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Clinical Study

# 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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**Abstract**

**BACKGROUND CONTEXT:** In response to increasing use of lumbar fusion for improving back pain, despite unclear efficacy, particularly among injured workers, some insurers have developed limited coverage policies. Washington State's workers' compensation (WC) program requires imaging confirmation of instability and limits initial fusions to a single level. In contrast, California requires coverage if a second opinion supports surgery, allows initial multilevel fusion, and provides additional reimbursement for surgical implants. There are no studies that compare population-level effects of these policy differences on utilization, costs, and safety of lumbar fusion.

**PURPOSE:** The purpose of this study was to compare population-level data on the use of complex fusion techniques, adverse outcomes within 3 months, and costs for two states with contrasting coverage policies.

**STUDY DESIGN AND SETTING:** The study design was an analysis of WC patients in California and Washington using the Agency for Healthcare Research and Quality's State Inpatient Databases, 2008–2009.

**PATIENT SAMPLE:** All patients undergoing an inpatient lumbar fusion for degenerative disease (n=4,628) were included the patient sample.

**OUTCOME MEASURE(S):** Outcome measures included repeat lumbar spine surgery, all-cause readmission, life-threatening complications, wound problems, device complications, and costs.

**METHODS:** Log-binomial regressions compared 3-month complications and costs between states, adjusting for patient characteristics.

**RESULTS:** Overall rate of lumbar fusion operations through WC programs was 47% higher in California than in Washington. California WC patients were more likely than those in Washington to undergo fusion for controversial indications, such as nonspecific back pain (28% versus 21%) and disc herniation (37% versus 21%), as opposed to spinal stenosis (6% versus 15%), and spondylolisthesis (25% versus 41%). A higher percentage of patients in California received circumferential procedures (26% versus 5%), fusion of three or more levels (10% versus 5%), and bone morphogenetic protein (50% versus 31%). California had higher adjusted risk for reoperation (relative risk [RR] 2.28; 95%

FDA device/drug status: Approved (Spinal fusion implants, Bone morphogenetic proteins).

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confidence interval [CI], 2.27–2.29), wound problems (RR 2.64; 95% CI, 2.62–2.65), device complications (RR 2.49; 95% CI, 2.38–2.61), and life-threatening complications (RR 1.31; 95% CI, 1.31–1.31). Hospital costs for the index procedure were greater in California ($49,430) than in Washington ($40,114).

**CONCLUSIONS:** Broader lumbar fusion coverage policy was associated with greater use of lumbar fusion, use of more invasive operations, more reoperations, higher rates of complications, and greater inpatient costs. 

*Keywords:* Lumbar spine fusion; Workers' compensation; Degenerative disease; Safety and quality; Readmission; Coverage and reimbursement

## Introduction

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 with non-WC 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 nonoperative care, fusion surgery is equivalent only 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 WC 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]. Because 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's 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, Ninth 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 multistate 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 were obtained from the US Census Bureau, along with estimates of the proportion of employed populations within each stratum.

### *Study population*

We identified adults (ages 20–65) undergoing thoracolumbar, lumbar, or lumbosacral fusion for degenerative

spinal conditions in 2008 or 2009 whose primary payer was WC. 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 follows: scoliosis, spondylolisthesis, stenosis, disc herniation (with and without myelopathy), and disc degeneration (eg, spondylosis).

We excluded patients with nondegenerative spinal pathology, such as vertebral fractures, spinal cord injury, intraspinal abscess, 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 (eg, ''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 3-year period. Therefore, we conducted a two-sensitivity analysis: (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.

EVIDENCE & METHODS

**Context**
Coverage policies vary between insurers. The authors aimed to assess whether this impacted practice patterns.

**Contribution**
They found that more liberal policies in California correlated with more complex surgeries being performed there relative to Washington State where workers' compensation coverage policies are stricter.

**Implications**
Many potential confounding factors were not considered in this database. That said, the study findings are in line with what most of us observe in the spine care community. As the movement toward evidence-based spine care progresses, it is hoped that surgical technique variation founded upon variations in reimbursement rates will be a thing of the past.

*—The Editors*

### *Measuring safety*

Repeat lumbar surgery, readmissions (all causes), wound problems, and 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 orthopedic device.

Table 1
Key components of workers' compensation programs for lumbar fusion in California and Washington

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

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 |

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 postoperative 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 (four or more vertebrae), use of instrumentation, and BMP.

### *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. Because 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 examined.

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.

Table 3
Patient characteristics, diagnosis, and operative features of workers compensation patients undergoing inpatient lumbar fusion

| Characteristic | California (n=4,082) | Washington (n=546) | Overall (n=4,628) | p Value for difference between states |
|---|---|---|---|---|
| Rate per 100,000 (95% CI) employed adults aged 20–65* | 19.0 (18.6–19.5) | 12.9 (12.0–13.8) | 18.0 (17.6–18.4) | <.001 |
| Age, mean (SD) | 47.1 (9.5) | 46.6 (9.4) | 47.0 (9.5) | .253 |
| Age group, n (%) | | | | |
| 20–24 | 29 (1) | 6 (1) | 35 (1) | .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, n (%) | | | | |
| Male | 2,614 (65) | 390 (71) | 3,004 (66) | .003 |
| Female | 1,405 (35) | 156 (29) | 1,561 (34) | |
| Charlson comorbidity,† n (%) | | | | |
| None | 3,157 (77) | 434 (79) | 3,591 (78) | .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) | <.001 |
| Diagnosis, n (%) | | | | |
| Disc degeneration | 1,161 (28) | 115 (21) | 1,276 (28) | <.001 |
| Herniated | 1,390 (34) | 102 (19) | 1,492 (32) | |
| Herniated+myelopathy | 111 (3) | 10 (2) | 121 (3) | |
| Stenosis | 257 (6) | 79 (15) | 336 (7) | |
| Spondylolisthesis | 999 (25) | 220 (41) | 1,219 (26) | |
| Scoliosis | 159 (4) | 17 (3) | 176 (4) | |
| Codes that imply previous surgery, n (%) | | | | |
| No | 3,203 (79) | 407 (75) | 3,610 (78) | .056 |
| Yes | 874 (21) | 136 (25) | 1,010 (22) | |
| Procedure, n (%) | | | | |
| Fusion only | 1,183 (29) | 154 (28) | 1,337 (29) | .707 |
| Fusion+decompression | 2,899 (71) | 392 (72) | 3,291 (71) | |
| Instrumentation, n (%) | | | | |
| No | 896 (22) | 112 (21) | 1,008 (22) | .445 |
| Yes | 3,186 (78) | 434 (79) | 3,620 (78) | |
| 3+ disc levels fused, n (%) | | | | |
| No | 3,654 (90) | 521 (95) | 4,175 (90) | <.001 |
| Yes | 428 (10) | 25 (5) | 453 (10) | |
| BMP, n (%) | | | | |
| No | 2,037 (50) | 378 (69) | 2,415 (52) | <.001 |
| Yes | 2,045 (50) | 168 (31) | 2,213 (48) | |
| Approach, n (%) | | | | |
| Posterior | 2,428 (60) | 475 (87) | 2,903 (63) | <.001 |
| Anterior | 586 (14) | 41 (8) | 627 (14) | |
| Circumferential | 1,054 (26) | 28 (5) | 1,082 (23) | |

BMP, bone morphogenetic protein; CI, confidence interval; SD, standard deviation.

* Age- and sex-adjusted rate of fusion for degenerative disease reimbursed through workers' compensation systems per 100,000 employed adults aged 20–65 based on US Census denominator.

† Charlson index modified to remove acute myocardial infarction and stroke.

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 nonwhite and Hispanic residents compared with 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 noncovered 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 (Stata Corp, 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 with 12.9 in Washington State (p<.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=.004). Mean age (47.0 years; standard deviation [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<.001) or disc herniation (37% versus 21%; p<.001), and less likely to have stenosis (6% versus 15%; p<.001) or spondylolisthesis (25% versus 41%; p<.001). The proportion of patients with scoliosis was small (4%), and similar between the two states (p=.38). A significantly higher proportion of patients in California received anterior (14% versus 8%; p<.001) or circumferential approaches (26% versus 5%; p<.001), had 3+disc levels fused (10% versus 5%; p<.001), and received BMP (50% versus 31%; p<.001). The two states had similar rates of instrumented fusion (78%; p=.45) and simultaneous decompression procedures (71%; p=.71).

### *Safety outcomes*

Workers in California had significantly higher rates of reoperation (5.0% versus 2.2%, p=.002) and readmission (14.4% versus 10.3%, p=.007) within 3 months, compared with those in Washington (Table 4). Adjusting for age, sex, comorbidity, previous surgery, and diagnosis, the rate of reoperation in California was 4.8%, compared with 1.9% in Washington (risk ratio [RR] 2.28, 95% confidence interval [CI] 2.27–2.29; p<.001); and the adjusted rate for any readmission in California was 14.0%, compared with 9.1% in Washington (RR 1.45, 95% CI 1.44–1.47; p<.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<.001), wound problems (4.2% versus 1.5%; RR 2.64, 95% CI 2.62–2.65; p<.001), and life-threatening complications (3.3% versus 2.4%; RR 1.31, 95% CI 1.31–1.31; p<.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). 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<.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 3 years (n=724), the risks for repeat surgery (RR 1.84, 95% CI 1.83–1.84; p<.001) or readmission (RR 1.11, 95% CI 1.08–1.13; p<.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

Table 4
Multivariate analysis of complications, repeat surgery, and rehospitalization within 3 months of an inpatient lumbar fusion, as well as hospital costs and charges

| Outcome by state | Unadjusted analysis* Rate | Adjusted analysis† RR (95% CI) | Adjusted analysis† Rate, % | Adjusted analysis excluding those with implied previous surgery codes† RR (95% CI) | Adjusted analysis excluding those with implied previous surgery codes† Rate, % | Adjusted analysis excluding those with implied surgery and, for California only, spine surgery observed in previous 3 years† RR (95% CI) | Adjusted analysis excluding those with implied surgery and, for California only, spine surgery observed in previous 3 years† 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 | .001 | <.001 | | <.001 | | <.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 | .003 | <.001 | | <.001 | | <.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 | .478 | <.001 | | <.001 | | <.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 | .001 | <.001 | | <.001 | | <.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 | .717 | <.001 | | <.001 | | <.001 | |

| Outcome by state | Unadjusted‡ USD | Adjusted§ USD (95% CI) | Adjusted§ USD (95% CI) | Adjusted§ 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 | <.001 | <.001 | <.001 | <.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 | <.001 | <.001 | <.001 | <.001 |

CI, confidence interval; RR, risk ratio.

* p value between states based on 2-sided Fisher exact chi-square.

† 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.

‡ US dollars. The p values and estimates based on *t* test.

§ US dollars. The p values and estimates based on generalized 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 and log link function.

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 with WC patients in California. Washington had lower use of complex procedures, including combined surgical approach procedures, multilevel 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 with 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 and Newhouse [21] summarized the deficiencies in the literature and called 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.

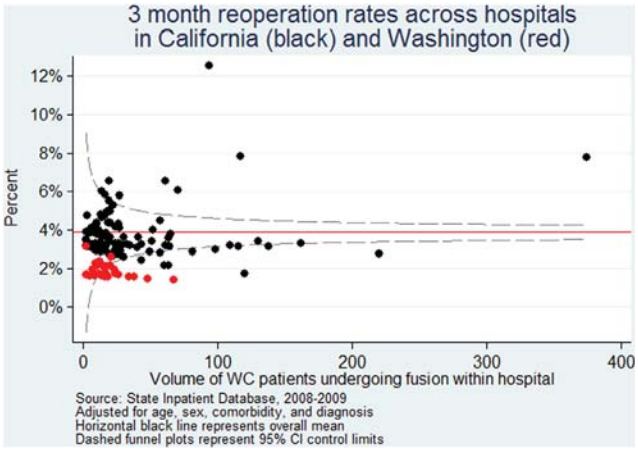


Figure. Rates of repeat lumbar surgery within 3 months among hospitals performing lumbar fusion operations among workers' compensation (WC) patients, State Inpatient Database 2008–2009 combined. Each point represents a single hospital from California (black) or Washington (red). The horizontal solid line represents the overall mean for all hospitals. 95% CI, 95% confidence interval.

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 examined only 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 are 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 nondegenerative 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 (eg, 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 nondegenerative spinal pathology, we have reduced some potential confounding.

Second, observational data are often prone to selection bias introduced by the nonrandom 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 populations that 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 with California, a higher proportion of Washington residents are employed in agriculture, forestry, fishing and hunting, and mining (2.5% compared with 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 are the only practical means for evaluating differences between statewide 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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