons. Our hypothesis was that there would be significant differences in costs based on geographical location, specialty training, years of experience, and the practice model (academic vs private).

Methods

An online survey was designed using the RedCAP Database (Research Electronic Data Capture; Vanderbilt University, Nashville, TN), to assess surgeon practice patterns for common lumbar pathologies. Details of this survey have been previously published.[2,6] In short, the survey was electronically sent to orthopedic and neurologic surgeons in the United States selected from a national spine surgeon database. Those surveyed were asked to provide details regarding the geographical location of their practice (based on regions), their specialty, fellowship training, type of practice (private, academic, hybrid), practice volume, years in practice, use of discograms, and whether or not the surgeon typically surgically treats back pain due to degenerative disc disease. The results of completed surveys were analyzed using R software (version 2.15.0; R Foundation, Vienna, Austria) and SAS software (version 9.3; SAS Inc, Cary, NC). Paired *t* tests and ANOVA analyses were used to compare cost data. Statistical significance was set at .01 to account for multiple comparisons.

Within this survey, multiple scenarios were posed with respondents having to select a specific treatment (ie, type of surgery vs no surgery) for the patient.[2,6] The analyzed pathologies included (1) first-time recurrent disc herniation and second-time recurrent disc herniation,[2] (2) low back pain refractory to conservative management with or without concordant discogram findings,[6] and (3) spondylolisthesis and neurogenic claudication with or without mechanical low back pain. The costs of the various treatment options were calculated and correlated based on surgeon demographic for a given pathology.

Costs were defined as all hospital charges to the patient undergoing the procedure (ie, the cost of resources used for treating a particular illness, or the direct cost). Medicare national payment amounts, which are publicly available and used nationally across health care systems, were used to estimate all cost data. The Medicare Severity-Diagnosis Related Group (MS-DRG) national Medicare payment amounts for hospitals were referenced in Ingenix's DRG Expert (institutional-level fees).[10] The American Medical Association online database and Center for Medicare and Medicaid Services were queued for Current Procedural Terminology (CPT) code Medicare national payment amounts based on the physician fee schedule (professional-level fees).[11,12] Total direct costs were defined as the sum of professional-level fees (CPT) and institutional-level fees (DRG), which were adjusted for inflation to 2016 dollars. Other direct costs, including physical therapy days, outpatient visits, and diagnostic imaging, as well as indirect costs (related to missed work opportunity costs) were not included. For the "No surgery" option, we assumed $0 in comparison to adding costs with a surgery. This does not take into account the real costs associated with nonoperative management.

Results

Demographics

A total of 445 spine surgeons completed the survey. Surgeons were characterized according to region, specialty, fellowship training, practice type, yearly surgical volume, and practice length. With respect to regional status, the Midwest, Northeast, and Southeast were most heavily represented with 126 (28%), 109 (24%), and 96 (22%) respondents, respectively, out of the total 445 respondents (331/445, 74%). Of the 445 total respondents, 318 (75%) were orthopedic surgeons and 107 (25%) were neurological surgeons. The vast majority were fellowship trained, with 340 (80%) reporting additional training. There were 241 (57%) surgeons who practiced in a private practice setting while 99 (23%) chose academia and 85 (20%) combined the two in a hybrid format. At 96 (23%) respondents, most surgeons reported performing 151 to 200 surgeries per year when compared to the other categories. In addition, most surgeons were older, as 163 (38%) respondents described a practice duration of over 20 years.

Direct Costs

The direct costs associated with each management plan are listed in Table 1. As would be expected, costs varied considerably based on the level of surgical involvement. Notably, the most distinguishing cost differences can be attributed to the DRG code associated with the procedure, rather than the CPT code associated costs. For example, DRG code 460 (spinal fusion, excluding cervical, without major complications) added over $11 000 to the direct costs of surgery when compared to DRG code 030 (nonfusion spine surgery without major complications).

Recurrent Lumbar Disc Herniation

Two clinical presentations were considered in the study of recurrent lumbar disc herniation.[2] Scenario 1 (Sc1) described a case of recurrent L5-S1 disc herniation after 1 microdiscectomy, whereas Scenario 2 (Sc2) demonstrated a recurrent L5-S1 disc herniation after 2 prior microdiscectomies. In Sc1, there was

Table 1. Spinal Procedure Costs.

Scenario	Procedure	CPT Code	CPT Cost	DRG Code	DRG Cost	Total Cost
1, 2	Revision microdiscectomy	63 042	$1350	030	$9092	$10 443
2	Revision microdiscectomy with PLIF/TLIF	63 042	$1350	460	$20 727	$23 714
		22 630	$1636			
3	ALIF	22 558	$1602	460	$20 727	$22 330
3, 5, 6	PLIF/TLIF	22 630	$1636	460	$20 727	$22 363
4	Two-level ALIF with posterior fixation	22 558	$1603	460	$20 727	$23 473
		22 840	$798			
		22 585	$345			
4	Two-level PLIF/TLIF	22 630	$1636	460	$20 727	$22 701
		22 632	$337			
5, 6	Laminectomy with PLF	63 005	$1235	460	$20 727	$23 617
		22 612	$1655			
6	Laminectomy with foraminotomy	63 047	$1150	030	$9092	$10 243
All	No surgery	—	$0.00	—	$0.00	$0.00

Abbreviations: CPT, Current Procedural Terminology; DRG, Diagnosis Related Group; PLIF, posterior lumbar interbody fusion; TLIF, transforaminal lumbar interbody fusion; ALIF, anterior lumbar interbody fusion.

Table 2. Cost Variability for the Treatment of Recurrent Lumbar Disc Herniation After 1 Microdiscectomy (Scenario 1).

Surgeon Characteristics	Revision microdiscectomy (%)	No Surgery (%)	Average Cost per Surgeon	P Value*
Region				.505
Midwest	103 (97)	3 (3)	$10 147	
Northeast	89 (96)	4 (4)	$9993	
Southeast	84 (99)	1 (1)	$10 320	
Southwest	44 (100)	0 (0)	$10 443	
West	57 (98)	1 (2)	$10 263	
Specialty				.812
Neurological surgery	97 (98)	2 (2)	$10 232	
Orthopedic surgery	280 (98)	7 (2)	$10 188	
Fellowship training				.535
Yes	304 (97)	8 (3)	$10 175	
No	73 (99)	1 (1)	$10 302	
Practice type				.719
Academic	89 (97)	3 (3)	$10 102	
Hybrid	73 (99)	1 (1)	$10 302	
Private	215 (98)	5 (2)	$10 205	
Surgeries per year				.686
0-100	39 (95)	2 (5)	$9933	
101-150	57 (98)	1 (2)	$10 263	
151-200	84 (98)	2 (2)	$10 200	
201-250	67 (100)	0 (0)	$10 443	
251-300	64 (97)	2 (3)	$10 126	
>300	66 (97)	2 (3)	$10 136	
Practice length in years				.648
<5	41 (100)	0 (0)	$10 443	
5-10	67 (99)	1 (1)	$10 289	
10-15	61 (98)	1 (2)	$10 274	
15-20	70 (96)	3 (4)	$10 013	
>20	138 (97)	4 (3)	$10 148	

*Statistically significant at $P < .01$

relatively widespread agreement among surgeons in choosing another revision microdiscectomy as the preferred surgical treatment, which billed at $10 442 in direct costs. As there was minimal variability in the treatments most surgeons selected, there were no cost implications found (Table 2).

However, Sc2 differed in that surgeons were relatively split in choosing either a third revision microdiscectomy ($10 442) or revision microdiscectomy with posterior lumbar interbody fusion (PLIF)/transforaminal lumbar interbody fusion (TLIF) ($23 713) as the preferred operation. Surgeons with shorter track records (<15 years in practice) and higher volume (200+ surgeries per year) were more likely to select revision microdiscectomy with PLIF/TLIF ($P < .01$). Yearly surgical volume ($P = .001$) and surgeon's practice length ($P < .001$) were also associated with significant cost implications (Table 3). Further analysis demonstrated that surgeons who operated less than 100 times per year were associated with lower costs than those who operated more than 200 times per year ($10 747 vs $16 178; $P < .001$). With respect to surgical experience, surgeons with 5 to 15 years were associated with higher costs than those with more than 15 years ($17 288 vs $13 194; $P < .001$). Less than 5 years of experience was not associated with any statistically significant difference in costs.

Lower Back Pain

Scenario 3 (Sc3) presented a 44-year-old man with mechanical lower back pain refractory to conservative management, no leg pain, and positive discogram at L4-L5 causing concordant pain. Scenario 4 (Sc4) presented a similar patient but with positive discogram at L4-L5 and L5-S1 causing concordant pain.

The most common responses for Sc3 were 1-level anterior lumbar interbody fusion (ALIF; $22 329), 1-level PLIF/TLIF ($22 363), and no surgery. Practice type ($P < .001$) and discogram use ($P < .001$) were associated with significant cost implications (Table 4). In particular, academic surgeons selected

Table 3. Cost Variability for the Treatment of Recurrent Lumbar Disc Herniation After 2 Microdiscectomies (Scenario 2).

Surgeon Characteristics	Revision Microdiscectomy (%)	Revision Microdiscectomy With PLIF/TLIF (%)	No Surgery (%)	Average Cost per Surgeon	*P* Value
Region					.052
Midwest	46 (43)	54 (50)	7 (7)	$16 457	
Northeast	49 (51)	35 (36)	13 (13)	$13 832	
Southeast	42 (49)	38 (45)	5 (6)	$15 761	
Southwest	22 (51)	17 (40)	4 (9)	$14 717	
West	31 (50)	21 (34)	10 (16)	$13 253	
Specialty					.362
Neurological surgery	48 (48)	44 (44)	7 (8)	$15 602	
Orthopedic surgery	142 (48)	121 (41)	32 (11)	$14 753	
Fellowship training					.933
Yes	154 (48)	135 (42)	32 (10)	$14 983	
No	36 (49)	30 (41)	7 (10)	$14 895	
Practice type					.415
Academic	43 (48)	41 (45)	6 (7)	$15 792	
Hybrid	39 (49)	30 (38)	10 (13)	$14 160	
Private	108 (48)	94 (42)	23 (10)	$14 920	
Surgeries per year					.001*
0-100	23 (58)	8 (20)	9 (22)	$10 747	
101-150	29 (54)	21 (39)	4 (7)	$14 830	
151-200	42 (47)	35 (39)	13 (14)	$14 095	
201-250	34 (44)	41 (53)	2 (3)	$17 238	
251-300	27 (43)	31 (49)	5 (8)	$16 144	
>300	35 (50)	29 (41)	6 (9)	$15 046	
Practice length in years					<.001*
<5	18 (41)	22 (50)	4 (9)	$16 129	
5-10	30 (39)	44 (57)	3 (4)	$17 619	
10-15	23 (37)	34 (55)	5 (8)	$16 878	
15-20	44 (63)	20 (29)	6 (8)	$13 339	
>20	75 (53)	45 (32)	21 (15)	$13 123	

Abbreviations: PLIF, posterior lumbar interbody fusion; TLIF, transforaminal lumbar interbody fusion.
*Statistically significant at $P < .01$.

treatments that were associated with costs about 55% lower than private practice surgeons ($5334 vs $11 839; $P < .001$). Moreover, surgeons who never or rarely used discograms were associated with significantly lower costs than those who used discograms more frequently (Supplementary Table 3; all supplementary tables are available at http://journals.sagepub.com/home/gsj).

With regard to Sc4, 2-level ALIF with posterior fixation ($23 473), 2-level PLIF/TLIF ($22 701), and no surgery ($0) were the most preferred management options. No significant cost implications were observed when comparing region, specialty, practice type, volume, fellowship training, or practice length. Using discograms often was associated with significant cost differences compared to rarely or never using them ($19 519 vs $3587; $P < .001$; Table 5). In addition, never- or rare-users of discograms tended to select treatment options that had significantly lower costs (Supplementary Table 4).

Spondylolisthesis

For the study of spondylolisthesis, the 2 scenarios presented were distinguished based on the presence or absence of mechanical back pain. Sc5 demonstrated L4-L5 spondylolisthesis with stenosis and correlative neurogenic claudication refractory to conservative treatment with mechanical back pain. A similar case was described in Sc6 but of a patient without mechanical back pain.

PLIF/TLIF ($22 363) and laminectomy with posterolateral fusion ($23 617) were the preferred management options in Sc1. Given that the costs of these procedures are relatively similar and very few surgeons chose not to operate, no significant cost differences were found (Table 6). In Sc6, laminectomy with foraminotomy ($10 243) was another common response in addition to the 2 procedures listed in Sc5. While specialty type trended toward significance, with neurosurgeons posting lower costs than orthopedic surgeons ($18 617 vs $20 518; $P = .011$), this did not reach statistical significance (Table 7).

Discussion

High-value care is an essential component in health care, and as such, understanding the variability in surgeon treatment decisions and the associated cost implications can allow for

Table 4. Cost Variability for the Treatment of Lower Back Pain With Positive Discogram at L4-L5 (Scenario 3).

Surgeon Characteristics	ALIF (%)	PLIF/TLIF (%)	No Surgery (%)	Average Cost per Surgeon	*P* Value
Region					.142
Midwest	17 (17)	20 (20)	65 (63)	$8106	
Northeast	17 (21)	18 (22)	47 (57)	$9538	
Southeast	15 (20)	26 (35)	34 (45)	$12 218	
Southwest	7 (25)	7 (25)	14 (50)	$11 173	
West	10 (23)	7 (16)	27 (61)	$8632	
Specialty					.320
Neurological surgery	15 (18)	25 (30)	43 (52)	$10 771	
Orthopedic surgery	51 (21)	53 (21)	144 (58)	$9371	
Fellowship training					.632
Yes	54 (20)	60 (23)	152 (57)	$9577	
No	12 (18)	18 (28)	35 (54)	$10 315	
Practice type					<.001*
Academic	8 (9)	13 (15)	67 (76)	$5333	
Hybrid	15 (26)	10 (17)	33 (57)	$9630	
Private	43 (23)	55 (30)	87 (47)	$11 838	
Surgeries per year					.077
0-100	4 (11)	7 (19)	26 (70)	$6644	
101-150	7 (14)	9 (18)	35 (68)	$7011	
151-200	20 (26)	19 (24)	39 (50)	$11 173	
201-250	11 (18)	14 (23)	36 (59)	$9159	
251-300	12 (24)	13 (25)	26 (51)	$10 954	
>300	12 (23)	16 (30)	25 (47)	$11 807	
Practice length in years					.322
<5	7 (19)	5 (14)	25 (67)	$7246	
5-10	10 (18)	12 (21)	34 (61)	$8779	
10-15	11 (24)	14 (30)	21 (46)	$12 146	
15-20	14 (20)	18 (26)	37 (54)	$10 364	
>20	24 (19)	29 (24)	70 (57)	$9629	
Discogram use					<.001*
Never	8 (8)	8 (8)	87 (84)	$3471	
Rarely	18 (15)	29 (23)	78 (62)	$8403	
Sometimes	25 (37)	25 (37)	17 (26)	$16 676	
Often	15 (42)	16 (44)	5 (14)	$19 243	

Abbreviations: ALIF, anterior lumbar interbody fusion; PLIF, posterior lumbar interbody fusion; TLIF, transforaminal lumbar interbody fusion.
*Statistically significant at $P < .01$.

creation of cost-effective treatment paradigms for common lumbar pathologies. A total of $90 billion is spent annually on the treatment of low back pain in the United States.[13] Previous studies have shown that there is significant variation in spine surgical treatment across geographic regions, contributing to increased expenditures.[1-9] Much of this variability exists due to a lack of high-level evidence and definitive clinical guidelines. In the present study, we analyzed the differences in costs associated with the variable treatment options for the different clinical scenarios.

In Mroz et al[2] (Study 1), the authors focused on the variability in treatment patterns for patients with first- and second-time recurrent lumbar disc herniation. Two scenarios were presented to those surveyed. Surgical treatment options included revision microdiscectomy, revision microdiscectomy with in situ fusion, revision microdiscectomy with posterolateral fusion using pedicle screws, revision microdiscectomy with PLIF/TLIF, ALIF with percutaneous screws, ALIF with open posterior instrumentation, or no surgery. Surgeons with shorter track records (<15 years in practice) and higher volume (200+ surgeries per year) were more likely to select revision microdiscectomy with PLIF/TLIF ($P < .01$). No significant differences existed for region, specialty, fellowship training, or practice type. Similarly, in the present study, average costs per surgeon were significantly ($P < .01$) different based on surgeon's volume and practice length. Specifically, those in practice for longer more frequently chose the less costly procedure (repeat decompression rather than fusion). Interestingly, as volume rose, a parabolic or bimodal pattern was observed whereby both surgeons with the lowest volumes and highest volumes chose lower cost operation (repeat discectomy) than those with mid-tier volumes (who more likely chose the fusion option). Geographic variation in costs trended toward significance ($P = .05$) with the lowest costs per surgeon found in the Northeast and West (vs the more expensive option in the Midwest).

In Lubelski et al[6] (Study 2), the authors focused on surgical treatment variability (same operative choices as Study 1) for low back pain and found substantial clinical equipoise ($\sim 75\%$

Table 5. Cost Variability for the Treatment of Lower Back Pain With Positive Discogram at L4-L5 and L5-S1 (Scenario 4).

Surgeon Characteristics	Two-level ALIF With Posterior Fixation (%)	Two-Level PLIF/TLIF (%)	No Surgery (%)	Average Cost per Surgeon	*P* Value
Region					.256
Midwest	12 (14)	16 (19)	58 (67)	$7499	
Northeast	15 (19)	23 (29)	41 (52)	$11 066	
Southeast	9 (12)	21 (28)	46 (61)	$9052	
Southwest	7 (26)	6 (22)	14 (52)	$11 130	
West	9 (21)	6 (14)	28 (65)	$8081	
Specialty					.075
Neurological surgery	10 (12)	31 (36)	44 (52)	$11 041	
Orthopedic surgery	42 (19)	41 (18)	143 (63)	$8481	
Fellowship training					.260
Yes	47 (19)	49 (20)	155 (62)	$8827	
No	5 (8)	23 (38)	32 (53)	$10 658	
Practice type					.110
Academic	16 (19)	10 (12)	60 (70)	$7007	
Hybrid	12 (20)	14 (24)	33 (56)	$10 161	
Private	24 (14)	48 (29)	94 (57)	$9958	
Surgeries per year					.572
0-100	2 (6)	9 (29)	20 (65)	$8105	
101-150	13 (23)	9 (16)	34 (61)	$9097	
151-200	9 (13)	20 (30)	38 (57)	$9929	
201-250	13 (23)	12 (21)	32 (56)	$10 133	
251-300	10 (20)	12 (24)	27 (55)	$10 350	
>300	5 (10)	10 (20)	36 (71)	$6752	
Practice length in years					.247
<5	6 (17)	4 (11)	26 (72)	$6434	
5-10	10 (17)	9 (16)	39 (67)	$7570	
10-15	10 (22)	13 (28)	23 (50)	$11 518	
15-20	8 (13)	12 (20)	41 (67)	$7544	
>20	18 (20)	15 (16)	58 (64)	$8385	
Discogram use					<.001*
Never	5 (5)	10 (10)	81 (84)	$3587	
Rarely	19 (15)	22 (18)	82 (67)	$7686	
Sometimes	17 (29)	23 (39)	19 (32)	$15 491	
Often	11 (33)	17 (52)	5 (15)	$19 519	

Abbreviations: ALIF, anterior lumbar interbody fusion; PLIF, posterior lumbar interbody fusion; TLIF, transforaminal lumbar interbody fusion.
*statistically significant at $P < .01$

disagreement) among surgeons. Surgeons working in academic practices were 4 times as likely to select "no surgery" or just continue conservative management as compared to their colleagues in hybrid and private practice. Disagreement was highest in the Southwest and there was least disagreement in the Midwest (82% vs 69%). In the present study, we found that this translated into an average cost per surgeon that was more than double ($11 838 vs $5333; $P < .01$) for private practice surgeons versus academic surgeons. No significant differences in cost were found based on geographic region or other surgeon variable.

In the third study, the authors focused on surgical treatment pattern variability for patients with grade 1 lumbar spondylolisthesis with and without mechanical low back pain (Lubelski et al, unpublished data, 2017). For patients without mechanical back pain, neurosurgeons were significantly ($P < .01$) more likely to select decompression-only as compared to orthopedic surgeons who more commonly fused. In addition, for patients with mechanical back pain, significant ($P < .01$) geographic, practice type, volume, and practice length variation existed. In the present study, when evaluating the financial implications, the average costs per surgeon for orthopedic surgeons trended toward significance ($20 518 vs $18 617; $P = .011$). No other differences in costs were discovered based on other surgeon variables. While there was substantial variability in surgical choices, the lack of cost differences is likely related to the similarity in costs between the various fusion options.

Overall, we found that there is variation in costs based on spine surgeon specialty, practice duration, operative volume, and practice model. However, there was no consistent surgeon-specific variable that explained the cost differences. Geographic variation in procedures and associated costs has been observed previously. Cook et al[7] examined (n = 23 143 from the Nationwide Inpatient Sample, years 1990-2000) the total

Table 6. Cost Variability for the Treatment of Spondylolisthesis With Mechanical Back Pain (Scenario 5).

Surgeon Characteristics	PLIF/TLIF (%)	Laminectomy With PLF (%)	No Surgery (%)	Average Cost per Surgeon	*P* Value*
Region					.783
Midwest	69 (64)	35 (32)	4 (4)	$21 941	
Northeast	46 (48)	46 (48)	3 (4)	$22 264	
Southeast	54 (68)	21 (27)	4 (5)	$21 564	
Southwest	22 (63)	11 (31)	2 (6)	$21 480	
West	32 (67)	15 (31)	1 (2)	$22 289	
Specialty					.484
Neurological surgery	67 (71)	25 (27)	2 (2)	$22 221	
Orthopedic surgery	156 (58)	103 (38)	12 (4)	$21 850	
Fellowship training					.846
Yes	181 (61)	103 (35)	11 (4)	$21 967	
No	42 (60)	25 (36)	3 (4)	$21 853	
Practice type					.189
Academic	47 (51)	41 (45)	4 (4)	$21 950	
Hybrid	48 (68)	23 (32)	0 (0)	$22 770	
Private	128 (63)	64 (32)	10 (5)	$21 654	
Surgeries per year					.448
0-100	11 (28)	26 (65)	3 (7)	$21 501	
101-150	33 (60)	20 (36)	2 (4)	$22 006	
151-200	46 (55)	32 (38)	6 (7)	$21 244	
201-250	48 (76)	15 (24)	0 (0)	$22 662	
251-300	39 (67)	17 (29)	2 (4)	$21 960	
>300	46 (71)	18 (28)	1 (1)	$22 367	
Practice length in years					.929
<5	27 (77)	7 (20)	1 (3)	$21 975	
5-10	48 (72)	18 (27)	1 (1)	$22 366	
10-15	40 (67)	18 (30)	2 (3)	$21 994	
15-20	44 (65)	21 (31)	3 (4)	$21 764	
>20	64 (47)	64 (47)	7 (6)	$21 798	
Discogram use					.917
Never	58 (56)	41 (39)	5 (5)	$21 782	
Rarely	77 (60)	47 (37)	4 (3)	$22 125	
Sometimes	51 (61)	30 (36)	3 (3)	$22 012	
Often	37 (76)	10 (20)	2 (4)	$21 706	

Abbreviations: PLIF, posterior lumbar interbody fusion; TLIF, transforaminal lumbar interbody fusion; PLF, posterolateral fusion.
*Statistically significant at $P < .01$.

inflation-adjusted charges associated with surgical care post-lumbar spine fusion for degenerative disc disease. The Northeast had the lowest charges (mean $24 405) followed by the Midwest, South, and West (mean $40 157; $P < .01$). In the present study, we only investigated direct costs of the procedures and did not include inpatient/outpatient costs or other indirect costs. It is certainly possible that the cost of perioperative care may be the major driver in variation observed in the study by Cook et al, rather than the difference in operative cost.

The results of the study by Cook et al showing the Northeast as the region with the lowest costs are contrasted by those of Goz et al,[14] who retrospectively analyzed the Medicare Provider Utilization and Payment database (CPT and DRG cost data) to determine the geographic variation in costs of anterior cervical discectomy and fusion (ACDF), posterolateral fusion (PLF), and total knee arthroplasty (TKA). Statistically significant ($P < .01$) differences in total costs among geographic regions existed for PLF and TKA with the lowest costs in the Midwest and highest in Northeast ($P < .01$). No significant differences in costs were found for ACDF. On a state level, however, Illinois and Minnesota, despite being in the Midwest and seen regionally as part of the low-cost conglomerate, serve as outliers as 2 states with the highest ACDF costs in the country. Finally, cost of living correlated strongly to procedure cost, but not enough to fully explain the cost trends. In addition to cost of living, 2 studies by Walid et al[15,16] show an impact of patient comorbidities, age, and body mass index on operative cost as well.

Epstein et al[17] showed a 10-fold variation in instrumentation costs ($4062 to $40 409) and 4.8-fold variation in total costs ($26 653 to $129 220) to patients undergoing single-level anterior cervical discectomies with fusion within a single year at one institution. Differences were largely attributed to length of stay and surgeon's choice of instrumentation. Specifically, the instrumentation charges for performing single-level ACDF varied from $4062 to $40 409.

This suggests that even for similar surgeries, the specific surgeon and the associated surgical instruments can have a

Table 7. Cost Variability for the Treatment of Spondylolisthesis Without Mechanical Back Pain (Scenario 6).

Surgeon Characteristics	PLIF/TLIF (%)	Laminectomy With PLF (%)	Laminectomy With Foraminotomy (%)	No Surgery (%)	Average Cost per Surgeon	*P* Value*
Region						.451
Midwest	49 (45)	47 (43)	10 (9)	4 (4)	$20 984	
Northeast	28 (31)	44 (48)	14 (15)	5 (5)	$19 876	
Southeast	36 (45)	26 (33)	16 (20)	2 (3)	$19 788	
Southwest	17 (41)	14 (34)	8 (20)	2 (5)	$19 336	
West	22 (38)	23 (40)	9 (16)	4 (7)	$19 437	
Specialty						.011
Neurological surgery	42 (45)	24 (26)	22 (24)	5 (5)	$18 617	
Orthopedic surgery	110 (38)	130 (45)	35 (12)	12 (4)	$20 518	
Fellowship training						.271
Yes	126 (41)	125 (41)	41 (13)	14 (5)	$20 228	
No	26 (35)	29 (39)	16 (22)	3 (4)	$19 327	
Practice type						.271
Academic	33 (35)	47 (51)	10 (11)	3 (3)	$20 972	
Hybrid	32 (45)	24 (34)	12 (17)	3 (4)	$19 794	
Private	87 (40)	83 (38)	35 (16)	11 (5)	$19 742	
Surgeries per year						.326
0-100	7 (18)	19 (48)	12 (30)	2 (5)	$18 205	
101-150	20 (34)	26 (45)	8 (14)	4 (7)		
151-200	30 (33)	47 (51)	8 (9)	7 (8)	$19 711	
201-250	35 (56)	20 (32)	8 (13)	0 (0)	$21 222	
251-300	30 (48)	20 (32)	10 (16)	2 (3)	$20 091	
>300	30 (46)	22 (34)	11 (17)	2 (3)	$20 048	
Practice length in years						.525
<5	21 (53)	13 (33)	6 (15)	0 (0)	$20 953	
5-10	34 (55)	18 (29)	7 (11)	3 (5)	$21 028	
10-15	28 (43)	22 (34)	12 (18)	3 (5)	$19 518	
15-20	28 (42)	26 (39)	8 (12)	5 (7)	$19 734	
>20	41 (28)	75 (51)	24 (16)	6 (4)	$20 096	
Discogram use						.326
Never	37 (37)	42 (42)	18 (18)	4 (4)	$19 839	
Rarely	58 (41)	57 (41)	19 (14)	6 (4)	$20 270	
Sometimes	33 (37)	42 (47)	11 (12)	3 (3)	$20 703	
Often	24 (48)	13 (26)	9 (18)	4 (8)	$18 719	

Abbreviations: PLIF, posterior lumbar interbody fusion; TLIF, transforaminal lumbar interbody fusion; PLF, posterolateral fusion.
*Statistically significant at $P < .01$.

major impact on the associated costs/charges. Similarly, Kazberouk et al[13] retrospectively analyzed intersurgeon variation for 1241 elective spine procedures at one institution over 3 years. When adjusted for patient characteristics, intersurgeon variation in cost per procedure was modest (factor of 1.31 between lowest and highest cost surgeons). They found that for different surgical procedures, the cost drivers varied. For example, for spinal fusions, instrumentation costs were the major driver of cost. On the other hand, for spinal decompressions, the cost varied by surgeon: for some the hospital length of stay was the major cost driver, whereas for others it was the operating room cost.

Given the variability in costs, the next question to consider, though not analyzed in this study, is differences in patient outcome (ie, are higher costs associated with better outcomes?). High-value care consortiums and hospital groups have already taken steps to reduce variability for non–spine-related procedures while maintaining standard of care for patients, such as with total knee replacements.[18,19] The overarching goal is to reduce unwarranted variation while maintaining or benefitting the standard of care for all patients. For example, implementation of a co-managed inpatient postoperative care consortium led to decreased complication rates and, as a result, shorter hospital stays.[18] Other hospitals have utilized pay for performance and nonblinded performance feedback tactics to normalize surgeon variation.[19] This may limit surgeon variability in costs substantially. By identifying significant variations in costs, surgical groups and hospital organizations can initiate discussions targeting value-based spine care and appropriate care-paths, when indicated.

Limitations of the present study include the relatively low response rate, which limits the generalizability of the study conclusions. In addition, the surveys enable broad evaluation of surgical costs, without allowing for more granular evaluation of intersurgeon variability for a given procedure, charges versus costs to the hospital, other hospital-related costs such as hospital length of study, as well as evaluation of indirect costs such as missed work days, physical therapy, and so on. We analyzed each operation's costs by the type of surgery alone, not including differences in instrumentation use, which, as described above, may have had a significant impact on costs. As discussed, our study cost data is unique to the Medicare population given the lack of readily available cost data from private insurers. Even Medicare payment data has been shown to vary widely across hospitals for various spine surgical procedures.[20] Finally, we did not analyze differences in patient outcome based on cost and specific clinical scenarios where guidelines for management may be controversial or highly variable. Nonetheless, this study signifies the first to provide a comprehensive evaluation of differences in costs associated with variability for treatment of common lumbar spine pathology. It provides an important starting point for which more substantive efforts can be built upon in the future.

Conclusions

Significant variation exists in surgical treatments of common lumbar pathologies. Variability in associated costs is seen based on geographical location, surgeon's specialty, practice type, and surgical volume. Understanding the underlying reasons for the variability in treatment selection is important for ensuring the most cost-effective delivery of care among spine surgeons.

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Supplemental Material

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

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