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How Do Coverage Policies Influence Practice Patterns, Safety, and Cost of Initial Lumbar Fusion Surgery? A Population-based Comparison of Workers' Compensation Systems

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Some health plans have implemented coverage restrictions to stem the increased use of lumbar fusion operations in patients with back pain associated with degenerative changes.[1–3] States have adopted a variety of coverage and reimbursement strategies for workers' compensation (WC) patients, whose outcomes are generally worse compared to non-workers compensation patients.[4, 5] However, there is little information about whether these policies modify the use, costs, or surgical safety of lumbar fusion.

Guidelines suggest that lumbar fusion may be an option for patients with severe back pain who have not improved with conservative treatment.[6, 7] Restricting motion and providing structural support with instrumented fusion may be effective for some diagnoses, including degenerative spondylolisthesis, fractures, and scoliosis.[8, 9] In randomized trials, although lumbar fusion is more effective than routine non-operative care, fusion surgery is only equivalent to structured rehabilitation, but less safe and more costly.[10–12] For patients with disc herniation or spinal stenosis, decompression alone is effective.[13, 14] The use of more complex lumbar procedures is associated with higher complication rates without evidence of improved functional outcomes. [15–17]

One insurance policy strategy has been to limit complex lumbar procedures, including those involving adding fusion to a decompression procedure for unilateral herniated disc with radiculopathy, multiple vertebral levels, certain implanted devices, and circumferential surgical approaches. This strategy was adopted by Washington State's Department of Labor and Industries in 1996 and revised in 2006 (Table 1), based on its analyses that lumbar fusion innovations did not improve worker disability or quality of life, but increased reoperations.[3, 5, 18] Washington uses a prospective utilization review of lumbar fusion requests, requires x-ray imaging confirmation of spinal instability, and limits initial fusions to a single disc level.[19]

In contrast, California's workers compensation system uses a legislated binding second opinion.[20] This policy requires an employer to authorize the procedure if the patient receives a second surgical opinion that concurs with the initial recommendation.[21] California allows additional payment for surgical instrumentation to stabilize adjacent vertebrae (screws, rods, plates, cages) and bone growth enhancers (bone morphogenetic protein, BMP).[22]

Hospital discharge registries allow for population-based comparisons of utilization, safety indicators, and costs between states. This information would help guide policy debate in the emerging area of cost and quality control related to spinal surgery.[23, 24] Since complex fusion surgery for back pain alone has little justification on the basis of patient-reported randomized trial data, differences in safety profiles may influence patients' opinions on acceptable risk for uncertain benefit. Therefore, we compared Washington and California's WC population data for rates of lumbar fusion surgery, complexity of surgery (use of instrumentation, fusion adjuncts, surgical approach), costs, readmissions, revision surgery, and other complications.

Methods

Data source

We examined the State Inpatient Database (SID) for California and Washington. The Agency for Healthcare Research and Quality (AHRQ) maintains SID, which is a component of the Healthcare Cost and Utilization Project (HCUP).[25] Data from HCUP has previously been used to study spinal procedures.[1, 26–29] SID is an all-payer inpatient discharge registry that provides *International Classification of Diseases, 9th revision, Clinical Modification* (ICD-9-CM) diagnoses and procedure codes, patient demographics, and hospital charges for approximately 90% of hospitals in participating states. AHRQ translates discharge information into uniform definitions to facilitate multi-state comparisons. Several states, including Washington and California, include encrypted patient identifiers that allow us to identify readmissions of individual patients even if care is provided by multiple hospitals.

Sex- and age-stratified (by 5-year age increments) population data within each state was obtained from the U.S. Census Bureau, along with estimates of the proportion of employed populations within each stratum.

Study population

We identified adults (age 20 – 65) undergoing thoracolumbar, lumbar, or lumbosacral fusion for degenerative spinal conditions in 2008 or 2009 whose primary payer was workers' compensation. Patients were identified using relevant diagnosis and procedure codes from the October 2010 ICD-9-CM update.[30] A detailed coding algorithm for classifying spine-related medical encounters into clinically meaningful diagnosis groups, procedure categories, and surgical safety measures is available from the lead author.

Each hospitalization in SID contained up to 25 diagnosis codes and 21 procedure codes. We searched all codes to classify respondents into a hierarchy of indications for fusion based on existing literature. This hierarchy classifies fusions from the least to the most controversial indications as: scoliosis, spondylolisthesis, stenosis, disc herniation (with and without myelopathy), and disc degeneration (e.g. spondylosis).

We excluded patients with non-degenerative spinal pathology such as vertebral fractures, spinal cord injury, intraspinal abcess, or inflammatory spondylopathy. We also excluded patients for accidents, neoplasm, immune deficiency, osteomyelitis, and cervical diagnoses or procedures (Table 2).

Lumbar fusions combined with discectomy or laminectomy were included, as were patients with codes implying previous spine surgery (e.g., "refusion"). However, because previous surgery increases the probability of yet further reoperations,[31] we included this as an adjustment variable.

Another approach to dealing with previous surgery is to exclude patients for whom we identify a previous spine operation within the database. Because the unique patient identifier for Washington changed in 2007, we were unable to "look back" in the database for previous spinal operations. In California, we *were* able to "look back" over a three year period. Therefore, we conducted a two sensitivity analyses: 1) excluding patients with procedure codes suggesting revision surgery during the index hospitalization in both states; and 2) additionally excluding patients with previous operations in California, but not Washington.

Patients undergoing artificial disc replacement, corpectomy, osteotomy, kyphectomy, and insertion of spinal spacers or dynamic stabilizing devices were excluded, even if performed in conjunction with a fusion.

Measuring safety

Repeat lumbar surgery, readmissions (all cause), wound problems, device and life-threatening complications within 3 months were identified for each patient. These outcomes were not mutually exclusive. With the exception of device complications, these well-accepted indicators of quality are part of the National Surgical Quality Improvement Program (NSQIP)[32] and the Healthcare Effectiveness Data and Information Set (HEDIS).[33] We used 3 month surveillance because readmissions and complications during this short interval are likely to be consequences of the index procedure, are associated with poor patient-reported outcomes, and are commonly-used as a quality indicator by the Medicare Payment Advisory Commission.[34, 35]

Device complications were defined as readmissions with diagnosis or procedure codes indicating loosening, breakage or malfunction of an internal orthopaedic device. Device complication codes used during the index operation were not counted because we could not determine whether they reflected problems at the index operation or a previous operation. Reoperations were identified as the first instance of any subsequent inpatient lumbar operation and not necessarily a repeat of the same procedure. We required device complications and reoperations to have a lumbar spine-specific ICD-9-CM diagnosis or procedure code.

Previous algorithms, which are similar to AHRQ quality indicators,[36] were used to identify life-threatening complications and wound problems during the index admission and during a 3-month post-operative period.[17] Life-threatening complications included major medical events such as respiratory failure, myocardial infarction, cardiopulmonary resuscitation, endotracheal intubation, pneumonia, stroke, and mechanical ventilation. Myocardial infarctions and strokes that were coded as being “present-on-admission” were not counted as a complication. Wound problems included hemorrhage, debridement, wound disruption, seroma, and hematoma. Complications requiring only ambulatory care were not counted.

Surgical characteristics

Operations were characterized by the use of surgical approach (anterior, posterior, or circumferential approach), fusions combined with decompression (discectomy or laminectomy), fusions of three or more disc levels (4 or more vertebrae), use of instrumentation, and bone morphogenetic protein.

Covariates

Because patient characteristics could explain differences in outcomes between states, we also adjusted for age, sex, comorbidity, previous surgery, and diagnosis. An “enhanced” version of the Charlson index was used to adjust for comorbidity.[37] This index was entered into our analysis as a categorical variable grouped as “none”, “one”, or “two or more”. The latter category was designed because only a small number of patients had two or more listed comorbidity conditions. Since this index includes myocardial infarctions and strokes, and these are among the life-threatening complications that we sought to identify, we excluded these items from the comorbidity score.

Analysis

The annual rates of lumbar fusion operations for degenerative diagnoses paid by WC programs were directly standardized by sex and age using state-specific population denominators of employed adults (ages 20–65) from the US Census Bureau. Direct standardization involves reporting the sum of the age- and sex-specific crude rates that we observed multiplied by their corresponding proportions in the denominator. The denominator for employed populations was calculated by multiplying the state-specific civilian population within each age and sex-stratum by their corresponding proportion for employed individuals.

Differences between the two state’s cohorts in patient characteristics, comorbidity, diagnoses, and surgical features were described along with chi-square or t-test comparisons (Table 3).

We then examined differences in the rates of reoperations, readmissions, and complications, including only the patients who had a minimum of 3 months of surveillance available to assess each outcome. We performed a log-binomial regression of each outcome, adjusting for patient age, sex, diagnosis, previous surgery and comorbidity. All variables except age were included as categorical variables. Age and age-squared (continuous polynomial) were only weakly important in some models, but retained in all models for precision and consistency. State-specific robust standard errors improved the precision of our estimates and our ability to test the difference between states.[38] We did not adjust for difference in operative features because their discretionary use is the target of the coverage and reimbursement policies that we examine.

Adjusted rates for each outcome were estimated from the regression models by setting all covariates to their mean distributions in the sample. Specifically, we used the results from the regression model to assess the risk of complication for an “average” patient. This was accomplished by setting the covariates for age, sex, previous surgery, and comorbidity to the mean sample distributions (including proportionate distributions for each level of the categorical covariates) as displayed in table 2. Each observation was then weighted using the beta-coefficient associated with the corresponding variables from our regression models. This produces a normative risk for each patient based on the experience of a sample with similar characteristics. To examine variation in outcomes across hospitals we added hospital-specific intercepts to the adjusted model.[39, 40]

California has a substantially higher proportion of non-white and Hispanic residents compared to Washington State. However, race and ethnicity was not included in our models because it was largely missing from Washington. To help understand the association of race and ethnicity on outcomes we separately examined models using only California.

Inpatient charges, excluding professional fees and non-covered services, are included with SID. HCUP hospital cost-to-charge ratios were used to estimate costs. A small number of cases (n=21) with missing charges were imputed by setting them to the mean values of the sample. To account for inflation, we referenced the medical component of the Consumer Price Index to adjust charges in 2007 to their 2008 equivalents.[41] We estimated average costs (charges) adjusting for age (age and age-squared), sex, comorbidity, previous surgery, and diagnosis using generalized linear regressions that accounted for skewed distributions (inverse Gaussian family with log link function).

Analyses were performed using StataMP, version 11 (College Station, TX), and a two-sided alpha level of 0.05. A waiver of human subjects review for publicly available data was obtained from the Committee for the Protection of Human Subjects at Dartmouth College.

Results

Study population

A total of 11,384 patients were identified as having an inpatient spinal fusion paid through WC programs in Washington (n=1,624; 14%) or California (n= 9,760; 86%). We excluded 6,756 patients (59%; Table 2), leaving 4,628 eligible patients with a diagnosis of lumbar degenerative disease. The age- and sex-adjusted rate of lumbar fusions for degenerative conditions paid by WC programs was 19.0 per 100,000 employed adults (aged 20–65) in California, compared to 12.9 in Washington State ($p<0.001$; table 3).

Of the 4,628 eligible patients who received an initial lumbar fusion, 546 (11.8%) were from Washington. A larger percentage of patients in California were female (35% versus 29%; p=0.004). Mean age (47.0 years; sd 9.5) and comorbidity (22% with any) did not differ between the two states (Table 3).

Workers undergoing fusion surgery in California were significantly more likely than those in Washington to have a diagnosis of disc degeneration (28% versus 21%; p<0.001) or disc herniation (37% versus 21%; p<0.001), and less likely to have stenosis (6% versus 15%; p<0.001) or spondylolisthesis (25% versus 41%; p<0.001). The proportion of patients with scoliosis was small (4%), and similar between the two states (p=0.38). A significantly higher proportion of patients in California received anterior (14% versus 8%; p<0.001) or circumferential approaches (26% versus 5%; p<0.001), had 3+ disc levels fused (10% versus 5%; p<0.001), and received bone morphogenetic protein (50% versus 31%; p<0.001). The two states had similar rates of instrumented fusion (78%; p=0.45) and simultaneous decompression procedures (71%; p=0.71).

Safety outcomes

Workers in California had significantly higher rates of reoperation (5.0% versus 2.2%, p=0.002) and readmission (14.4% versus 10.3%, p=0.007) within 3 months, compared to those in Washington (Table 4). Adjusting for age, sex, comorbidity, previous surgery, and diagnosis, the rate of reoperation in California was 4.8%, compared to 1.9% in Washington (RR 2.28; 95%CI 2.27 – 2.29; p<0.001); and the adjusted rate for any readmission in California was 14.0%, compared to 9.1% in Washington (RR 1.45; 95%CI 1.44 – 1.47; p<0.001).

After adjusting for age, sex, comorbidity, previous surgery, and diagnosis, California also had higher rates of device complications (0.7% versus 0.3%; RR 2.49; 95%CI 2.39 – 2.61; p<0.001), wound problems (4.2% versus 1.5%; RR 2.64; 95%CI 2.62 – 2.65; p<0.001) and life threatening complications (3.3% versus 2.4%; RR 1.31; 95%CI 1.31 – 1.31; p<0.001).

Hospital outcomes

To examine whether these differences were due to hospitals with outlying surgical rates or concentrated in hospitals with low or high surgical volume, we examined variation in adjusted reoperation rates aggregated across hospitals (Figure 1). Low-volume hospitals had a greater variance around the mean, but our findings were not driven by the few hospitals with unusually high rates.

Costs

Mean hospitalization costs were higher in California than in Washington ($49,430 versus $40,327; p< 0.001), after adjusting for age, sex, comorbidity, and diagnosis.

Sensitivity analysis

Codes implying previous spine operations were associated with higher rates of complications and readmission, and these effects were greater in California than in Washington. However, the low frequency of these outcomes in Washington (the referent) prohibited us from examining an interaction term. The risk ratio for readmissions in California did not substantially change after excluding patients with previous surgery codes, and complications were only slightly attenuated. When we further excluded patients from California (but not Washington) who had a spine operation in the previous three years (n=724), the risks for repeat surgery (RR 1.84; 95%CI 1.83 – 1.84; p<0.001) or readmission (RR 1.11 95%CI 1.08 – 1.13; p<0.001) in California were reduced, but still greater than in Washington. Wound and life threatening complication risks in California did not substantially change.

We found no association between race or ethnicity and outcomes within California, but had poor power to detect difference for some race and ethnicity categories.

Discussion

Rate of surgery, selection of surgical technique, and occurrence of major complications differed substantially between California and Washington WC patients undergoing lumbar fusion. These empirical differences may in part be due to differences in coverage policies. After adjusting for demographic and clinical characteristics, WC patients with degenerative conditions in Washington had a significantly lower rate of fusion operations, reoperations, readmissions, wound problems, device complications, and life threatening complications, when compared to WC patients in California. Washington had lower use of complex procedures including, combined surgical approaches procedures, multi-level fusions, and bone morphogenetic proteins. Even though a smaller proportion of California’s WC patients had the strongest evidence-based indications for fusion, such as spondylolisthesis, they were more likely to undergo complex procedures compared to WC patients in Washington. Similar patient age and comorbidity suggest that California’s WC patients were not “sicker” than those in Washington, and previous surgery does not account for the worse outcomes in California. Inpatient costs (22% higher) and length of stay (42% higher) were greater in California than in Washington.

Coverage and reimbursement policies may account for the differences in utilization, costs and safety differences that we observed between Washington and California. Limited empirical data are available to confirm the common, largely anecdotal, belief that second surgical opinion consults are often performed by surgical colleagues who are unlikely to disagree with an initial surgical recommendation. The review by Lindsey & Newhouse[21] summarize the deficiencies in the literature and call into question the costs and value of second surgical opinion programs.

Operative features were associated with differences in utilization and outcomes between Washington and California. For example, the decision to use BMP is largely discretionary and controversial. [42] The high rate of use in California relative to Washington is not supported by evidence of improved outcomes or lower rates of reoperations.[43] As in previous claims-based studies,[39] we found that BMP use was associated with higher complication rates.

We only examined adverse outcomes reliably captured in administrative data. Our study consisted of a large population, which is advantageous for comparisons of rare safety outcomes. Discharge databases are useful for understanding how health systems influence clinical practice outside the controlled conditions of a clinical trial. Although research based on ICD-9-CM codes lack some clinical detail, administrative data capture care occurring at different institutions, improve generalizability, and reduce recruitment, measurement, and investigator biases problematic in clinical trials.[42] Although SID does not include pain intensity, imaging findings, or specific vertebral levels, we were able to describe important operative characteristics, including surgical approach and use of instrumentation. Administratively derived patient safety indicators are used by NSQIP and based on HEDIS measures; they appear to be reliable for ascertaining major complications.[44] Measuring readmission or reoperations in our analysis did not depend on ICD-9-CM codes for complications. Our estimates of readmissions and complications may be conservative because we excluded non-degenerative spinal comorbidity and previous surgery. In addition, by only counting events requiring an inpatient admission, our estimates of complication rates may underestimate the actual rate (e.g. some infections may be treated in outpatient settings).

Analyses involving observational data, such as HCUP's claims-based discharge registries, have some inherent limitations. First, unobserved differences between WC populations in California and Washington may account for the differences in the choice of procedure and safety outcomes that we observed. For such factors to influence our findings, they would have to be substantially different between California and Washington, but not be directly related to the policies that we contrast. By excluding patients with trauma, cancer, infections, and non-degenerative spinal pathology, we have reduced some potential confounding.

Second, observational data is often prone to selection bias introduced by the non-random process of placing patients into comparison groups. Obviously, we could not randomly allocate patients to different jurisdictions and surgical management strategies. Therefore, differences in the patient population who are served by the policies might be thought of as drawn from the consequences of these policies.

We adjusted our models for observed differences in patient age, sex, comorbidity, previous surgery and diagnosis, although it is not clear why California had a higher proportion of female WC patients. One possibility is that work injuries are more common in occupations with a preponderance of male workers, and that these are more common in Washington. Compared to California, a higher proportion of Washington residents are employed in agriculture, forestry, fishing and hunting, and mining (2.5% compared to 1.9%), as well as construction (7.0% versus 6.2%).[45] This also suggests that worse outcomes in California cannot be attributed to a higher proportion of manual labor.

Finally, because we rely on an observational research design, it is technically incorrect to infer that differences in coverage policies causally lead to difference in utilization, costs and outcomes. Given their limitations, the use of observational data must be viewed with caution. However, because population-based observational data is the only practical means for evaluating differences between state-wide coverage and reimbursement policies, our results might reasonably be used as part of the decision-making process for guiding treatments.

Approval and reimbursement policies among WC programs influence utilization, cost and safety of lumbar fusion surgery. Broader coverage policy was associated with more aggressive practice, higher rates of reoperation, readmission and other complications. Some insurers have recently instituted coverage policies dramatically limiting lumbar fusion coverage for degenerative disc disease and chronic low back pain.[2] Future work should examine whether these restrictive policies are associated with differences in return-to-work and patient-reported outcomes.

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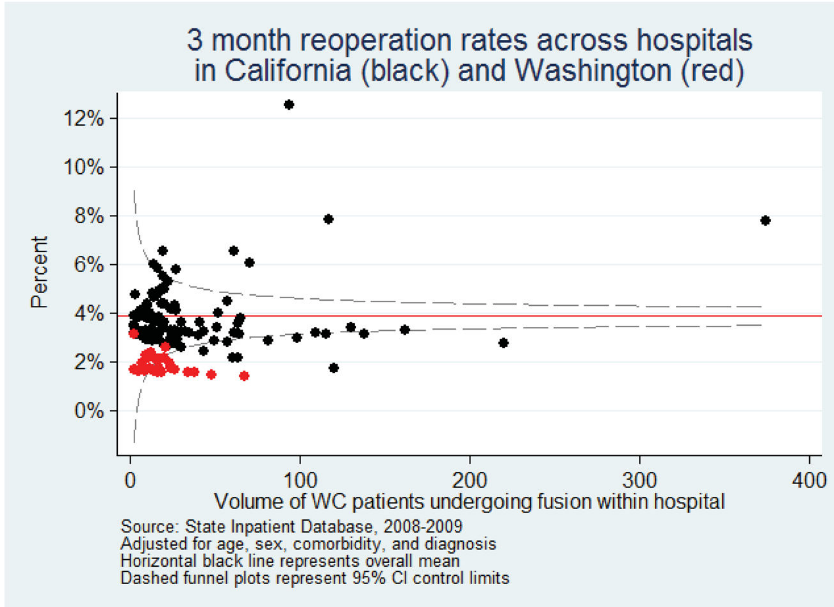

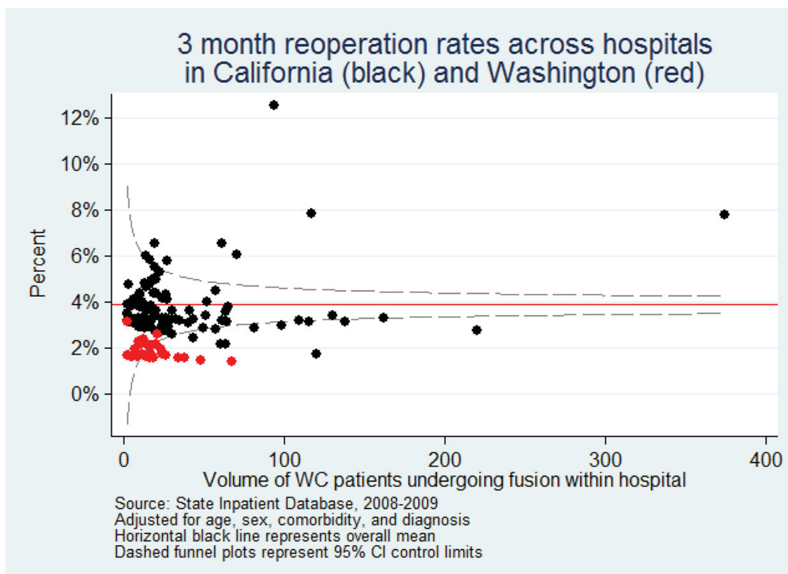

Figure 1.

Rates of repeat lumbar surgery within 3 month among hospitals performing lumbar fusion operations among worker compensation patients, State Inpatient Database 2008–2009 combined. Each point represents a single hospital from California (black) or Washington (red). The horizontal solid line represents the overall mean for all hospitals.

Table 1

Key components of Workers' Compensation Programs for lumbar fusion in Washington and California.

Policy Component	Washington State	California
Review Process	Prospective review	Prospective review
Claims processing	Through state Labor & Industries fund, unless employer is certified as self-insured.	Through employer-purchased private policy, unless employer is certified as self-insured.
Procedure type	Limited to single level	Not limited
Repeat spine surgery approval	Subject to utilization review & approval unless emergent	Not limited
Second opinion	No requirement	Binding
Payment	Based on DRG	Based on DRG + additional reimbursement for surgical implants

DRG, Diagnosis Related Group.

Table 2

Reasons for exclusion.

Exclusion factors (not mutually exclusive)	Number with exclusion
Cervical diagnosis or procedures	4,268
Less than 3 months of surveillance	613
Trauma	354
Age > 65	332
Artificial disc replacement	217
Open treatment of fracture	174
Not an initial observed lumbar fusion admission	174
Congenital or other anomaly	154
Fracture or dislocation	85
Neurological impairment	57
Drug abuse	40
Cancer	34
Osteomyelitis	17
Dynamic stabilizing device	16
Spinal spacer	12
HIV or immune deficiency	7
Intraspinal abscess	4
Inflammatory spondylopathy	3
Spinal cord injury	1
Pregnancy	0
ANY OF ABOVE EXCLUSIONS	***6,756***

Table 3

Patient characteristics, diagnosis and operative features of workers compensation patient undergoing inpatient lumbar fusion.

		California (n = 4,082)	Washington (n = 546)	Overall (n = 4628)	P-value for difference between states
Rate per 100,000 (95%CI) employed adults aged 20–65 [1]		19.0 (18.6 – 19.5)	12.9 (12.0 – 13.8)	18.0 (17.6 – 18.4)	<0.001
Age, mean (sd)		47.1 (9.5)	46.6 (9.4)	47.0 (9.5)	0.253
Age group	20–24	29 (1%)	6 (1%)	35 (1%)	0.691
	25–29	149 (4%)	18 (3%)	167 (4%)	
	30–34	288 (7%)	44 (8%)	332 (7%)	
	35–39	443 (11%)	64 (12%)	507 (11%)	
	40–44	619 (15%)	70 (13%)	689 (15%)	
	45–49	789 (19%)	111 (20%)	900 (19%)	
	50–54	755 (18%)	108 (20%)	863 (19%)	
	55–59	618 (15%)	80 (15%)	698 (15%)	
	60–64	392 (10%)	45 (8%)	437 (9%)	
Sex, %	Male	2614 (65%)	390 (71%)	3004 (66%)	0.003
	Female	1405 (35%)	156 (29%)	1561 (34%)	
Charlson comorbidity [2], %	None	3157 (77%)	434 (79%)	3591 (78%)	0.384
	1	795 (19%)	93 (17%)	888 (19%)	
	2+	130 (3%)	19 (3%)	149 (3%)	
Length of stay, days (SD)		4.39 (2.8)	3.06 (1.8)	4.2 (2.8)	<0.001
Diagnosis	Disc Degeneration	1161 (28%)	115 (21%)	1276 (28%)	<0.001
	Herniated	1390 (34%)	102 (19%)	1492 (32%)	
	Herniated + myelopathy	111 (3%)	10 (2%)	121 (3%)	
	Stenosis	257 (6%)	79 (15%)	336 (7%)	
	Spondylolisthesis	999 (25%)	220 (41%)	1219 (26%)	
	Scoliosis	159 (4%)	17 (3%)	176 (4%)	
Codes that imply previous surgery	No	3203 (79%)	407 (75%)	3610 (78%)	0.056
	Yes	874 (21%)	136 (25%)	1010 (22%)	
Procedure	Fusion only	1183 (29%)	154 (28%)	1337(29%)	0.707

		California (n = 4,082)	Washington (n = 546)	Overall (n = 4628)	P-value for difference between states
	Fusion + decompression	2899 (71%)	392 (72%)	3291(71%)	
Instrumentation	No	896 (22%)	112 (21%)	1008 (22%)	0.445
	Yes	3186 (78%)	434 (79%)	3620 (78%)	
3+ disc levels fused	No	3654 (90%)	521 (95%)	4175 (90%)	<0.001
	Yes	428 (10%)	25 (5%)	453 (10%)	
BMP [3]	No	2,037 (50%)	378 (69%)	2415 (52%)	<0.001
	Yes	2,045 (50%)	168 (31%)	2213 (48%)	
Approach	Posterior	2428 (60%)	475 (87%)	2903 (63%)	<0.001
	Anterior	586 (14%)	41 (8%)	627 (14%)	
	Circum.	1054 (26%)	28 (5%)	1082 (23%)	

[1] Age- and sex-adjusted rate of fusion for degenerative disease reimbursed through WC systems per 100,000 employed adults aged 20–65 based on U.S. Census denominator.

[2] Charlson index modified to remove acute myocardial infarction and stroke

[3] BMP, Bone Morphogenetic Proteins

Table 4

Multivariate analysis of complications, repeat surgery, and re-hospitalization within 3 months of an inpatient lumbar fusion, as well as hospital costs and charges.

		Unadjusted analysis [1]	Adjusted analysis [2]		Adjusted analysis excluding those with implied previous surgery codes [2]		Adjusted analysis excluding those with implied surgery and, for CA only, spine surgery observed in previous three years [2]	
		Rate	**RR (95% CI)**	**Rate**	**RR (95%CI)**	**Rate**	**RR (95%CI)**	**Rate**
Repeat lumbar surgery	**Washington**	12/546 (2.2%)	1.00 (ref)	1.9%	1.00 (ref)	1.4%	1.00 (ref)	1.2%
	California	210/4,082 (5.1%)	2.28 (2.27 – 2.29)	4.8%	2.91 (2.91 – 2.92)	4.7%	1.84 (1.83 – 1.84)	2.4%
	p-value	0.001	<0.001		<0.001		<0.001	
Readmission (all cause)	**Washington**	56/546 (10.3%)	1.00 (ref)	9.1%	1.00 (ref)	9.2%	1.00 (ref)	9.0%
	California	607/4,082 (14.9%)	1.45 (1.44 – 1.47)	14.0%	1.30 (1.27 – 1.33)	13.3%	1.11 (1.08 – 1.13)	11.0%
	p-value	0.003	<0.001		<0.001		<0.001	
Device complication	**Washington**	3/546 (0.6%)	1.00 (ref)	0.3%	1.00 (ref)	<0.1	1.00 (ref)	<0.01%
	California	41/4,082 (1.0%)	2.49 (2.38 – 2.61)	0.7%	2.09 (1.80 – 2.43)	0.2	1.47 (1.19 – 1.82)	0.2%
	p-value	0.478	<0.001		<0.001		<0.001	
Wound problems	**Washington**	11/546 (2.0%)	1.00 (ref)	1.5%	1.00 (ref)	1.1%	1.00 (ref)	1.1%
	California	207/4,082 (5.1%)	2.64 (2.62 – 2.65)	4.2%	2.67 (2.62 – 2.71)	3.3%	2.49 (2.42 – 2.57)	3.2%
	p-value	0.001	<0.001		<0.001		<0.001	
Life-threatening problems	**Washington**	18/546 (3.3%)	1.00 (ref)	2.4%	1.00 (ref)	2.4%	1.00 (ref)	2.5%
	California	154/4,082 (3.7%)	1.31 (1.31 – 1.31)	3.3%	1.11 (1.10 – 1.12)	2.7%	1.09 (1.07 – 1.11)	2.8%
	p-value	0.717	<0.001		<0.001		<0.001	
		Unadjusted [3]	**Adjusted** [4]		**Adjusted** [4]		**Adjusted** [4]	
		USD	**USD (95% CI)**		**USD (95% CI)**		**USD (95% CI)**	
Charges, mean	**Washington**	104,170	103,221 (102,512 – 103,931)		98,868 (98,417 – 99,318)		99,293 (98,724 – 99,861)	
	California	161,015	160,988 (160,529 – 161,447)		158,813 (158,678 – 158,948)		158,565 (158,433 – 158,697)	
	p-value	<0.001	< 0.001		<0.001		<0.001	
Costs, mean	**Washington**	40,693	40,327 (40,114 – 40,542)		38,660 (38,518 – 38,801)		38,858 (38,681 – 39,036)	
	California	49,565	49,430 (49,347 – 49,512)		48,525 (48,507 – 48,542)		48,425 (48,407 – 48,444)	
	p-value	<0.001	<0.001		<0.001		<0.001	

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[1] P-value between states based on 2-sided Fisher exact chi-square

[2] P-values and estimates based on log-binomial regression with state specific robust standard errors, controlling for age, age-squared, sex, comorbidity, previous surgery (except where excluded as specified), and diagnosis.

[3] U.S. dollars. P-values and estimates based on t-test.

[4] U.S. dollars. P-values and estimates based on generalize linear regression with robust standard errors, controlling for age, age-squared, sex, comorbidity, previous surgery (except where excluded as specified) and diagnosis. Wald distributional family & log link function.