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Early Predictors of Lumbar Spine Surgery after Occupational Back Injury: Results from a Prospective Study of Workers in Washington State

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Abstract

Study Design—Prospective population-based cohort study

Objective—To identify early predictors of lumbar spine surgery within 3 years after occupational back injury

Summary of Background Data—Back injuries are the most prevalent occupational injury in the United States. Little is known about predictors of lumbar spine surgery following occupational back injury.

Methods—Using Disability Risk Identification Study Cohort (D-RISC) data, we examined the early predictors of lumbar spine surgery within 3 years among Washington State workers with new worker's compensation temporary total disability claims for back injuries. Baseline measures included worker-reported measures obtained approximately 3 weeks after claim submission. We

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The manuscript submitted does not contain information about medical devices or drugs.

used medical bill data to determine whether participants underwent surgery, covered by the claim, within 3 years. Baseline predictors (P < 0.10) of surgery in bivariate analyses were included in a multivariate logistic regression model predicting lumbar spine surgery. The model's area under the receiver operating characteristic curve (AUC) was used to determine the model's ability to identify correctly workers who underwent surgery.

Results—In the D-RISC sample of 1,885 workers, 174 (9.2%) had a lumbar spine surgery within 3 years. Baseline variables associated with surgery (P < 0.05) in the multivariate model included higher Roland Disability Questionnaire scores, greater injury severity, and surgeon as first provider seen for the injury. Reduced odds of surgery were observed for those under age 35, women, Hispanics, and those whose first provider was a chiropractor. 42.7% of workers who first saw a surgeon had surgery, in contrast to only 1.5% of those who saw a chiropractor. The multivariate model's AUC was 0.93 (95% CI 0.92–0.95), indicating excellent ability to discriminate between workers who would versus would not have surgery.

Conclusion—Baseline variables in multiple domains predicted lumbar spine surgery. There was a very strong association between surgery and first provider seen for the injury, even after adjustment for other important variables.

Even when controlling for severity of condition and other measures, 43% of workers with low back pain who saw a surgeon first ended up having surgery versus 1.5% of workers who saw a chiropractor first.

Keywords

Lumbar spine surgery; back injury; worker's compensation; predictors; prospective study

Introduction

Back pain is the most costly and prevalent occupational health condition among the U.S. working population.[1, 2] Costs relating to occupational back pain increased over 65% from 1996 through 2002, after adjustment for medical and general inflation.[3] Spine surgeries, including those after occupational back injury, represent a significant proportion of these costs and have faced increasing scrutiny regarding effectiveness and efficacy.[4,5] Spine surgeries are associated with little evidence for improved population outcomes,[4] yet rates have increased dramatically since the 1990s.[6–9] Reducing unnecessary spine surgeries is important for improving patient safety and outcomes and reducing surgery complications and health care costs.[10,11] Although previous studies have investigated predictors of outcomes following lumbar spine surgery,[12–16] little research has focused on identifying early (after injury) factors associated with receipt of surgery.[17,18] Knowledge of early predictors of lumbar spine surgery following occupational back injury may help identify workers likely to undergo surgery, which in turn has potential to improve patient outcomes by targeting evidence-based care to such workers. Furthermore, such information is essential for comparative effectiveness studies so that factors associated with receipt of surgery can be assessed and included in adjustment or matching techniques to increase comparability of treatment groups.

In non- workers compensation claim cases, high co-pays can deter patients from seeking chiropractic care and may lead them to seek care from a surgeon as a first treatment option. This may contribute to the dramatic rise in rates of spine surgeries since the 1990s despite little evidence for improved population outcomes. Reducting unnecessary spine surgeries is important for improving patient safety and outcomes and health care costs.

We used data from the Washington State Worker's Compensation Disability Risk Identification Study Cohort (D-RISC), a sample of workers with early wage replacement for temporary total disability due to a back injury, to examine the incidence of lumbar fusion and decompression spine surgeries by 3 years after claim submission, identify early predictors of surgery, develop a multivariate predictive model of surgery, and evaluate the model's ability to predict surgery. We used previous occupational injury, back injury, chronic back pain-related disability, and lumbar spine surgery literature to identify potential early predictors available in the D-RISC baseline data, which include measures in seven domains (sociodemographic, employment-related, pain and function, clinical status, health care, health behavior, and psychological).[19–22] We hypothesized that the following baseline variables would be associated with subsequent lumbar spine surgery: older age,[8,9] higher pain ratings,[16,19,23,24] prescription of opioid medication within 6 weeks from the first medical visit for the injury,[17,25] worker perception that the job is "hectic",[19] no employer offer of job accommodation after the injury,[19] worse psychological factors,[15,16,21,22] worse injury severity,[4–5,17,19] and rural residence.[8,26] We also hypothesized that Hispanic,[9,16,27,28] non-white,[8,9,16,28] and female[8,9,28] workers would have reduced odds of surgery. Finally, we explored whether other variables predicted subsequent surgery.

Materials and Methods

Setting and Participants

The D-RISC study has been described previously.[19–22,25,29] In brief, workers with back injuries were identified prospectively through weekly claims review from the Washington State Department of Labor and Industries (DLI) State Fund, which covers approximately two-thirds of the state's non-federal workforce. Workers who received some wage-replacement compensation for temporary total disability (four days off work) due to the injury were potentially eligible for the study.

In the D-RISC study, 4,354 potential participants were identified from the DLI claims database between June 2002 and April 2004. As previously reported,[19] 1178 (27.1%) could not be contacted successfully soon after the injury, 909 (20.9%) declined enrollment into the study, and 120 (2.8%) were ineligible. The remaining 2147 (49.3%) enrolled in D-RISC and completed a telephone interview, which was conducted a median of 18 days after claim receipt. Study participants were excluded from the D-RISC analysis sample if they were not eligible for compensation in the claim's first year (n=240), were hospitalized for the initial injury (n=16), were missing data on age (n=3), or did not have a back injury according to medical record review (n=3). Thus, 1885 (43.3%) were included in the D-RISC analysis sample. As previously reported,[19] this sample, as compared to workers who received wage-replacement compensation for a back injury but were not in D-RISC, was slightly older [mean age (SD) = 39.4 (11.2) vs. 38.2 (11.1) years, P = 0.001]; contained more women (32% vs. 26%, P <0.001); and had more workers receiving wage-replacement compensation 1 year after claim submission (13.8% vs. 11.3%, P =0.02).

Baseline variables

The D-RISC baseline data came from three sources: administrative claims and medical bill data, medical record review, and worker self-report in telephone interviews.[19–22,25,29] A measure of injury severity was developed for D-RISC and trained occupational health nurses reviewed medical records of visits for the injury and rated injury severity.[22] See Table 1 and

Appendix 1 for additional information about the baseline variables. 52 of 111 available D-RISC variables were examined bivariately.

Outcome measures

To determine whether a worker had lumbar spine surgery covered by DLI within 3 years, we used the DLI computerized medical bill database, which includes dates of service and Current Procedural Terminology (CPT) codes for all medical bills paid by DLI in the claim. We identified all lumbar spine surgery bills using the CPT codes shown in Appendix 2. Our CPT codes vary slightly from a previous code list[30] for lumbar spine surgery; there were no differences in counts or types of surgeries when we used that list. The date of surgery was defined as the first date of service for an included CPT code. We identified operations within 3 years (1095 days) from the date DLI received the claim for the back injury. This period was the longest amount of time surgical data were available for all 1885 D-RISC participants. We categorized the surgeries into fusion, decompression, or both operations for descriptive purposes, but combined them for analytical purposes.

Statistical Analyses

Initially, we conducted bivariate logistic regression analyses to examine associations between baseline variables of interest and lumbar spine surgery, adjusted for worker age and gender. We then constructed a multivariate model for predicting surgery that included baseline variables bivariately associated ($P < 0.10$) with lumbar spine surgery. This criterion of $P < 0.10$ was used because a standard 0.05 P-value level in a bivariate analysis may exclude variables that may be significant in a multivariate model.[31] Analyses were conducted using Stata versions IC10 and MP12.[32] To evaluate the ability of the multivariate model to distinguish between workers who did versus did not undergo surgery by 3 years, we determined the area under the receiver operating characteristic curve (AUC) and used 10-fold cross validation to estimate the AUC in different sub-samples of the D-RISC data.[33] An AUC from 0.70 to 0.80 is considered acceptable and 0.80 to 0.90 is considered excellent.[19,31]

Results

Sample characteristics

Study participants (N=1885) were mostly white non-Hispanic (71%; Hispanic 15% and Other 14%) and male (68%). By 3 years after claim receipt, 174 (9.2%) of the workers underwent one or more lumbar spine operations covered by DLI under the same claim as the index back injury. Among the 174 workers with an operation, 137 (78.7%) had decompression only as the first operation in the claim, 6 (3.4%) had fusion only, and 31 (17.8%) had both procedures on the same day.

Bivariate Analyses

Table 1 shows the baseline variables that had bivariate associations with surgery with $P < 0.10$. Variables that were not significant in bivariate analyses are listed in Appendix 1. All seven domains contained variables associated with lumbar spine surgery. All variables from the pain and function, health care, and psychological domains were associated with lumbar spine surgery in bivariate analyses. In the sociodemographic domain, suburban residence was associated with higher odds of surgery; younger age, female gender, Hispanic ethnicity, and non-white race were associated with reduced odds. Perception of job as fast-paced, working at current job for less than 6 months, not having returned to original work duties, and not receiving a job accommodation offer from the employer were associated with greater odds of surgery. In the clinical status domain, injury severity, pain radiating below the knee, missing at least 1 month of work due to a previous occupational injury (any type), and receipt of an opioid prescription for the injury were associated with surgery. Using tobacco daily (health behavior domain) was also associated with surgery.

Multivariate Model

The multivariate model (Table 2) included variables that were associated with surgery in bivariate analyses. Due to concerns about collinearity, we examined correlations among the variables in the pain and function and psychological domains; as a result, we did not include variables for pain interference with daily activities,[49] pain interference with work,[49] SF-36 v2 Physical Function,[35] and SF-36 v2 Role Physical[35] in the multivariate model. We did include number of pain sites, pain intensity, Roland-Morris Disability Questionnaire (RMDQ),[34] and all of the variables in the psychological domain. Finally, we did not include self-report of radiating pain below the knee due to its similarity to radiculopathy in the injury severity measure.[19]

Due to missing data on some variables, the multivariate model included 1,857 (98.5%) workers. These workers, as compared to the 28 who were in the D-RISC sample but not in the multivariate model, were less likely to have some college education (52% vs. 61%, P=0.01) No other differences, including undergoing surgery, were identified.

Six variables from four domains contributed independently ($P < 0.05$) to the prediction of lumbar spine surgery in the multivariate model. Workers with high baseline RMDQ scores had six times the odds of surgery compared with those with low scores. Those with greater injury severity and those whose first provider seen for the injury was a surgeon also had significantly higher odds of surgery, after adjusting for all other variables. The surgery provider category included orthopedic surgeons (n=104 workers seen), neurosurgeons (34), and general surgeons (33). Factors associated with significantly reduced odds of surgery included age younger than 35 years, female gender, Hispanic ethnicity, and chiropractor as first provider seen for the injury. No measures in the employment-related, health behavior, or psychological domains were significant.

The AUC value was 0.93 (95% CI 0.92–0.95), indicating a very high ability for the model to distinguish between participants who did and did not undergo lumbar spine surgery.[31] The cross-validation AUC was also 0.93 (95% CI 0.91–0.95). In additional analyses, inclusion of only the RMDQ score, injury severity, and first provider seen for the injury resulted in an AUC value of 0.89 (95% CI 0.87–0.91) and a cross-validation AUC of 0.89 (95% CI 0.86–0.91).

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Discussion

In this sample, 9.2% of workers receiving temporary total disability compensation soon after an occupational back injury went on to have lumbar spine surgery in the next three years. This rate is similar to rates of lumbar spine surgery following occupational back injury reported in other studies (9.8%[17] and 10.8%[27]). Measures in four domains predicted surgery: sociodemographic, pain and function, clinical status, and health care.

In an adjusted multivariate model, workers with baseline RMDQ scores of 17 or higher on the 0 – 24 scale had 6 times the odds (adjusted OR=6.12, 95% CI=1.84–20.42) of surgery, as compared with those with scores of 0–8. The RMDQ has also been shown to be predictive of chronic work disability (in a previous study involving the D-RISC sample),[19] longer duration of sick leave,[36] chronic pain,[24] and other measures of function.[37] In a previous D-RISC study of predictors of chronic work disability after back injury, baseline measures in the psychological domain were highly significant in bivariate analyses, but remained significant in a multivariate model only when the RMDQ was excluded from the model.[19] Previous studies noted that participants with lumbar spinal stenosis and discogenic back pain who did versus did not have surgery did not differ prior to surgery on measures of mental health and pain catastrophizing.[18,38] In the current study, several psychological variables were significant in bivariate analyses, but none were significant in the multivariate model, with or without inclusion of RMDQ scores. There is evidence that psychological measures predict patient pain and function outcomes after spine surgery[39,40] and research is needed to identify which combination of disease status, psychosocial, and other measures might best guide treatment decision-making for patients with back pain.

The D-RISC injury severity rating also predicted surgery in the multivariate model. This is consistent with previous findings that radiculopathy influences back pain outcomes, including surgeries.[16,17,24,37] Surgeries may be appropriate treatment for radiculopathy.[41] Odds of surgery were highest for workers with reflex, sensory, or motor abnormalities (19 of 58, or 32.8%, received surgery). Odds were also high for workers with symptomatic radiculopathy without such abnormalities (85 of 344, or 24.7%, received surgery). In future studies investigating lumbar spine surgery, it may be informative, if the number of cases is sufficient, to separate these categories.

In Washington State worker's compensation, injured workers may choose their medical provider. Even after controlling for injury severity and other measures, workers with an initial visit for the injury to a surgeon had almost nine times the odds of receiving lumbar spine surgery compared to those seeing primary care providers, whereas workers whose first visit was to a chiropractor had significantly lower odds of surgery (adjusted OR 0.22, 95% CI=0.10–0.50). Approximately 43% of workers who saw a surgeon had surgery within 3 years, in contrast to only 1.5% of those who saw a chiropractor. It is possible that these findings indicate that "who you see is what you get."[42] Previous studies have noted similar findings using provider surveys of hypothetical patients.[42,43] Persons with occupational back injuries who first saw a chiropractor had lower odds of chronic work disability and early receipt of magnetic resonance imaging (MRIs) in previous reports of data from the D-RISC sample,[19,29] and higher rates of satisfaction with back care.[44] However, patients who

Persons with occupational back injuries who first saw a chiropractor had lower odds of chronic work disability and early receipt of MRI and higher rates of satisfaction with back care. Preventing chronic disability can prevent the necessity of using opiates to treat the chronic pain.

see chiropractors may differ from patients who choose other provider types.[19,45] It may be of interest to worker's compensation programs to evaluate a gatekeeper approach to help ensure the need for lumbar spine surgery.

As hypothesized, Hispanic participants had lower odds of surgery. Prior research has also observed lower rates of spine surgery among Hispanics.[8,9,27,28,46] In an earlier study, Spanish-speaking workers had significantly fewer lumbar spine surgeries within two years of work injury compared to non-Hispanic whites (7.4% vs. 11.0%).[27] These lower odds may reflect cultural barriers and less willingness to undergo surgeries;[9,47] lack of familiarity or understanding of surgery;[9,48] fewer physician referrals to surgery;[28] and discouragement, lack of information, or bias from employers.[4]

Receipt of a prescription for an opioid medication within 6 weeks of claim receipt was not significant in the multivariate model. A previous study linked early opioid use to receiving lumbar spine surgery for a work-related injury, although the study inclusion criteria and methods differed from those of D-RISC.[17] When we matched our inclusion criteria and methods to that study, an opioid prescription was still not significant. We speculate that the difference may be that in the previous study, a measure of worker-related function was not included, whereas in our study the RMDQ was a highly significant predictor of surgery and opioid prescription was no longer significant after adjusting for RMDQ socres.[17]

The multivariate model had excellent ability to distinguish between workers who did or did not have surgery. A model that included only the RMDQ, injury severity, and first provider seen for the injury also had a very high ability to identify workers who did or did not undergo surgery. These three variables may be of use in future research to predict lumbar spine surgery after occupational back injury; they are relatively simple to obtain, use, and interpret.

Our study has some limitations. We had no ability to capture information on surgery covered outside DLI, although it is reasonable to assume that surgeries for the index back injury would be covered by DLI. Although the D-RISC sample consisted of workers with back injuries, some of the CPT codes are not restricted to lumbar-specific spine surgeries. The extent to which our findings may generalize to other settings is unknown. Nonetheless, the study has notable strengths, including complete data for the entire sample on surgery covered by worker's compensation and a large prospective sample of workers who provided detailed information shortly after injury on several factors, as well as data from other sources.

Variables from several domains predicted lumbar spine surgery after occupational back injury. Surgeries were predicted by factors beyond aspects of the injury, such as age, gender, ethnicity, and first provider seen for the injury. Knowledge of surgery predictors may inform interventions or studies on care management of workers with occupational back injuries, including comparative effectiveness studies of surgery for back pain.

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Key Points

- 174 (9.2%) of 1885 workers had one or more lumbar spine surgeries within 3 years of filing a worker's compensation claim for temporary total disability from an occupational back injury. 137 had a decompression procedure, 6 had a fusion without decompression, and 31 had both as the first surgery in the claim.

- Significant worker baseline variables in a multivariate model predicting one or more lumbar spine surgeries within 3 years of claim submission included higher Roland-Morris Disability Questionnaire scores, greater injury severity, and first seeing a surgeon for the injury. Participants younger than 35 years, females, Hispanics, and participants whose first visit for the injury was to a chiropractor had lower odds of surgery.

- The multivariate model had excellent ability to distinguish between those who did and did not undergo lumbar spine surgery (area under the receiver operating characteristic curve = 0.93).

Table 1

Baseline Variables Associated (P < 0.10) with Lumbar Spine Surgery by Three Years after Claim Receipt for Occupational Back Injury*

Domain and variables	No surgery (n=1,711)	Surgery (n=174)	Odds ratio^	95% CI	P-value
Sociodemographics					
Age, years (ref= 35–44 years)	507	72			<0.001
≤24 years	194	4	0.15	0.05 – 0.41	
25 – 34 years	450	27	0.42	0.26 – 0.66	
45 – 54 years	394	48	0.86	0.59 – 1.27	
≥ 55 years	166	23	1.00	0.61 – 1.66	
Gender (ref=male)	1154	128			0.08
Female	557	46	0.73	0.51 – 1.04	
Region of worker residence ⋄† (ref=urban)	1016	90			0.06
Suburban	257	41	1.77	1.16 – 2.69	
Large town	207	18	1.02	0.60 – 1.75	
Rural	179	18	1.15	0.65 – 2.03	
Race/ethnicity (ref=White non-Hispanic)	1173	145			<0.001
Hispanic	295	12	0.36	0.20 – 0.67	
Other	243	17	0.56	0.33 – 0.95	
Employment-related					
Fast pace (ref=strongly disagree/disagree)	416	35			0.02
Agree	687	63	1.21	0.78 – 1.88	
Strongly agree	602	76	1.78	1.16 – 2.74	
Job duration ≥ 6 months	1319	129			0.09
< 6 months	388	45	1.38	0.95 – 1.98	
Employer offered job accommodation (ref=Yes)	800	55			0.001
No/don't know	911	119	1.78	1.27 – 2.49	
Returned to paid work by baseline interview (ref=Yes, same job)	593	14			<0.001
Yes, light duty or different job	444	25	2.44	1.25 – 4.76	
No	673	135	8.28	4.72 – 14.56	
Pain and function					
Number pain sites (ref=0–2 sites)	840	28			<0.001

Domain and variables	No surgery (n=1,711)	Surgery (n=174)	Odds ratio^	95% CI	P-value
3 – 4 sites	607	110	5.15	3.34 – 7.94	
5 – 8 sites	264	36	4.22	2.50 – 7.11	
Pain intensity, past week (0= no pain, ref= 0–3)[49]	451	7			<0.001
4 – 5	457	38	5.50	2.42 – 12.48	
6 – 7	456	53	8.23	3.68 – 18.37	
8 – 10	344	76	15.26	6.90 – 33.72	
Pain interference with daily activities, past week (0=no interference, ref=0–3)[49]	587	7			<0.001
4 – 5	384	26	5.80	2.48 – 13.52	
6 – 7	333	49	13.04	5.82 – 29.26	
8 – 10	398	98	19.82	9.05 – 43.38	
Pain interference with work, past week (0=no interference, ref=0–3)[49]	625	7			<0.001
4 – 5	314	22	6.44	2.72 – 15.29	
6 – 7	312	39	11.41	5.03 – 25.88	
8 – 10	449	105	21.34	9.80 – 46.48	
Roland-Morris Disability Questionnaire[34€] (0=no disability) (ref=0–8)	524	4			<0.001
9 – 16	601	37	8.55	3.02 – 24.19	
17 – 24	586	133	31.69	11.59 – 86.63	
SF-36 v2 Physical Function[35¶] (ref=>50)	445	8			<0.001
41 – 50	325	5	0.85	0.28 – 2.64	
30 – 40	469	29	3.53	1.59 – 7.83	
< 30	471	132	16.16	7.77 – 33.62	
SF-36 v2 Role Physical[35¶] (ref=>50)	402	3			<0.001
41 – 50	332	7	2.85	0.73 – 11.13	
30 – 40	446	29	8.88	2.68 – 29.43	
< 30	528	135	33.71	10.63 – 106.93	
Pain change since injury (ref=better)	1213	65			<0.001
Same	325	54	3.31	2.24 – 4.87	
Worse	157	54	6.72	4.46 – 10.12	
Clinical status					
Injury severity[22††] (ref=mild strain/sprain)	991	38			<0.001

Domain and variables	No surgery (n=1,711)	Surgery (n=174)	Odds ratio^	95% CI	P-value
Major strain/sprain with substantial immobility but no evidence of radiculopathy	361	20	1.36	0.78 – 2.38	
Evidence of radiculopathy	306	95	7.80	5.21 – 11.68	
Reflex, sensory or motor abnormalities	43	21	11.57	6.19 – 21.65	
Pain radiates below knee (ref=no)	1303	57			<0.001
Yes	408	117	6.43	4.58 – 9.05	
Previous injury (any type) with ≥ 1 month off work (ref=no)	1275	100			<0.001
Yes	429	74	1.83	1.32 – 2.54	
Opioid Rx within 6 weeks of injury ° (ref=no)	1131	77			<0.001
Yes	541	94	2.46	1.78 – 3.39	
Health care					
Specialty, first provider seen for injury ° (ref=primary care)	635	45			<0.001
Surgeon	98	73	10.41	6.72 – 16.11	
Occupational medicine	107	16	2.09	1.13 – 3.87	
Chiropractor	534	8	0.21	0.10 – 0.45	
Other	337	32	1.36	0.84 – 2.19	
Time from injury to first medical visit for injury ° (ref=0–6 days)	1336	119			<0.001
7 – 13 days	193	20	1.08	0.65 – 1.79	
≥ 14 days	138	32	2.58	1.67 – 3.98	
Health behavior					
Tobacco use (ref=no)	986	84			0.07
Occasionally/frequently	267	24	1.04	0.64 – 1.67	
Daily	505	66	1.49	1.06 – 2.11	
Psychological					
Catastrophizing[50‡‡] (ref=0–1)	551	15			<0.001
Low (>1 – <2)	282	23	3.02	1.55 – 5.90	
Moderate (2 – <3)	490	70	5.30	2.99 – 9.42	
High (3 – 4)	388	66	6.39	3.57 – 11.43	
Recovery expectations[51] (0–10 scale, 10 = extremely certain will be working in 6 months, ref=10)	993	65			<0.001
High (7 – 9)	331	65	3.04	2.10 – 4.40	
Low (0 – 6)	328	39	1.86	1.22 – 2.84	

Domain and variables	No surgery (n=1,711)	Surgery (n=174)	Odds ratio^	95% CI	P-value
Blame for injury[51] (ref=work)	823	92			0.02
Self	339	20	0.52	0.31 – 0.85	
Someone/something else	237	33	1.25	0.81 – 1.92	
Nothing/no one	265	28	0.91	0.58 – 1.42	
Work fear-avoidance[52]°° (ref= <3, very low)	361	15			<0.001
Low-moderate (>3 – <5)	567	39	1.71	0.93 – 3.16	
High (5 – 6)	783	120	3.85	2.21 – 6.70	
SF-36 v2 Mental Health[35]¶ (ref=>50)	688	30			<0.001
41 – 50	417	56	3.27	2.05 – 5.20	
≤ 40	604	88	3.53	2.29 – 5.45	

ref = reference group

*Missing, "don't know," and refusal responses for each variable were combined into one response (unless stated otherwise) for each variable if ≥15 of responses qualified (results not shown). The following variables had missing responses: region of worker residence (n=59), fast pace (6), job duration (4), returned to paid work by baseline interview (1), pain intensity (3), pain interference with daily activities (9), pain interference with work (12), SF-36 v2 Physical Function (1), SF-36 v2 Role Physical (3), pain change since injury (17), injury severity (10), previous injury (any type) with ≥ 1 month off work (7), opioid RX within 6 weeks of injury (42), time from injury to first medical visit for injury (48), tobacco use (3), recovery expectations (64), blame for injury (48), and SF-36 v2 Mental Health (2).

^Age and gender were included in bivariate analyses along with the variable of interest

°From the DLI database

†By residential zipcode, using the Washington State guidelines classifications at http://www.doh.wa.gov/Data/Guidelines/RuralUrban

€Measures self-reported back disability; higher scores indicate more disability

¶Short-Form-36 version 2 (SF-36v2) Physical Function, Role Physical, and Mental Health scales; higher scores indicate better functioning

††Rated by trained nurses based on medical records early in the claim

‡‡Mean of responses to three questions from the Pain Catastrophizing scale

°°Mean of responses to two questions from the Fear-Avoidance Beliefs Questionnaire work scale

Table 2

Multivariate Model Predicting Lumbar Spine Surgery by Three Years from Baseline Variables

Domain and variables	Bivariate OR^	Bivariate 95% CI	Multivariate OR^^	Multivariate 95% CI	Multivariate P-Value
Sociodemographics					
Age, years (ref= 35–44 years)					0.003
≤24 years	0.15	0.05 – 0.41	0.23	0.07 – 0.73	
25 – 34 years	0.42	0.26 – 0.66	0.49	0.27 – 0.89	
45 – 54 years	0.86	0.59 – 1.27	0.70	0.41 – 1.18	
≥ 55 years	1.00	0.61 – 1.66	1.43	0.73 – 2.82	
Gender (ref=male)					0.0001
Female	0.73	0.51 – 1.04	0.40	0.25 – 0.65	
Region of worker residence (ref=urban)					0.17
Suburban	1.77	1.16 – 2.69	2.00	1.17 – 3.41	
Large town	1.02	0.60 – 1.75	1.31	0.65 – 2.64	
Rural	1.15	0.65 – 2.03	1.08	0.55 – 2.13	
Race/ethnicity (ref=White non-Hispanic)					0.002
Hispanic	0.36	0.20 – 0.67	0.30	0.14 – 0.66	
Other	0.56	0.33 – 0.95	0.51	0.26 – 0.9991	
Employment-related					
Fast pace (ref=strongly disagree/disagree)					0.25
Agree	1.21	0.78 – 1.88	1.45	0.81 – 2.61	
Strongly agree	1.78	1.16 – 2.74	1.63	0.90 – 2.95	
Job duration ≥ 6 months					0.71
< 6 months	1.38	0.95 – 1.98	1.10	0.68 – 1.77	
Employer offered job accommodation (ref=Yes)					0.43
No/don't know	1.77	1.26 – 2.48	1.22	0.74 – 2.01	
Returned to paid work by baseline interview (ref=Yes, same job)					0.74
Yes, light duty or different job	2.44	1.25 – 4.76	1.23	0.55 – 2.88	
No	8.28	4.72 – 14.56	1.34	0.64 – 2.79	
Pain and function					
Number pain sites (ref=0–2 sites)					0.60

Domain and variables	Bivariate OR^	Bivariate 95% CI	Multivariate OR^^	Multivariate 95% CI	Multivariate P-Value
3 – 4 sites	5.15	3.34 – 7.94	1.34	0.76 – 2.35	
5 – 8 sites	4.22	2.50 – 7.11	1.28	0.65 – 2.52	
Pain intensity, past week (0= no pain, ref= 0–3)[49]					0.18
4 – 5	5.50	2.42 – 12.48	2.39	0.90 – 6.36	
6 – 7	8.23	3.68 – 18.37	1.67	0.62 – 4.49	
8 – 10	15.26	6.90 – 33.72	2.36	0.86 – 6.50	
Roland-Morris Disability Questionnaire[34 €] (0=no disability) (ref=0–8)					0.0003
9 – 16	8.55	3.02 – 24.19	2.52	0.78 – 8.10	
17 – 24	31.69	11.59 – 86.63	6.12	1.84 – 20.42	
Pain change since injury (ref=better)					0.50
Same	3.31	2.24 – 4.87	1.06	0.62 – 1.80	
Worse	6.72	4.46 – 10.12	1.56	0.84 – 2.90	
Clinical status					
Injury severity (ref=mild strain/sprain)					<0.0001
Major strain/sprain with substantial immobility but no evidence of radiculopathy	1.36	0.78 – 2.38	0.84	0.43 – 1.62	
Evidence of radiculopathy	7.80	5.21 – 11.68	4.34	2.62 – 7.17	
Reflex, sensory or motor abnormalities	11.57	6.19 – 21.65	5.73	2.62 – 12.52	
Previous injury (any type) with ≥ 1 month off work (ref=no)					0.32
Yes	1.83	1.32 – 2.54	1.19	0.86 – 1.66	
Opioid Rx within 6 weeks of injury (ref=no)					0.38
Yes	2.46	1.78 – 3.39	0.87	0.65 – 1.18	
Health care					
Specialty, first provider seen for injury (ref=primary care)					<0.0001
Surgeon	10.41	6.72 – 16.11	8.69	5.03 – 15.01	
Occupational medicine	2.09	1.13 – 3.87	1.39	0.67 – 2.87	
Chiropractor	0.21	0.10 – 0.45	0.22	0.10 – 0.50	
Other	1.36	0.84 – 2.19	1.38	0.78 – 2.45	
Time from injury to first medical visit for injury (ref=0–6 days)					0.32
7 – 13 days	1.08	0.65 – 1.79	0.74	0.39 – 1.40	
≥ 14 days	2.58	1.67 – 3.98	1.49	0.82 – 2.72	
Health behavior					

Domain and variables	Bivariate OR^	Bivariate 95% CI	Multivariate OR^^	Multivariate 95% CI	Multivariate P-Value
Tobacco use (ref=no)					0.38
Occasionally/frequently	1.04	0.64 – 1.67	0.66	0.36 – 1.21	
Daily	1.49	1.06 – 2.11	0.95	0.60 – 1.50	
Psychological					
Catastrophizing[50] ‡‡ (ref=0–1)					0.18
Low (>1 – <2)	3.02	1.55 – 5.90	1.75	0.73 – 4.18	
Moderate (2 – <3)	5.30	2.99 – 9.42	2.28	1.05 – 4.93	
High (3 – 4)	6.39	3.57 – 11.43	2.15	0.94 – 4.90	
Recovery expectations[50] (0–10 scale, 10 = extremely certain will be working in 6 months, ref=10)					0.38
High (7 – 9)	3.04	2.10 – 4.40	0.87	0.51 – 1.48	
Low (0 – 6)	1.86	1.22 – 2.84	0.97	0.56 – 1.67	
Blame for injury[51] (ref=work)					0.09
Self	0.52	0.31 – 0.85	0.72	0.38 – 1.35	
Someone/something else	1.25	0.81 – 1.92	1.17	0.67 – 2.06	
Nothing/no one	0.91	0.58 – 1.42	0.96	0.52 – 1.76	
Work fear-avoidance[52] ** (ref= <3, very low)					0.27
Low-moderate (>3 – <5)	1.71	0.93 – 3.16	1.00	0.47 – 2.16	
High (5 – 6)	3.85	2.21 – 6.70	1.47	0.71 – 3.04	
SF-36 v2 Mental Health[35] (ref=>50)					0.26
41 – 50	3.27	2.05 – 5.20	1.31	0.72 – 2.40	
≤ 40	3.53	2.29 – 5.45	0.87	0.48 – 1.58	

Each baseline variable included in this table was associated (P < 0.10) in bivariate analyses with back surgery by three years after occupational back injury

ref = reference group

^ adjusted for age and gender, except for age and gender

^^ adjusted for all other variables in the multivariate model

Appendix 1

Non-Significant Bivariate Associations ($P \geq 0.10$) of Baseline Variables with Lumbar Spine Surgery by One Year after Initial Claim Receipt for Occupational Back Injury[*]

Domain and variables	No surgery (n=1,711)	Surgery (n=174)	Odds ratio^	95% CI	P-value
Sociodemographics					
Education (ref=high school)	581	65			0.25
Less than high school	234	17	0.64	0.36 – 1.12	
Vocational or some college	745	80	0.90	0.64 – 1.28	
College	150	12	0.64	0.34 – 1.23	
Marital status (ref=married/living with partner)	1107	112			0.32
Other	601	62	1.15	0.82 – 1.60	
Employment-related					
Worker's industry °‡ (ref=trade/transportation)	423	40			0.42
Natural resources	86	8	1.01	0.45 – 2.25	
Construction	292	44	1.62	1.02 – 2.57	
Manufacturing	137	13	0.92	0.48 – 1.79	
Management	281	27	1.00	0.59 – 1.67	
Education and health	262	22	0.93	0.51 – 1.68	
Hospitality	230	20	1.04	0.59 – 1.85	
Co-worker relations (0 – 10 scale, ref=10, get along extremely well)	889	101			0.24
8 – 9	610	60	0.93	0.66 – 1.31	
0 – 7	197	13	0.61	0.33 – 1.12	
Heavy lifting (ref=not at all/rarely/occasionally)	810	77			0.27
Frequently	526	63	1.29	0.90 – 1.84	
Constantly	372	34	1.03	0.67 – 1.59	
Whole body vibration (ref=not at all/rarely)	1163	108			0.35
Occasionally/frequently	361	42	1.19	0.80 – 1.78	
Constantly	184	24	1.34	0.82 – 2.19	
Physical demands (ref=sedentary/light)	356	28			0.22
Medium	538	57	1.37	0.85 – 2.21	
Heavy	407	40	1.31	0.78 – 2.21	

Domain and variables	No surgery (n=1,711)	Surgery (n=174)	Odds ratio^	95% CI	P-value
Very heavy	400	49	1.69	1.02 – 2.80	
Excessive amount of work (ref=strongly disagree/disagree)	746	73			0.29
Strongly agree/agree	945	101	1.19	0.86 – 1.64	
Enough time to do job (ref=Strongly agree/agree)	1226	131			0.43
Strongly disagree/disagree	485	43	0.86	0.60 – 1.24	
Very hectic (ref=Strongly disagree/disagree)	463	56			0.28
Agree	775	68	0.74	0.51 – 1.08	
Strongly agree	463	49	0.90	0.59 – 1.36	
Supervisor listens to my work problems (ref=agree)	987	94			0.40
Strongly disagree/disagree	337	36	1.15	0.76 – 1.73	
Strongly agree	361	42	1.30	0.88 – 1.93	
Satisfaction with job (ref=Somewhat or very satisfied)	1456	152			0.70
Not at all or not too satisfied	251	21	0.91	0.56 – 1.47	
Job type at time of injury (ref=full-time)	1548	165			0.12
Part-time	162	9	0.58	0.29 – 1.19	
Seasonal job at injury (ref=no)	1595	165			0.45
Yes	115	9	0.77	0.38 – 1.56	
Temporary job at injury (ref=no)	1599	162			0.83
Yes	110	11	0.93	0.49 – 1.78	
Pain and function (all significant)					
Clinical status					
Previous similar back injury (ref=no)	971	95			0.59
Yes	739	78	0.91	0.66 – 1.26	
Number of self-reported worker's compensation claims before current injury (ref=0)	720	48			0.13
1	498	61	1.53	1.02 – 2.28	
2 – 3	327	44	1.57	1.01 – 2.44	
≥ 4	148	19	1.39	0.78 – 2.46	
Work days missed because of back, previous year (ref=0)	1140	122			0.54
1 – 10	399	33	0.80	0.53 – 1.20	
> 10	138	14	0.90	0.50 – 1.63	
Work days missed because of other health problems, previous year (ref=0)	730	72			0.39

Domain and variables	No surgery (n=1,711)	Surgery (n=174)	Odds ratio^	95% CI	P-value
1 – 10	835	86	1.12	0.80 – 1.56	
> 10	106	15	1.53	0.84 – 2.80	
Number other major medical problems (ref=0)	1454	139			0.36
≥ 1	255	35	1.21	0.80 – 1.83	
Current health aside from injury (ref=excellent)	331	36			0.84
Very good	608	63	0.97	0.63 – 1.49	
Good	553	56	0.92	0.59 – 1.44	
Fair/poor	216	19	0.89	0.49 – 1.59	
General health, year prior to injury (ref=excellent)	380	51			0.15
Very good	625	59	0.69	0.46 – 1.03	
Good	524	45	0.63	0.41 – 0.96	
Fair/poor	179	19	0.83	0.47 – 1.46	
Health care					
Health insurance (ref=yes)	1154	121			0.96
No	555	52	0.99	0.70 – 1.40	
Health behavior					
Alcohol Use Disorder Identification Test-	1220	124			0.56
Consumption (AUDIT-C)[53] ^^ (ref=negative, AUDIT-C score of 0 – 3 for males, 0 – 2 for females)					
Positive (4 – 12 for males, 3 – 12 for females)	481	50	1.11	0.78 – 1.58	
Baseline Body Mass Index (BMI) (ref=<25)	521	38			0.13
25 – 29 (overweight)	660	72	1.32	0.87 – 2.00	
≥ 30 (obese)	489	62	1.54	1.01 – 2.37	
Psychological (all significant)					

ref = reference group

*Missing, "don't know," and refusal responses for each variable were combined into one response for each variable as needed. They were not included in analyses. The following variables had missing responses: education (n=1), marital status (3), co-worker relations (15), heavy lifting (3), whole body vibration (3), physical demands (10), excessive amount of work (20), very hectic (11), supervisor listens to my work problems (28), satisfaction with job (5), job type at time of injury (1), seasonal job at injury (1), temporary job at injury (3), previous similar back injury (2), number of self-reported worker's compensation claims before current injury (20), work days missed because of back in the previous year (39), work days missed because of other health problems in the previous year (41), other major medical problems (2), current health aside from injury (3), general health in year before injury (3), health insurance (3), AUDIT-C (10), and baseline BMI (43)

^Adjusted for age and gender

°Obtained from DLI database

‡Derived from standard industrial codes (SIC)

^^The AUDIT-C score is a screening test for problematic alcohol usage

Appendix 2

CPT codes identifying lumbar spine surgeries by fusion and decompression operations

CPT Codes	
Fusion	
20930	Allograft, morselized, or placement of osteopromotive material, for spine surgery only
20931	Allograft, structural, for spine surgery only
20937	Autograft for spine surgery only (includes harvesting the graft); morselized (through separate skin or fascial incision)
20938	Autograft for spine surgery only (includes harvesting the graft); structural, bicortical or tricortical (through separate skin or fascial incision)
22558	Arthrodesis, anterior interbody technique, including minimal discectomy to prepare interspace (other than for decompression); lumbar
22585	Arthrodesis, anterior interbody technique, including minimal discectomy to prepare interspace (other than for decompression); each additional interspace (List separately in addition to code for primary procedure)
22612	Arthrodesis, posterior or posterolateral technique, single level; lumbar (with or without lateral transverse technique)
22614	Arthrodesis, posterior or posterolateral technique, single level; each additional vertebral segment
22625	Lumbar spine fusion
22630	Arthrodesis, posterior interbody technique, including laminectomy and/or discectomy to prepare interspace (other than for decompression), single interspace; lumbar
22632	Arthrodesis, posterior interbody technique, including laminectomy and/or discectomy to prepare interspace (other than for decompression), single interspace; each additional interspace
22830	Exploration of spinal fusion
22840	Posterior non-segmental instrumentation (eg, Harrington rod technique, pedicle fixation across 1 interspace, atlantoaxial transarticular screw fixation, sublaminar wiring at C1, facet screw fixation)
22842	Posterior segmental instrumentation (eg, pedicle fixation, dual rods with multiple hooks and sublaminar wires); 3 to 6 vertebral segments
22843	Posterior segmental instrumentation (eg, pedicle fixation, dual rods with multiple hooks and sublaminar wires); 7 to 12 vertebral segments
22844	Posterior segmental instrumentation (eg, pedicle fixation, dual rods with multiple hooks and sublaminar wires); 13 or more vertebral segments
22845	Anterior instrumentation; 2 to 3 vertebral segments
22846	Anterior instrumentation; 4 to 7 vertebral segments
22847	Anterior instrumentation; 8 or more vertebral segments
22849	Reinsertion, spinal fixation device
22850	Removal, posterior nonsegmental instrumentation (not specifically lumbar)
22851	Application of intervertebral biomechanical device(s) (eg, synthetic cage(s), methylmethacrylate) to vertebral defect or interspace
22852	Removal, posterior segmental instrumentation (not specifically lumbar)
22855	Removal, anterior instrumentation (not specifically lumbar)
Decompression	
22102	Partial excision of posterior vertebral component (eg, spinous process, lamina or facet) for intrinsic bony lesion, single vertebral segment; lumbar
63005	Laminectomy with exploration and/or decompression of spinal cord and/or cauda equina, without facetectomy, foraminotomy or discectomy (eg, spinal stenosis), 1 or 2 vertebral segments; lumbar, except for spondylolisthesis
63012	Laminectomy with removal of abnormal facets and/or pars inter-articularis with decompression of cauda equina and nerve roots for spondylolisthesis, lumbar (Gill type procedure)
63017	Laminectomy with exploration and/or decompression of spinal cord and/or cauda equina, without facetectomy, foraminotomy or discectomy (eg, spinal stenosis), more than 2 vertebral segments; lumbar

63030	Laminotomy (hemilaminectomy), with decompression of nerve root(s), including partial facetectomy, foraminotomy and/or excision of herniated intervertebral disc, including open and endoscopically-assisted approaches; 1 interspace, lumbar
63035	Laminotomy (hemilaminectomy), with decompression of nerve root(s), including partial facetectomy, foraminotomy and/or excision of herniated intervertebral disc, including open and endoscopically-assisted approaches; each additional interspace, cervical or lumbar
63042	Laminotomy (hemilaminectomy), with decompression of nerve root(s), including partial facetectomy, foraminotomy and/or excision of herniated intervertebral disc, reexploration, single interspace; lumbar
63044	Laminotomy (hemilaminectomy), with decompression of nerve root(s), including partial facetectomy, foraminotomy and/or excision of herniated intervertebral disc, reexploration, single interspace; each additional lumbar interspace
63047	Laminectomy, facetectomy and foraminotomy (unilateral or bilateral with decompression of spinal cord, cauda equina and/or nerve root[s], [eg, spinal or lateral recess stenosis]), single vertebral segment; lumbar
63048	Laminectomy, facetectomy and foraminotomy (unilateral or bilateral with decompression of spinal cord, cauda equina and/or nerve root[s], [eg, spinal or lateral recess stenosis]), single vertebral segment; each additional segment, cervical, thoracic, or lumbar
63056	Transpedicular approach with decompression of spinal cord, equina and/or nerve root(s) (eg, herniated intervertebral disc), single segment; lumbar (including transfacet, or lateral extraforaminal approach) (eg, far lateral herniated intervertebral disc)
63057	Transpedicular approach with decompression of spinal cord, equina and/or nerve root(s) (eg, herniated intervertebral disc), single segment; each additional segment, thoracic or lumbar
63087	Vertebral corpectomy (vertebral body resection), partial or complete, combined thoracolumbar approach with decompression of spinal cord, cauda equina or nerve root(s), lower thoracic or lumbar; single segment
63088	Vertebral corpectomy (vertebral body resection), partial or complete, combined thoracolumbar approach with decompression of spinal cord, cauda equina or nerve root(s), lower thoracic or lumbar; each additional segment
63090	Vertebral corpectomy (vertebral body resection), partial or complete, transperitoneal or retroperitoneal approach with decompression of spinal cord, cauda equina or nerve root(s), lower thoracic, lumbar, or sacral; single segment
63091	Vertebral corpectomy (vertebral body resection), partial or complete, transperitoneal or retroperitoneal approach with decompression of spinal cord, cauda equina or nerve root(s), lower thoracic, lumbar, or sacral; each additional segment
63102	Vertebral corpectomy (vertebral body resection), partial or complete, lateral extracavitary approach with decompression of spinal cord and/or nerve root(s) (eg, for tumor or retropulsed bone fragments); lumbar, single segment
63103	Vertebral corpectomy (vertebral body resection), partial or complete, lateral extracavitary approach with decompression of spinal cord and/or nerve root(s) (eg, for tumor or retropulsed bone fragments); thoracic or lumbar, each additional segment
63267	Laminectomy for excision or evacuation of intraspinal lesion other than neoplasm, extradural; lumbar
63709	Repair of dural/cerebrospinal fluid leak or pseudomeningocele, with laminectomy