Early Predictors of Re-Injury, Clinically Significant Weight Gain, and Lumbar Spine Surgery Following Occupational Back Injury: A Prospective Study of Workers in Washington State

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Abstract

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Back injuries are the costliest and most prevalent disabling occupational injuries in the United States. Little is known about early predictors for outcomes following occupational back injury. This dissertation identifies early predictors and prevalence for three outcomes following occupational back injury: occupational back re-injury within 1 year, clinically significant weight gain (7%) by 1 year, and undergoing lumbar spine surgery within 3 years. The Washington Workers' Compensation Disability Risk Identification Study Cohort provided a large, population-based sample with variables obtained early after injury in eight domains: sociodemographic, employment-related, pain and function, clinical status, health care, administrative/legal, health behavior, and psychological. Telephone interviews were conducted with workers 3 weeks and 1 year after submission of a time-loss claim for the injury. Computerized claims and medical records provided additional measures. Potential predictors were identified ($P \leq 0.10$) in bivariate analyses. Those variables were then included in multivariate logistic regression models predicting the outcomes following the index injury. 1123, 1263, and 1885 workers were included in the re-injury, weight gain, and surgery analyses, respectively. 26% of workers self-reported a back re-injury, 14% self-reported weights that represented a clinically significant increase, and 9% underwent surgery. Early predictors of re-injury included male gender, constant whole body vibration at work, a history of previous similar injury, 4 or more previous workers' compensation claims of any type, possession of health insurance, and high fear-avoidance scores; baseline obesity was associated with reduced odds. Female gender was a baseline predictor of weight gain; time-loss compensation at 1 year was highly associated with weight gain. Baseline predictors of surgery included higher Roland Disability Questionnaire scores, greater injury severity, and first seeing a surgeon for the injury; reduced odds were observed for those under age 35, women, Hispanics, and those whose first health care provider for the injury was a chiropractor. Baseline variables across multiple domains predicted the outcomes of interest in all analyses. Increased knowledge of early predictors of re-injury, weight gain, and lumbar spine surgery may help lead to effective interventions that lower the risk of negative outcomes following occupational back injury.

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Introduction

American adults had health care expenditures of approximately $86 billion for back problems in 2005, which was a 65% increase from 1997.[1] Approximately 30% of all medically-treated injuries occur at work.[2] Among American workers, back pain and injuries accounted for 25% of all occupational claims,[3] 33% of worker's compensation (WC) costs,[4,5] 40% of work absences,[4,5] and 101,800,000 lost workdays yearly.[5]

Workers with occupational back re-injuries are believed to have higher costs and durations of disability compared to the index injury.[6] However, no set definition of re-injury exists, making it difficult to assess the prevalence, incidence, and costs of re-injury reliably.[7] Previous estimates of occupational back re-injury range from 5 – 82%, reflecting this inconsistency.[8] Few studies have analyzed occupational back re-injuries and several have conflicting findings; none identified early predictors of occupational back re-injury in a large dataset across all industries.[6-14]

Occupational back injury is associated with obesity.[15] Additionally, obesity is associated with higher occupational injury rates, WC costs, lost workdays, and lower worker productivity.[15-18] However, little research exists on how occupational back injuries are associated with clinically significant weight gain.

The efficacy of lumbar spine surgery operations is questionable.[19-22] Individuals with WC surgeries are associated with poor outcomes compared to individuals who underwent non-WC surgeries.[23] Persons with WC back injuries vary significantly than work-eligible persons with non-WC back injuries across several outcome measures for certain types of lumbar spine surgery, including the benefit of surgery.[22,24] Surgery also did not impact work or disability outcomes on WC or non-WC persons with back injuries.[22] Few studies on lumbar spine surgery procedures identified early predictors for undergoing back surgery after occupational injury.[22,24-29]

Little is known about how occupational back injuries impact future outcomes, including occupational back re-injury, clinically significant weight gain, and undergoing lumbar spine surgery as a result of the injury. This dissertation seeks to identify early predictors for these outcomes of interest in a cohort of Washington State workers with occupational back injuries. Additionally, the incidence of back re-injury and clinically significant weight gain will be determined, as consistent rates are unavailable in previous literature.

The Washington State Workers' Compensation Disability Risk Identification Study Cohort was used in the dissertation as the main data source. Data were obtained from June 2002 through April 2004; workers entered D-RISC if they received at least 1 day of time-loss compensation for temporary total disability and accepted study entry. 1,885 injured workers were included in D-RISC. Each analysis had additional criteria and used smaller samples of 1123, 1263, and 1624 D-RISC participants, respectively. Variables were obtained in worker telephone interviews 3 weeks and 1 year after the index occupational back injury in eight domains of interest, including sociodemographic, employment-related, pain and function, clinical status, health care, administrative/legal, health behavior, and psychological.[31] Select additional variables were obtained from computerized administrative claims and medical bill data.

Bivariate analyses for the outcome of interest, along with age and gender, were conducted to determine significant ($P<0.10$) bivariate associations.[32] Multivariate logistic regression models were then constructed to predict ($P<0.05$) the outcome that included all baseline variables bivariately associated with the outcome. The area under the receiving operating characteristic curve (AUC) was determined in the re-injury and surgery analyses to evaluate the models' ability to distinguish between workers who did or did not self-report a re-injury or undergo lumbar spine surgery.[32]

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Early Predictors of Occupational Back Re-Injury

Study Design

Prospective population-based cohort study

Objective

To identify early predictors of self-reported occupational back re-injury within 1 year after work-related back injury

Summary of Background Data

Back injuries are the costliest and most prevalent disabling occupational injuries in the United States. A substantial proportion of workers with back injuries have re-injuries after returning to work, yet there are few studies of risk factors for occupational back re-injuries.

Methods

We aimed to identify the rate and early predictors of self-reported back re-injury within 1 year among newly injured workers in Washington State. The Washington Workers' Compensation Disability Risk Identification Study Cohort (D-RISC) provided a large, population-based sample with information on variables in eight domains: sociodemographic, employment-related, pain and function, clinical status, health care, administrative/legal, health behavior, and psychological. We conducted telephone interviews with workers 3 weeks and 1 year after submission of a time-loss claim for the injury. We first identified predictors (p-values < 0.10) of self-reported re-injury within 1 year in bivariate analyses. Those variables were then included in a multivariate logistic regression model predicting occupational back re-injury.

Results

290 (25.8%) of 1,123 workers who completed the one year follow-up interview and returned to work reported re-injuring their back at work. Baseline variables significantly associated with re-injury (p-value < 0.05) included male gender, constant whole body vibration at work, a history of previous similar injury, 4 or more previous claims of any type, possessing health insurance, and high fear-avoidance scores. Baseline obesity was associated with reduced odds of re-injury.

Conclusion

One-fourth of workers who received work disability compensation for a back injury self-reported re-injury after returning to work. Baseline variables in multiple domains predicted occupational back re-injury. Increased knowledge of early factors for re-injury may help lead to interventions effective in lowering the risk of re-injury.

Introduction

Back pain is the costliest and most prevalent disabling occupational disorder in the United States.[1, 2] Costs related to occupational back pain and injuries have increased 65% (in real dollars) in recent years.[3] Workers with back re-injuries or pain recurrences have higher costs and durations of disability,[4] yet occupational back re-injuries are rarely studied relative to initial injuries.[5] No generally agreed upon case definition of occupational back re-injury exists, challenging further research efforts in this field. Additionally, re-injuries are not distinguished among general occupational injuries by the US Bureau of Labor Statistics; national re-injury statistics are unavailable.[5] Reported prevalence estimates range from 5-82%;[6] this wide range likely reflects the variation and inconsistency regarding definitions and data sources. In addition, few predictors of re-injury have been assessed across multiple studies and even when the same variable has been assessed in multiple studies, there have been conflicting findings.[4 – 12] Identification of early predictors of occupational back re-injury may assist in focusing re-injury prevention efforts on workers at high risk, with the potential to lower the risks of occupational back re-injury and long-term disability, and reduce associated medical and lost work time costs.

We used the Washington State Workers' Compensation Disability Risk Identification Study Cohort (D-RISC) data to examine the rate of occupational back re-injury by 1 year, identify early predictors of occupational back re-injury, develop a multivariate predictive model, and evaluate the ability of the multivariate model to predict re-injury. Possible predictive variables were identified within domains of interest that were used previously for occupational injury research.[13 – 16] Eight domains (sociodemographic, employment-related, pain and function, clinical status, health care, administrative/legal, health behavior, and psychological)[13] were assessed in baseline telephone interviews to identify potential risk factors for self-reported occupational back re-injury. Based on previous research, we hypothesized that initial injury severity, worker fear-avoidance, prior work injury, Roland Disability Questionnaire (RDQ) score,[19] lack of offer of job accommodation, poor overall health status, and lack of provider mention of re-injury prevention strategies would be significant predictors of re-injury.[2, 5, 13, 17, 18]

Methods

Setting and Participants

The D-RISC study has been described in previous reports.[13, 14] D-RISC was a prospective, population-based study that identified workers with new occupational back injury claims in the Washington State Department of Labor and Industries (DLI) state fund claims database between June 2002 and April 2004. To be eligible for the study, workers must have received at least one day of temporary total disability wage replacement. All non-federal employees in the state whose employer does not self-insure (approximately two-thirds of the non-federal workforce) are covered by the DLI state fund. Injured workers were identified by weekly claims review.

From the claims database, 4,354 potential participants were identified for D-RISC. Of those, 1178 (27.1%) could not be contacted, 909 (20.9%) declined enrollment, and 120 (2.8%) could not complete the initial phone interview in English or Spanish. The remaining 2147 (49.3%) were enrolled in D-RISC and completed the baseline interview. After the baseline interview, study participants were excluded from the analysis sample if they were not eligible for wage replacement compensation (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 original D-RISC analysis sample. This sample, compared to those who received compensation but were not in the study, 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-disability compensation after 1 year (13.8% vs. 11.3%, P = 0.02).[13]

Of the 1885, 1319 (70.0%) completed the 1-year follow-up interview. Compared to the 566 workers who did not complete the 1-year follow-up assessment, the 1319 who did complete the one-year follow-up were slightly older on average [mean age (SD) = 40.3 (11.1) vs. 37.1 (11.2) years, P < 0.001]; more educated (less than high school education: 11% vs. 19%, P = 0.006); less likely to be Hispanic (14% vs. 22%, P < 0.001); more likely to be married or living with partners (68% vs. 57%, P < 0.001); and more likely to have general health insurance (72% vs. 58%, P < 0.001). The two groups did not differ significantly in time-loss days by 1 year [mean time-loss (SD) = 85 (126) vs. 79 (119) days, P = 0.33). Of the 1319 workers, 13 workers declined or did not know the answer to the question in the follow-up interview indicating re-injury status, and 183 workers reported that they never returned to any paid work in the year after the baseline interview (and hence could not be re-injured while at work). Thus, 1,123 injured workers were included for our analyses.

Measures

Baseline variables

Approximately 111 variables were assessed during the D-RISC structured telephone baseline interview, while approximately 13 variables were obtained from DLI and patient medical records. Baseline measures were selected primarily based upon previous occupational back re-injury research that suggested their potential importance. Because the occupational back re-injury literature is sparse, variables were also selected based upon related injury or worker's compensation research, such as that predicting chronic disability as a result of occupational back injury.[13] Baseline information from the DLI included region of the worker's residence, employer size, industry type, and time from injury to first medical visit. Worker medical records were reviewed to rate injury severity.[16] Please see Tables 1 and 3 for more information about the baseline variables.

Outcome measure

The D-RISC 1-year follow-up structured telephone interview included the following yes/no question used as the outcome variable:

"Since you filed a claim for your back injury around [claim date], have you re-injured your back at work?"

Statistical Analyses

We first conducted logistic regression analyses to examine bivariate associations between baseline variables of interest and re-injury, adjusted for age and gender. Missing, unknown, and refusal answers for each variable were combined into one response and included in the analysis. Variables that were associated with re-injury bivariately were examined for collinearity or redundancy prior to forming the multivariate model.

We then constructed a multivariate model for predicting re-injury that included age, gender, and all baseline variables with bivariate associations ($P < 0.10$). This criterion 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.[26] Analyses were conducted using Stata Version 10.[27]

In order to evaluate the ability of the multivariate model to distinguish between workers who did versus did not report an occupational back re-injury by 1 year, we determined the area under the receiver operating characteristic curve (AUC). An AUC over 0.70 is considered acceptable.[26]

Results

Sample Characteristics

The sample of workers (N=1,123) was mostly white non-Hispanic (73%; 14% Hispanic; and 14% other) and male (67%). At 1 year, 290 of the 1,123 workers self-reported at least 1 occupational re-injury after their initial injury (25.8%). Variables with the most missing data included region of worker residence (n=33), time from injury to first medical visit (n=31), source of blame for the injury (n=24), work days missed due to non-back health problems in the previous year (n=21), work days missed due to back problems in the previous year (n=14), whether the supervisor listens to work-related problems (n=12), and whether the employer offered job accommodations (n=10).

Bivariate Analyses

Table 1 displays baseline variables that were associated ($P < 0.10$) with occupational back re-injury. (See Table 3 for the non-significant variables.) All domains contained at least one association except for administrative/legal. In the sociodemographic domain, gender and race/ethnicity were associated with re-injury. In the employment-related domain, overall amounts of heavy lifting, whole body vibration, physical demands, fast pace, and excessive amounts of work were associated with re-injury. Neither employer-specific variable (employer size and industry) was related to re-injury.

In the pain and function domain, number of pain sites, pain intensity in the past week, the worker's RDQ score,[19] and SF-36 Version 2[24] physical function and role-physical scores were associated with re-injury. Several variables in the clinical domain were associated with re-injury, including a history of previous similar back injury, having a previous occupational injury of any type that resulted in at least one month off work, self-reported previous claims (any type) before the current injury, and work days missed in the previous year for non-back health reasons. In the health care domain, not having general health insurance was associated with a lower risk of re-injury. BMI was the only ($P < 0.10$) predictor in the health behavior domain. In the psychological domain, the worker's source of blame for the injury, fear-avoidance, and SF-36v2 mental health score were associated with re-injury.

Multivariate Model

The multivariate model (Table 2) includes age, gender, and other variables that were associated with re-injury bivariately. Seven variables from 6 domains contributed significantly ($P < 0.05$) to the prediction of self-reported occupational back re-injury by 1 year. These include male gender, constant whole body vibration, history of previous similar back injury, more than 3 previous worker's compensation claims of any type before this injury, having health insurance, obesity (BMI ≥ 30), and elevated work fear-avoidance scores.

Due to concern about having too many similar pain and function variables in the multivariate model (i.e. collinearity), we conducted a sensitivity analysis repeating the logistic regression with only two baseline variables from this domain, chosen based on past research showing their relationship to subsequent clinical outcomes[7, 13]: the number of pain sites and the RDQ score. None of the baseline measures of pain and function variables were statistically significant in either multivariate model.

The AUC value was 0.72, indicating acceptable ability of the model to distinguish workers who reported a re-injury by 1 year from those who did not.[26]

The strongest predictors of occupational back re-injury in the multivariate model were the number of prior worker's compensation claims and the baseline fear-avoidance score. Workers who reported more than 3 prior claims had 2.29 times the odds (95% CI 1.34 – 3.92) of self-reported re-injury as compared with workers who reported no previous claims. Compared to workers with low fear-avoidance (score <3), workers with high (score of 5 to 6) or low-moderate (3 to <5) fear-avoidance scores had approximately twice the odds of reporting a re-injury [OR=2.03 (95% CI 1.27 – 3.23) and OR=1.84 (95% CI 1.13 – 2.99), respectively].

Discussion

To our knowledge, this is the first population-based study to examine early predictors of occupational back re-injury from multiple domains of potential risk factors across all industries. Variables from 6 domains (sociodemographic, employment-related, clinical status, health care, health behavior, and psychological) were significant early predictors of occupational back re-injury. This suggests that back re-injuries may be influenced by factors beyond aspects of clinical care and the severity of the initial injury.[13]

The strongest predictor in the final multivariate model was self-report of more than 3 previous worker's compensation claims of any type, even after adjustment for a previous similar back injury. To our knowledge, the worker's history of claims has not been examined in previous occupational back re-injury literature. Further research is needed to better understand why a history of previous claims is associated with greater odds of re-injury, and how knowledge of previous claims could be used to help prevent re-injury.

Fear-avoidance has been found to be associated with occupational disability in previous studies.[13, 15] However, we are not aware of prior research examining fear-avoidance as a predictor of occupational back re-injury. It is notable that a variable in the psychological domain predicts re-injury even after adjustment for measures of pain and function. This study contributes to the body of research supporting the potential value of screening patients with back injuries for psychological factors such as fear-avoidance that may affect their clinical outcomes, and suggests the importance of assessing fear-avoidance early after injury and addressing fear-avoidance when present (e.g., through education and graded activity to promote recovery).[13]

Worker self-report of whole body vibration in job tasks contributed independently to the prediction of re-injury in the multivariate model. To our knowledge, this variable has not been examined in other studies of predictors of occupational re-injury. A number of other job demands variables were predictive of re-injury when examined bivariately; similarly, prior occupational back re-injury studies have found significant predictors related to job demands, including a fast-paced environment[7, 8] and physical demands.[7 – 9] Our results were also consistent with those of previous studies that found no association between re-injury and worker job satisfaction.[10]

Surprisingly, not having general health insurance was associated with lower odds of back re-injury. One previous study found that having general health insurance was significantly and positively associated with reporting and seeking treatment for occupational injuries.[28] It is possible that workers who have general health insurance may be more likely to seek care for an injury because care will be covered by insurance even if they do not have an accepted worker's compensation claim for the injury. It is also possible that this variable is a marker for another unmeasured characteristic associated with re-injury or a reflection of baseline differences between our analysis sample and other D-RISC participants that did not complete the 1-year follow-up interview.

Compared to workers of normal weight, obese participants (BMI ≥ 30) had lower odds of occupational back re-injury. One previous study that assessed BMI found no association with re-injury.[8] Multiple studies have observed associations between obesity and occupational back injuries, including higher rates of initial injuries.[17, 29, 30] Obese workers have also been found to have lower physical productivity.[31] Obese participants may be more likely to have jobs that do not have physical demands associated with re-injury. In additional bivariate analyses of our data, we found that obese participants were significantly less likely to report a fast pace or excessive amount of work compared to participants of normal weight; however, no other physical job demands differences were found.

Our study has some limitations. First, the outcome was a binary yes-no question about back re-injury; we do not have information concerning the extent and severity of the re-injury. Our response rate for the 1-year follow-up interview was 70.0% of the participants who completed the baseline interview, and respondents and non-respondents differed significantly on some baseline measures. We did not assess some variables found in previous studies to be associated with occupational back re-injury, including a history of substance abuse,[9] the ratio of salary to wage-loss payments,[9] and the lengths of previous employment.[9] Finally, we analyzed a large number of variables and some associations might have been significant due to chance alone; findings need to be confirmed in future studies. Despite these limitations, this study has numerous strengths, including a large, population-based sample across all industries; a prospective design; several sources of baseline data; and baseline variables reflecting multiple domains of interest.

In sum, biological, psychosocial, and environmental factors may all be involved in occupational back re-injury. Approximately 25% of our sample reported an occupational back re-injury within one year of initial submission of a claim involving loss of at least four days of work due to back injury. Understanding risk factors for occupational back re-injury may increase knowledge about why some workers are re-injured while others are not. This knowledge may lead to improved re-injury prevention efforts by employees, employers, and providers.

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Table 1. Bivariate Associations (P ≤ 0.10) of Baseline Variables with Occupational Back Re-Injury by One Year after Initial Occupational Back Injury

Domain and variables	Not re-injured N=833 %(n)	Re-injured N=290 %(n)	Odds ratio^	95% CI	P-value
Sociodemographic					
Gender (ref=male)	64 (531)	74 (216)			< 0.01
Female	36 (302)	26 (74)	0.60	0.47 – 0.81	
Race/ethnicity (ref=White non-Hispanic)	72 (603)	74 (214)			0.04
Hispanic	15 (123)	10 (30)	0.64	0.41 – 0.99	
Other	13 (107)	16 (46)	1.26	0.86 – 1.86	
Employment-related					
Worker's description of job in following variables					
Heavy lifting (ref=not at all/rarely/occasionally)	51 (423)	41 (119)			0.02
Frequently	32 (264)	38 (111)	1.46	1.07 – 1.97	
Constantly	17 (145)	21 (60)	1.47	1.01 – 2.13	
Whole body vibration (ref=not at all/rarely)	71 (592)	62 (179)			0.01
Occasionally/frequently	21 (175)	23 (67)	1.08	0.77 – 1.54	
Constantly	8 (64)	15 (44)	1.94	1.25 – 3.00	
Physical demands (ref=sedentary/light)	23 (191)	17 (49)			0.02
Medium	34 (281)	31 (89)	1.20	0.81 – 1.79	
Heavy	22 (186)	26 (74)	1.45	0.95 – 2.22	
Very heavy	20 (168)	27 (78)	1.70	1.11 – 2.60	
Fast pace (ref=strongly disagree/disagree)	27 (229)	21 (61)			0.04
Agree	40 (336)	41 (120)	1.36	0.95 – 1.94	
Strongly agree	32 (265)	37 (108)	1.66	1.14 – 2.40	
Excessive amount of work (ref=strongly disagree/disagree)	49 (409)	41 (120)			0.01
Strongly agree/agree	50 (417)	58 (168)	1.45	1.10 – 1.92	
Pain and function					
Number pain sites (ref=0-2 sites)	53 (445)	45 (131)			0.01
3 – 4 sites	34 (287)	40 (115)	1.43	1.06 – 1.92	
5 – 8 sites	12 (101)	15 (44)	1.70	1.12 – 2.58	
Pain intensity, past week (0=no pain, ref=0-3)[34]	31 (257)	25 (72)			0.08
4 – 5	27 (228)	28 (81)	1.36	0.94 – 1.96	
6 – 7	24 (199)	28 (81)	1.59	1.10 – 2.32	
8 – 10	18 (149)	19 (56)	1.49	0.99 – 2.25	
Roland questionnaire € (0=no disability) (ref=0-8)[19]	34 (287)	28 (81)			0.04
9 – 16	36 (301)	37 (108)	1.33	0.95 – 1.85	

17 – 24	29 (245)	35 (101)	1.55	1.10 – 2.20	
SF-36 v2 Physical Function ¶ (ref=>50)[24]	29 (244)	22 (65)			0.03
41 – 50	20 (168)	22 (64)	1.43	0.96 – 2.14	
30 – 40	25 (206)	31 (90)	1.75	1.20 – 2.55	
< 30	26 (215)	24 (71)	1.31	0.89 – 1.94	
SF-36 v2 Role Physical ¶ (ref=>50)[24]	27 (223)	21 (60)			0.10
41 – 50	20 (168)	19 (56)	1.29	0.85 – 1.97	
30 – 40	23 (192)	29 (83)	1.62	1.10 – 2.39	
< 30	30 (250)	31 (91)	1.38	0.95 – 2.02	
Clinical status					
Previous similar back injury (ref=no)	57 (471)	42 (122)			< 0.01
Yes	43 (362)	58 (168)	1.73	1.31 – 2.29	
Previous injury (any type) with ≥ 1 month off work (ref=no)	78 (646)	69 (200)			0.01
Yes	22 (184)	31 (89)	1.51	1.11 – 2.06	
Number of self-reported worker's compensation claims before current injury (ref=0)	42 (349)	29 (83)			< 0.01
1	30 (253)	28 (82)	1.33	0.93 – 1.89	
2 – 3	13 (161)	25 (73)	1.77	1.21 – 2.58	
≥ 4	8 (64)	17 (50)	2.99	1.90 – 4.71	
Work days missed because of other health problems, previous year (ref=0)	40 (333)	37 (106)			0.05
1 – 10	50 (418)	58 (167)	1.34	1.01 – 1.79	
> 10	8 (66)	5 (14)	0.74	0.40 – 1.38	
Health care					
Health insurance (ref=yes)	72 (596)	81 (236)			< 0.01
No	28 (236)	19 (54)	0.59	0.42 – 0.82	
Administrative/legal (None significant)					
Health behavior					
Body Mass Index (BMI) (ref=<25)	28 (235)	30 (86)			0.03
25 – 29 (overweight)	37 (312)	44 (129)	1.01	0.73 – 1.41	
≥ 30 (obese)	34 (286)	26 (75)	0.67	0.47 – 0.96	
Psychological					
Blame for injury[35] (ref=work)	46 (380)	53 (155)			0.06
Self	23 (190)	19 (54)	0.67	0.47 – 0.95	
Someone/something else	15(124)	16 (45)	0.65	0.42 – 1.00	
Nothing/no one	14 (118)	11 (33)	0.90	0.61 – 1.34	
Work fear-avoidance (ref= <3, very low) ◊◊	24 (203)	11 (33)			< 0.01
Low-moderate (>3 – <5)	33(272)	38 (109)	2.49	1.62 – 3.84	
High (5 – 6)	43 (358)	51 (148)	2.63	1.73 – 4.00	
SF-36 v2 Mental Health ¶ (ref=>50)[24]	45 (371)	39 (114)			0.06
41 – 50	23 (194)	30 (87)	1.49	1.07 – 2.08	
≤ 40	32 (268)	31 (89)	1.11	0.80 – 1.54	

Missing, “don’t know,” and refusal responses for each variable were combined into one response for each variable (results not shown)

^ Odds ratios for all variables except age and gender were adjusted for age and gender

€ Roland-Morris Disability Questionnaire[19 – 21]

¶ Short-Form-36 version 2 (SF-36v2) Physical Function, Role Physical, and Mental Health scales; higher scores indicate better functioning.[24]

◊◊ Mean of responses to two questions from the Fear-Avoidance Beliefs Questionnaire work scale[23]

Table 2. Multivariate Model Predicting Occupational Back Re-Injury by One Year from Baseline Variables

Baseline Predictor	Bivariate Analyses		Multivariate Analysis		P-Value
	OR	95% CI	OR	95% CI	
Age, yr (ref = 35 – 44)					
≤ 24	0.53	0.29 – 0.95	0.67	0.35 – 1.28	0.23
25 – 34	1.13	0.79 – 1.62	1.35	0.90 – 2.01	0.14
45 – 54	1.05	0.74 – 1.49	1.12	0.76 – 1.66	0.57
≥ 55	0.85	0.52 – 1.38	1.01	0.59 – 1.74	0.97
Gender (ref = males)					
Females	0.60	0.47 – 0.81	0.68	0.47 – 0.99	0.04
Race/ethnicity (ref = white non-Hispanic)					
Hispanic	0.64	0.41 – 0.99	1.01	0.60 – 1.69	0.98
Other	1.26	0.86 – 1.86	1.38	0.91 – 2.11	0.13
Heavy lifting (ref = not at all/rarely/ occasional)					
Frequent	1.46	1.07 – 1.97	1.36	0.94 – 1.98	0.11
Constant	1.47	1.01 – 2.13	1.10	0.69 – 1.76	0.68
Whole body vibration (ref = not at all/rarely / occasional)					
Frequent	1.08	0.77 – 1.54	0.89	0.61 – 1.30	0.54
Constant	1.94	1.25 – 3.00	1.66	1.02 – 2.69	0.04
Physical demands of job (ref = sedentary/ light)					
Medium	1.20	0.81 – 1.79	0.94	0.60 – 1.48	0.79
Heavy	1.45	0.95 – 2.22	0.94	0.55 – 1.59	0.82
Very heavy	1.70	1.11 – 2.60	1.14	0.66 – 1.98	0.64
Fast pace (ref = strongly disagree / disagree)					
Agree	1.36	0.95 – 1.94	1.19	0.80 – 1.79	0.39
Strongly agree	1.66	1.14 – 2.40	1.17	0.73 – 1.83	0.49
Excessive Amount of Work (ref = strongly disagree/disagree)					
Strongly agree/agree	1.45	1.10 – 1.92	1.11	0.79 – 1.55	0.55
Number of Pain Sites (ref = 0 – 2)					
3 – 4 sites	1.43	1.06 – 1.92	1.17	0.82 – 1.66	0.39
5 – 8 sites	1.70	1.12 – 2.58	1.34	0.82 – 2.20	0.25
Pain intensity, past week (ref=0 – 3, 0 = no pain)					
4 – 5	1.36	0.94 – 1.96	1.00	0.65 – 1.55	1.00

6 – 7	1.59	1.10 – 2.32	1.30	0.81 – 2.09	0.28
8 – 10	1.49	0.99 – 2.25	1.21	0.71 – 2.06	0.49
Roland disability score (ref = 0 – 8)					
9 – 16	1.33	0.95 – 1.85	0.95	0.58 – 1.56	0.85
17 – 24	1.55	1.10 – 2.20	1.36	0.72 – 2.57	0.34
SF-36 v2 Physical Function (ref=>50)					
41 – 50	1.43	0.96 – 2.14	1.08	0.66 – 1.78	0.76
30 – 40	1.75	1.20 – 2.55	1.16	0.65 – 2.06	0.61
< 30	1.31	0.89 – 1.94	0.79	0.40 – 1.53	0.48
SF-36 v2 Role Physical (ref=>50)					
41 – 50	1.29	0.85 – 1.97	1.10	0.65 – 1.85	0.73
30 – 40	1.62	1.10 – 2.39	1.16	0.63 – 2.12	0.63
< 30	1.38	0.95 – 2.02	0.87	0.45 – 1.69	0.68
Previous similar back injury (ref=no)					
Yes	1.73	1.31 – 2.29	1.47	1.06 – 2.02	0.02
Previous injury (any type) with ≥ 1 month off work (ref=no)					
Yes	1.51	1.11 – 2.06	1.14	0.80 – 1.64	0.46
Number of self-reported worker's compensation claims before this initial injury (ref = 0)					
1	1.33	0.93 – 1.89	1.02	0.69 – 1.52	0.92
2 – 3	1.77	1.21 – 2.58	1.32	0.85 – 2.06	0.22
> 3	2.99	1.90 – 4.71	2.29	1.34 – 3.92	< 0.01
Work days missed because of other problems, previous year (ref = 0)					
1 – 10	1.34	1.01 – 1.79	1.21	0.88 – 1.66	0.24
> 10	0.74	0.40 – 1.38	0.52	0.26 – 1.01	0.06
Health insurance (ref = yes)					
No	0.59	0.42 – 0.82	0.62	0.43 – 0.89	0.01
Body Mass Index (BMI) (ref = <25)					
25-29	1.01	0.73 – 1.41	0.93	0.65 – 1.33	0.70
≥ 30	0.67	0.47 – 0.96	0.59	0.40 – 0.88	0.01
Blame for injury (ref = work)					
Self	0.67	0.46 – 0.95	0.78	0.52 – 1.15	0.21
Someone / something	0.90	0.61 – 1.34	0.93	0.61 – 1.42	0.75

else					
No one / nothing	0.65	0.42 – 1.00	0.75	0.47 – 1.22	0.25
Fear-avoidance [ref = <3 (very low)]					
Low-moderate (>3 - <5)	2.49	1.62 – 3.84	2.03	1.27 – 3.23	< 0.01
High (5 – 6)	2.63	1.73 – 4.00	1.84	1.13 – 2.99	0.01
SF-36 v2 Mental Health (ref = >50)					
41 – 50	1.49	1.07 – 2.08	1.27	0.87 – 1.85	0.22
≤ 40	1.11	0.80 – 1.54	0.92	0.61 – 1.40	0.70

Missing, “don’t know,” and refusal responses for each variable were combined into one response for each variable (results not shown)

Each baseline variable included in this table was associated (P < 0.10) in bivariate analyses with occupational back re-injury by one year of initial occupational back injury

Ref indicates reference group

*Adjusted only for age and gender. The age and gender variables were unadjusted.

^Adjusted for all other variables in the multivariate model

Table 3. Non-Significant Bivariate Associations (P > 0.10) of Baseline Variables with Occupational Back Re-Injury by One Year After Initial Occupational Back Injury

Domain and variables	Not re-injured N=833 % (n)	Re-injured N=290 % (n)	Odds ratio^	95% CI	P-value
Sociodemographic					
Age, years (ref= 35-44 years)	30 (250)	31 (89)			0.16
≤24 years	10 (85)	6 (16)	0.53	0.29 – 0.95	
25 – 34 years	23 (191)	27 (77)	1.13	0.79 – 1.62	
45 – 54 years	26 (214)	28 (80)	1.05	0.74 – 1.49	
≥ 55 years	11 (93)	10 (28)	0.85	0.52 – 1.38	
Region of worker residence † (ref=urban)	58 (481)	59 (171)			0.92
Suburban	17 (139)	15 (44)	0.89	0.61 – 1.32	
Large town	12 (100)	12 (34)	0.97	0.63 – 1.49	
Rural	11 (92)	10 (29)	0.89	0.57 – 1.41	
Education (ref=high school)	33 (273)	28 (80)			0.46
Less than high school	10 (84)	11 (31)	1.19	0.73 – 1.94	
Vocational or some college	46 (387)	50 (145)	1.27	0.93 – 1.75	
College	11 (89)	12 (34)	1.33	0.83 – 2.13	
Marital status (ref=married/living with partner)	68 (565)	71 (207)			0.65
Other	32 (268)	29 (83)	0.93	0.69 – 1.26	
Employment-related					
Worker's Employer size (ref=>200 employees)	23 (195)	26 (74)			0.37
76 – 200 employees	21 (173)	15 (43)	0.63	0.41 – 0.98	
26 – 75 employees	22 (180)	23 (67)	0.92	0.62 – 1.37	
11 – 25 employees	16 (134)	18 (51)	0.89	0.58 – 1.36	
1 – 10 employees	18 (148)	18 (53)	0.82	0.54 – 1.26	
Worker's industry ‡ (ref=trade/transportation)	24 (197)	29 (85)			0.80
Natural resources	5 (41)	4 (13)	0.69	0.35 – 1.36	
Construction	15 (128)	17 (49)	0.82	0.54 – 1.25	
Manufacturing	7 (55)	8 (22)	0.90	0.51 – 1.57	
Management	19 (158)	17 (49)	0.73	0.48 – 1.10	
Education and health	18 (148)	14 (41)	0.84	0.53 – 1.35	
Hospitality	13 (106)	11 (31)	0.78	0.48 – 1.27	
Worker's description of job in following variables					
Enough time to do job (ref=Strongly agree/agree)	26 (216)	30 (87)			0.11
Strongly disagree/disagree	74 (617)	70 (203)	0.79	0.58 – 1.06	
Very hectic (ref=Strongly disagree/disagree)	28 (232)	29 (85)			0.29
Agree	46 (385)	44 (127)	0.94	0.68 – 1.30	
Strongly agree	26 (213)	27 (78)	1.16	0.80 – 1.68	

Able to take breaks when desired (ref=Strongly disagree/disagree)	50 (416)	51 (148)			0.39
Strongly agree/agree	50 (417)	49 (142)	0.89	0.68 – 1.17	
Supervisor listens to my work problems (ref=agree)	58 (481)	58 (168)			0.32
Strongly disagree/disagree	18 (153)	16 (47)	0.93	0.64 – 1.37	
Strongly agree	23 (193)	24 (69)	1.08	0.78 – 1.50	
Satisfaction with job (ref=Somewhat or very satisfied)	87 (724)	89 (257)			0.68
Not at all or not too satisfied	13 (109)	11 (33)	0.92	0.60 – 1.40	
Co-worker relations (0 – 10 scale, ref=10, get along extremely well)	52 (434)	48 (139)			0.50
9	19 (156)	18 (52)	1.03	0.71 – 1.50	
8	19 (159)	21 (61)	1.18	0.83 – 1.68	
0 – 7	9 (78)	13 (37)	1.42	0.91 – 2.21	
Job type at time of injury (ref=full-time) Part-time	91 (755)	94 (274)			0.23
Part-time	9 (77)	6 (16)	0.71	0.41 – 1.24	
Seasonal job at injury (ref=no)	94 (786)	96 (278)			0.70
Yes	6 (47)	4 (11)	1.07	0.75 – 1.53	
Temporary job at injury (ref=no)	94 (783)	97 (280)			0.13
Yes	6 (47)	3 (10)	0.59	0.30 – 1.16	
Job duration ≥ 6 months	81 (673)	82 (237)			0.98
< 6 months	19 (160)	18 (53)	1.00	0.70 – 1.43	
Employer offered job accommodation (ref=Yes)	52 (432)	48 (139)			0.46
No	47(394)	51 (148)	1.11	0.84 – 1.45	
Pain and function					
Pain interference with daily activities, past week (0=no interference, ref=0-3)[34]	39 (328)	32 (93)			0.13
4 – 5	22 (185)	28 (80)	1.58	1.11 – 2.24	
6 – 7	17 (145)	18 (52)	1.28	0.86 – 1.91	
8 – 10	21 (172)	22 (63)	1.35	0.93 – 1.98	
Pain interference with work, past week (0=no interference, ref=0-3)[34]	41 (341)	38 (109)			0.33
4 – 5	18 (151)	20 (59)	1.26	0.86 – 1.83	
6 – 7	18 (149)	15 (44)	0.92	0.62 – 1.38	
8 – 10	23 (189)	26 (76)	1.32	0.93 – 1.88	
Pain change since injury (ref=better)	74 (613)	75 (218)			0.60
Same	17 (139)	17 (49)	1.03	0.71 – 1.48	
Worse	9 (76)	7 (20)	0.77	0.46 – 1.31	
Clinical status					
Injury severity †† (ref=mild strain/sprain)[16]	57 (476)	60 (174)			0.73
Major strain/sprain with substantial	20 (164)	20 (58)	0.99	0.70 – 1.40	

immobility but no evidence of radiculopathy					
Evidence of radiculopathy or abnormalities	23 (188)	19 (56)	0.82	0.58 – 1.17	
Pain radiates below knee (ref=no)	75 (627)	77 (222)			0.74
Yes	25 (206)	23 (68)	0.95	0.69 – 1.30	
Work days missed because of back, previous year (ref=0)	68 (570)	64 (185)			0.14
1 – 10	22 (185)	24 (71)	1.22	0.88 – 1.69	
> 10	9 (71)	9 (27)	1.16	0.72 – 1.86	
Number other major medical problems (ref=0)	82 (687)	87 (251)			0.15
≥ 1	17 (145)	13 (39)	0.75	0.50 – 1.11	
Current health aside from injury (ref=excellent)	17 (143)	23 (68)			0.21
Very good	39 (325)	37 (106)	0.68	0.47 – 0.98	
Good	33 (275)	30 (87)	0.66	0.45 – 0.97	
Fair/poor	11 (89)	10 (28)	0.68	0.40 – 1.14	
General health, year prior to injury (ref=excellent)	20 (167)	27 (78)			0.16
Very good	40 (330)	36 (105)	0.67	0.47 – 0.95	
Good	31 (259)	30 (86)	0.70	0.48 – 1.01	
Fair/poor	9 (76)	7 (20)	0.61	0.34 – 1.07	
Health care					
Specialty, first provider seen for injury ◊ (ref=primary care)	38 (314)	38 (110)			0.92
Occupational medicine	5 (43)	6 (16)	1.01	0.54 – 1.88	
Chiropractor	30 (251)	32 (92)	1.01	0.73 – 1.41	
Other	27 (225)	25 (72)	0.90	0.64 – 1.28	
Health care provider recommended exercise (ref=yes)	71 (593)	72 (208)			0.98
No	29 (238)	28 (82)	0.98	0.74 – 1.35	
Health care provider discussed ways to prevent further injury (ref=yes)	61 (509)	66 (191)			0.18
No	39 (322)	33 (97)	0.80	0.60 – 1.06	
Administrative/legal					
Time from injury to first medical visit for injury ◊ (ref=0-6 days)	77 (644)	77 (224)			0.53
7 – 13 days	11 (90)	13 (38)	1.17	0.78 – 1.77	
≥ 14 days	9 (74)	8 (22)	0.83	0.50 – 1.37	
Health behavior					
Tobacco use (ref=no)	55 (462)	57 (164)			0.73
Yes (occasionally/frequently/daily)	44 (370)	43 (126)	0.95	0.73 – 1.25	
Alcohol Use Disorder Identification Test-Consumption (AUDIT-C)^^ (ref=negative) (AUDIT-C score of 0 – 3 for males, 0 – 2 for females)[25]	71 (591)	69 (200)			0.53

Positive (4 – 12 for males, 3 – 12 for females)	29 (242)	31 (90)	1.10	0.82 – 1.48	
Psychological					
Catastrophizing ‡‡ (ref=0-1)	34 (285)	35 (101)			0.16
Low (>1 – <2)	18 (150)	13 (39)	0.76	0.50 – 1.16	
Moderate (2 – <3)	29 (240)	29 (85)	1.03	0.74 – 1.45	
High (3 – 4)	19 (158)	22 (65)	1.30	0.89 – 1.90	
Recovery expectations[35] (0-10 scale, 10 = extremely certain will be working in 6 months, ref=10)	63 (528)	64 (185)			0.91
Low (0 – 6)	17 (143)	18 (52)	1.03	0.72 – 1.48	
High (7 – 9)	19 (162)	18 (53)	0.94	0.66 – 1.34	

Each baseline variable included in this table was associated (P < 0.10) in bivariate analyses with occupational back re-injury by one year of initial occupational back injury

Ref indicates reference group

^ Odds ratios for all variables except age and gender were adjusted for age and gender

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

‡ Derived from standard industrial codes (SIC)

¶ Short-Form-36 version 2 (SF-36v2) Physical Function, Role Physical, and Mental Health scales; higher scores indicate better functioning[24]

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

◊ From workers' compensation database

^^ The AUDIT-C score is a screening test for problematic alcohol usage[25]

‡‡ Mean of responses to three questions from the Pain Catastrophizing scale[22]

Clinically Significant Weight Gain One Year After Occupational Back Injury

Objective: To examine the incidence of clinically significant weight gain one year after occupational back injury, and risk factors for that gain.

Methods: A cohort of Washington State workers with wage-replacement benefits for back injuries completed baseline and 1-year follow-up telephone interviews. We obtained additional measures from claims and medical records.

Results: Among 1,263 workers, 174 (13.8%) reported clinically significant weight gain (≥7%) 1 year after occupational back injury. Women and workers who had >180 days on wage replacement at 1 year were twice as likely (adjusted OR=2.17, 95% CI=1.54–3.07; adjusted OR=2.40, 95% CI=1.63–3.53, respectively; both P<0.001) to have clinically significant weight gain.

Conclusions: Women and workers on wage replacement >180 days may be susceptible to clinically significant weight gain following occupational back injury.

Introduction

The dangers of obesity to general health and specific diseases are well-known. Obesity is strongly associated with a shorter lifespan, lower quality of life, and higher rates of cardiovascular disease, various cancers, and type-II diabetes.[1] In occupational settings, rates of back injury and increased workers' compensation costs are also associated with obesity, as are overall rates of occupational injury, lower worker productivity, and reporting of non-injury back pain.[2-5] Being overweight or obese is also associated with more workers' compensation claims, more lost workdays, higher medical claims costs, and higher indemnity claims costs.[4,6] Self-reported need for mental health services is associated with weight gain among injured workers.[7] Although much is known about obesity's impact on back injuries and workers' compensation, little is known about the extent of weight gain among injured workers or about the early predictors of weight gain.

We conducted an exploratory study, using a sample of workers with wage-replacement claims (at least one day of temporary total disability wage replacement) for work-related back injuries, to determine the incidence of clinically significant weight gain 1 year after occupational back injury. We expected that a subset of workers might gain a clinically significant amount of weight after injury (e.g., due to decreased physical activity and more time at home engaged in sedentary activities). If risk factors for such weight gain could be identified early after injury and before weight gain, preventive interventions might be developed. Therefore, a second objective of the study was to identify early predictors of clinically significant weight gain and develop an exploratory multivariate predictive model for weight gain. Finally, we explored the association of clinically significant weight gain with receipt of wage replacement (time-loss) benefits at 1 year after injury. We hypothesized that extended receipt of wage replacement benefits would be associated positively with weight gain. Based on previous research, we hypothesized that the following baseline variables would predict clinically significant weight gain 1 year after occupational back injury: higher baseline body mass index (BMI), greater injury severity, higher baseline pain and disability levels, lower work physical demands, greater worker fear-avoidance and worse mental health, lower education attainment, poor overall health status, an opioid prescription within 6 weeks after seeing a provider for the back injury, not using tobacco, and not returning to work by the baseline interview.[1,3,4,7-10,12-24]

Methods

Sample

We used the Washington State Workers' Compensation Disability Risk Identification Study Cohort (D-RISC)[9] data to examine the prevalence of overweight and obesity at the time of injury, the incidence of clinically significant weight gain in the year after injury, and early predictors of weight gain 1 year after occupational back injury. In D-RISC, potential risk factors for chronic disability were assessed in domains of interest that were used previously for occupational injury research.[8-11] Eight domains (sociodemographic, employment-related, pain and function, clinical, health care, administrative/legal, health behavior, and psychological)[8] were assessed in baseline telephone interviews with workers with recent back injuries.

D-RISC was a prospective, population-based study that recruited Washington State Workers Compensation State Fund workers from June 2002 through April 2004 with accepted and provisional claims for occupational back injuries. Weekly claims review identified workers who missed at least 4 days from work and received wage replacement benefits (temporary total disability). Approximately two-thirds of the non-federal Washington workforce is covered by the State Fund. The remaining third are covered by large, self-insured companies and were not included due to insufficient administrative data.

In D-RISC, from the claims database, 4,354 workers were identified. Of those, 1178 (27.1%) could not be contacted, 909 (20.9%) declined enrollment, and 120 (2.8%) were ineligible.[9] The remaining 2,147 (49.3%) were enrolled in D-RISC and completed baseline interviews. Persons were later excluded from the analysis sample if they were not eligible for wage-replacement benefits in the first year after claim submission (n=240), were hospitalized for the injury (n=16), were missing information on age (n=3) or were not confirmed to have a back injury upon medical review (n=3).[9] Hence, 1,885 (43.3%) were included in D-RISC. Of the 1,885, 1,319 participants completed the follow-up interview approximately 1 year after claim receipt and 1,269 (96.2%) participants reported their weight during both interviews.

Upon inspection of the data, 16 participants had very large weight changes after 1 year (≥ 50 lbs). From additional administrative records, we were able to obtain other data on weight for 3 of the 16 participants, and used these data in the analyses. We excluded 6 of the 16 participants from analysis due to inconsistencies between self-report and clinical data that could not be reconciled. The self-reported and clinical data of the remaining 7 participants, among the 16, were very similar and the original self-reported weights were retained in the data, creating a final analysis sample of 1,263 participants.

The analysis sample was slightly older [mean age (SD) 40.3 (11.1) vs. 37.5 (11.2) years, $P < 0.001$], had fewer workers of Hispanic ethnicity (14% vs. 21%, $P = 0.008$), was more educated (less than high school 11% vs. 19%, $P < 0.001$), was more likely to be married or living with a partner (68% vs. 57%, $P < 0.001$), and contained more workers with general health insurance (72% vs. 60%, $P < 0.001$), as compared to the 622 persons who did not complete the follow-up survey or were excluded due to problematic weight data.

Measures

Study participants completed structured telephone interviews at baseline and at 1 year. Workers were asked their current weight in both interviews. The baseline interview also asked for participant height, which was used to determine baseline BMI (weight in pounds divided by (height in inches^2 x 703)).[25] Baseline measures for the current study were a subset of those obtained in the larger study, with selection based upon prior research pertaining to occupational injury, BMI, and weight and weight change. Additional data were obtained from the Washington State Department of Labor and Industries (DLI) claims database, including the region of the worker's residence, the worker's type of industry, the specialty of the first provider seen for the injury, and the number of days between the injury and the first medical visit for the injury. Additionally, medical record review by trained occupational nurses, with substantial inter-rater reliability, was used to determine injury severity.[11] (See Tables 4 and 7 for more information about the measures.)

A weight gain at one year of at least 7% of baseline weight was used as a measure of clinically significant weight change.[14, 16 – 18] Definitions of clinically significant weight change are not consistent in the literature. Weight changes of any,[7] 3%,[27] and 5% have also been used,[12, 13, 28] but we chose the more conservative measure of a 7% gain.

To test our hypothesis that weight gain was associated with receiving wage replacement benefits at one year after claim submission, we used a measure of wage replacement receipt obtained from administrative records that corresponded to a similar timeline as our weight change measure: whether or not workers were receiving wage replacement benefits 365 days after the date the claim was received by DLI. Additionally, we categorized the accumulated days on wage replacement by 1 year after claim receipt (1 – 29, 30 – 89, 90 – 179, 180+ days) to determine if there was a dose-response relationship with clinically significant weight gain.

Statistical Analyses

We first conducted bivariate logistic regression analyses to examine associations between baseline variables of interest in each domain and clinically significant weight change, adjusted by age and gender. Missing, "don't know," and refusal responses for each variable were combined into one response and included in the analysis. Variables with the most missing data included time from the date of injury to the first medical visit (n=36), region of worker residence (35), paid bill for an opioid prescription within 6 weeks of the first medical visit for the injury (33), recovery expectations (29), source of blame for the injury (26), days of work missed due to non-back health problems in the previous year (23), days of work missed due to back problems in the previous year (18), worker self-report of whether his/her supervisor listens to work-related problems (17), worker self-report of whether the employer had offered job accommodations to allow him/her to work (16), worker self-report of number of previous worker's compensation claims (11), and worker self-report of change in pain since the injury (11).

Next, we created a multivariate logistic regression model predicting clinically significant weight gain (yes/no). We entered as independent variables all baseline variables with P-values < 0.10 in the bivariate analysis, along with age and gender. A standard 0.05 P-value for determining statistical significance of bivariate associations may exclude variables that might be significant in a multivariate model.[29] Analyses were conducted with Stata Version 10.[30]

Results

Sample Characteristics

The sample of workers (N=1,263) was mostly non-Hispanic White (73%; 14% Hispanic; 14% other) and male (69%). At the baseline interview, 29.7% of the study participants were of normal weight (BMI < 25), 40.0% were overweight (25 ≤ BMI ≤ 30), and 30.3% were obese (BMI > 30). At one year, 174 (13.8%) participants self-reported weight that represented clinically significant (7%) weight gain from baseline and 103 (8.2%) participants gained more than 10% of their baseline weight. Sixty-two participants went from normal to overweight status, 66 went from overweight to obese, and 1 participant went from normal weight to obese, for a total of 129 (10.2%) participants with an increase in BMI category by 1 year.

Baseline predictors of weight gain in bivariate analyses

Table 4 shows the variables associated with clinically significant weight gain in the bivariate analyses. Six of 8 domains contained variables associated ($P < 0.10$) with weight gain. These included female gender (sociodemographics), having a fast-paced work environment prior to injury and not returning to work by the baseline interview (employment-related). The pain and function domain contained one predictor: activity interference due to pain was associated positively with weight gain. Worse current health, aside from injury, was the only predictor of weight gain in the clinical status domain. In the health care domain, weight gain was associated with the specialty of the first health care provider seen for the injury (occupational medicine specialist relative to primary care provider). Three variables were identified in the psychological domain: greater catastrophizing, poorer SF-36[40] Mental Health scale scores, and lower recovery expectations for the back injury were associated with weight gain. No factors from the administrative/legal or health behavior domains were associated with weight gain. Variables that were not associated with weight gain are listed in Table 7; these include baseline BMI, injury severity, physical demands at work, fear-avoidance, education, opioid prescription for the injury, and tobacco use status.

Multivariate model predicting weight gain

Table 5 shows results from the multivariate model that included age and the 9 variables that were associated ($P < 0.10$) bivariately with clinically significant weight gain. Gender was the only significant predictor of clinically significant weight gain. Women had approximately twice the odds of weight gain, as compared to men (adjusted OR = 2.17, 95% CI 1.54 – 3.07).

Association of receiving wage replacement compensation with weight gain at one year

Receipt of wage replacement compensation at one year (189 of 1,263 participants) was associated with clinically significant weight gain after adjustment for age and gender (adjusted OR for receipt of wage replacement versus no wage replacement at one year = 2.24, 95% CI 1.51 – 3.33, $P < 0.001$; Table 6). Almost 25% of participants on wage replacement at 1 year after the injury had clinically significant weight gain, while 13.4% of those not receiving wage replacement compensation at 1 year gained significant weight. In the analysis examining categories of days on wage replacement, adjusting for age and gender, only wage replacement for more than 180 days was associated with clinically significant weight gain, compared to 1 – 29 days (adjusted OR 2.40, 95% 1.63 – 3.53, overall $P < 0.001$).

Discussion

To our knowledge, this is the first prospective study to examine the incidence and predictors of clinically significant weight gain after an occupational injury. Almost 14% of participants reported weight gain at 1 year of at least 7% of baseline weight. Female gender was the only significant early predictor. Additionally, receiving wage-replacement benefits at 1 year was highly associated with clinically significant weight gain.

In this sample, accrued from 2002 – 2004, the baseline distribution of workers in different BMI categories (29.7% normal weight, 40.0% overweight, 30.3% obese) was fairly similar to that in the 2000 general U.S. population (35.5%, 34%, and 30.5%, respectively).[31] The men in our sample had a slightly higher rate of obesity as compared to the national sample (29.7% versus 27.7%), whereas the women were less likely to be obese (31.5% versus 34.0%).

The mean weight change of a 1.44 pound increase over 1 year in our sample was within the range of mean weight change in 1 year reported in previous studies of the American adult population (0.4 to 1.8 pound increases).[27,32–37] In one study of a racially and socioeconomically diverse sample, fewer than 10% of participants gained more than 3% of their body weight in 1 year, compared to 14% of participants gaining more than 7% of their body weight in our sample of injured workers.[27] In our data, men had an overall mean weight change of a 0.93 pound increase (SD 13.52) while women had a mean increase of 1.78 pounds (SD 14.4); these differences in overall weight change were not statistically significant (P = 0.31). One other study reported mean weight change separately by men and women over 1 year; those authors also found no statistical differences.[27]

Female gender was the only predictor of clinically significant weight gain. Other studies have noted that women in the United States have a higher prevalence of obesity, overweight, and weight gain compared to men.[27,49,50] However, one study noted that adult women appear to be leveling off for overweight and obesity prevalence, while adult men are still increasing yearly.[50] Of note, we were unable to discern pregnancy status in our data; one study noted that pregnancy status contributes to weight misreporting.[51]

Low recovery expectations (less certainty that he/she will be working in six months) at the baseline interview was associated significantly with clinically significant weight gain in bivariate analyses, but not statistically significant in the multivariate model. Low recovery expectations have been previously shown in this sample and in other studies to predict several outcomes of occupational back injury, including slower claim closure, slower end of payment benefits, and still being on disability leave after 6 months.[10, 52] Recovery expectations may have been associated with weight gain in our study, at least in part, due to its association with being off work for a longer period of time, which we found to be strongly associated with weight gain.

Self-reported poor or fair health, apart from the back injury, was associated with weight gain in bivariate analyses, but not in the multivariate model. Worse self-reported health has been associated with high BMI scores and weight gain in multiple studies.[53–55] Worse overall health may be associated with less physical activity, which may lead to weight gain.[56] In addition, worse health may be associated with greater use of medications that may cause weight gain.[53,57] These associations warrant study in further research.

Our work includes significant limitations. First, our outcome of weight gain is based upon two self-reported weights. Self-reported weight may not be accurate. However, in previous studies, participants appeared to misreport consistently, making multiple measures over time by an individual feasible to use in weight change research.[51,58–61] Additionally, persons who are already overweight or obese may underreport their weight compared to persons of normal weight. [58,59] A model including age, gender, and pregnancy status has been suggested as a method to adjust for weight misreporting;[51] age and gender were both included in our multivariate model. Another limitation is that our weight gain outcome is binary: whether the participant did or did not gain 7% of baseline body weight 1 year after occupational back injury. We did not assess weight trends among our sample in years prior to the injury. However, 7% weight gain is a marker for clinically significant weight change.[14,16–18] Additionally, we were unable to include in our analysis some key known correlates of weight gain, such as diet, exercise, and social support status.[62,63] We may also have sample selection bias; people who did not report their weight and thus were excluded from the study (n=50) may differ in important ways from those who reported their weight. If participants gained weight after the injury but before the baseline interview, we may be underestimating the proportion who gained clinically significant weight and thus underestimating some associations. Lastly, 30.0% of the D-RISC participants did not complete the 1-year follow-up interview, and we do not know whether results would have differed had weight at 1 year been available for the entire sample. We emphasize the exploratory nature of the analyses and the need to replicate findings in other samples.

This study has several strengths. These include a large, prospective, population-based sample in Washington State. We utilized different data sources (two telephone surveys, administrative data, and medical record review) for our variables among eight domains of interest. Our study is the first, to our knowledge, to explore variables associated with clinically significant weight gain in a cohort of workers with back injuries.

In sum, female workers with occupational back injuries were twice as likely as males to have clinically significant weight gain in the year after injury. In addition, receiving wage-replacement benefits 1 year after injury was associated with clinically significant weight gain. Approximately 10.8% of men and 20.3% of women in our sample gained a clinically significant amount of weight following an occupational back injury, possibly resulting in decreased quality of life, increased susceptibility to weight-influenced medical conditions, and increased medical costs. Factors influencing weight gain and obesity are multi-faceted and complex. Increasing our knowledge of weight gain may inform future interventions for preventing weight gain after occupational back injury.

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Table 4. Baseline Variables Associated Bivariately (P < 0.10) with Clinically Significant Weight Gain (7%) One Year after Baseline Interview

Domain and variables	No significant weight gain n=1089 (%)	Significant weight gain n=174 (%)	Odds ratio^	95% CI	P-value
Sociodemographic					
Gender (ref=male)	775 (89.2)	94 (10.8)			< 0.001
Female	314 (79.7)	80 (20.3)	2.10	1.52 – 2.91	
Employment-related					
Fast pace (ref=strongly disagree/disagree)	277 (89.9)	31 (10.1)			0.09
Agree	441 (86.5)	69 (13.5)	1.34	0.85 – 2.13	
Strongly agree	366 (83.2)	74 (16.8)	1.57	0.99 – 2.48	
Returned to paid work by baseline interview (ref=Yes, same job)	365 (88.6)	47 (11.4)			0.02
Yes, light duty or different job	293 (88.0)	40 (12.0)	1.02	0.65 – 1.61	
No	431 (83.2)	87 (16.8)	1.61	1.09 – 2.37	
Pain and function					
Pain interference with daily activities, past week (0=no interference, ref=0-3)[40]	379 (88.8)	48 (11.2)			0.04
4 – 5	250 (88.3)	33 (11.7)	1.06	0.66 – 1.70	
6 – 7	188 (81.7)	42 (18.3)	1.75	1.11 – 2.76	
8 – 10	270 (84.6)	49 (15.4)	1.40	0.90 – 2.18	
Clinical status					
Current health aside from injury (ref=excellent)	219 (89.0)	27 (11.0)			0.01
Very good	424 (88.1)	57 (11.9)	1.08	0.66 – 1.76	
Good	336 (84.4)	62 (15.6)	1.45	0.89 – 2.37	
Fair/poor	110 (80.3)	27 (19.7)	1.90	1.06 – 3.43	
Health care					
Specialty, first provider seen for injury ◊ (ref=primary care)	412 (88.2)	55 (11.8)			0.095
Occupational medicine	60 (78.9)	16 (21.1)	2.06	1.10 – 3.87	
Chiropractor	302 (84.6)	55 (15.4)	1.46	0.97 – 2.20	
Other	315 (86.8)	48 (13.2)	1.19	0.78 – 1.82	
Administrative/legal (No significant variables)					
Health behavior (No significant variables)					
Psychological					
Catastrophizing ‡‡ (ref=0-1)	352 (89.1)	43 (10.9)			0.06
Low (>1 – <2)	173 (85.2)	30 (14.8)	1.44	0.87 – 2.40	
Moderate (2 – <3)	334 (87.4)	48 (12.6)	1.13	0.72 – 1.76	
High (3 – 4)	230 (81.3)	53 (18.7)	1.78	1.14 – 2.78	
Recovery expectations[39] (0-10 scale, 10 = extremely certain will be working in 6 months, ref=10)	651 (88.8)	82 (11.2)			0.01

High (7 – 9)	215 (83.3)	43 (16.7)	1.61	1.08 – 2.42	
Low (0 – 6)	198 (81.5)	45 (18.5)	1.84	1.23 – 2.76	
SF-36 v2 Mental Health ¶ (ref=>50)[39]	449 (88.6)	58 (11.4)			0.07
41 – 50	275 (87.3)	40 (12.7)	1.09	0.70 – 1.68	
≤ 40	365 (82.8)	76 (17.2)	1.52	1.04 – 2.22	

All measures were obtained from worker baseline interviews unless stated otherwise

Missing, “don’t know,” and refusal responses for each variable were combined into one response for each variable (results not shown)

Ref indicates reference group.

^ All odds ratios were adjusted for age and gender, except for gender

¶ Score from the Short-Form-36 version 2 (SF-36v2) Mental Health scale; higher scores indicate better functioning[39]

◊ From worker’s compensation database

‡‡ Mean of responses to three questions from the Pain Catastrophizing scale[45]

Table 5. Multivariate Model Predicting Clinically Significant Weight Gain (7%) at One Year from Baseline Variables Associated Bivariately with Weight Gain

Baseline Predictor	Adjusted OR^	95% CI	P-value
Age, yr (ref = 35 – 44)			0.14
≤ 24	1.12	0.60 – 2.08	
25 – 34	1.41	0.91 – 2.19	
45 – 54	0.96	0.61 – 1.51	
≥ 55	0.59	0.29 – 1.21	
Gender (ref=male)			< 0.001
Female	2.17	1.54 – 3.07	
Fast pace (ref=strongly disagree /disagree)			0.40
Agree	1.20	0.75 – 1.92	
Strongly agree	1.43	0.89 – 2.30	
Return to paid work by baseline interview (ref=Yes, same job)			0.30
Yes, light duty or different job	1.00	0.62 – 1.60	
No	1.35	0.87 – 2.10	
Pain interference with daily activities, past week (0=no interference, ref=0-3)[39]			0.58
4 – 5	0.92	0.55 – 1.53	
6 – 7	1.29	0.75 – 2.21	
8 – 10	0.93	0.53 – 1.64	
Current health aside from injury (ref=excellent)			0.14
Very good	1.12	0.67 – 1.85	
Good	1.45	0.87 – 2.40	
Fair/poor	1.86	1.00 – 3.45	
Specialty, first provider seen for injury ◊ (ref=primary care)			0.15
Occupational medicine	1.85	0.97 – 3.53	
Chiropractor	1.43	0.94 – 2.18	
Other	1.08	0.70 – 1.67	
Catastrophizing ‡‡ (ref=0-1)			0.38
Low (>1 – <2)	1.29	0.76 – 2.21	
Moderate (2 – <3)	0.92	0.56 – 1.51	
High (3 – 4)	1.29	0.76 – 2.22	
Recovery expectations[32] (0-10 scale, ref=10, 10 = extremely certain will be working in 6 month)			0.08
High (7 – 9)	1.45	0.92 – 2.28	
Low (0 – 6)	1.53	1.00 – 2.33	
SF-36 v2 Mental Health (ref=>50)[39]			0.86
41 – 50	0.89	0.56 – 1.42	
≤ 40	0.99	0.62 – 1.57	

^Adjusted for all other variables in the multivariate model.

Each baseline variable included in this table was associated significantly (P < 0.10) in bivariate analyses with clinically significant weight gain by one year of initial occupational back injury. Age was included as an adjusting variable.

Missing, “don’t know,” and refusal responses for each variable were combined into one response for each variable (results not shown)

Ref indicates reference group.

Table 6. Associations of Clinically Significant Weight Gain (7%) at 1 Year and Wage Replacement Status by 1 Year after Occupational Back Injury, adjusted for age and gender

	Wage Replacement Status	# Persons (N=1,263)	Adjusted OR	95% CI	P-Values
At 1 Year	No	1,070			<0.001
	Yes	193	2.24	1.51 – 3.33	
By 1 Year	1 – 29 days	754			<0.001
	30 – 89 days	163	1.17	0.69 – 1.98	
	90 – 179 days	98	1.37	0.74 – 2.55	
	> 180 days	248	2.40	1.63 – 3.53	

Table 7. Non-Significant Bivariate Associations (P ≥ 0.10) of Baseline Variables with Clinically Significant Weight Gain (7%) by One Year after Initial Occupational Back Injury

Domain and variables	No significant weight gain N=1089	Significant weight gain N=174	Odds ratio^	95% CI	P-value
Sociodemographic					
Age, years (ref= 35-44 years)	339	53			0.14
≤24 years	94	17	1.16	0.64 – 2.09	
25 – 34 years	244	50	1.31	0.86 – 1.99	
45 – 54 years	289	43	0.95	0.62 – 1.47	
≥ 55 years	123	11	0.57	0.29 – 1.13	
Region of worker residence † (ref=urban)	633	97			0.64
Suburban	184	33	1.17	0.75 – 1.80	
Large town	124	22	1.14	0.68 – 1.89	
Rural	115	20	1.12	0.66 – 1.90	
Race/ethnicity (ref=White non-Hispanic)	798	122			0.34
Hispanic	142	30	1.35	0.86 – 2.11	
Other	149	22	0.88	0.54 – 1.45	
Education (ref=high school)	364	58			0.68
Less than high school	120	14	0.73	0.39 – 1.36	
Vocational or some college	495	84	1.05	0.73 – 1.52	
College	110	18	1.00	0.56 – 1.78	
Marital status (ref=married/living with partner)	748	114			0.78
Other	340	60	1.05	0.74 – 1.48	
Employment-related					
Worker's industry ‡ (ref=trade/transportation)	285	39			0.57
Natural resources	49	6	0.97	0.38 – 2.43	
Construction	201	27	1.11	0.65 – 1.89	
Manufacturing	83	8	0.75	0.34 – 1.68	
Management	192	26	0.96	0.56 – 1.64	
Education and health	155	36	1.25	0.73 – 2.14	
Hospitality	124	32	1.56	0.92 – 2.65	
Heavy lifting (ref=not at all/rarely/occasionally)	510	83			0.42
Frequently	363	51	0.90	0.61 – 1.32	
Constantly	215	39	1.19	0.78 – 1.83	
Whole body vibration (ref=not at all/rarely)	708	127			0.46
Occasionally/frequently	254	34	0.94	0.61 – 1.46	
Constantly	125	13	0.74	0.40 – 1.39	
Physical demands (ref=sedentary/light)	211	43			0.49
Medium	357	47	0.69	0.44 – 1.09	
Heavy	257	44	0.99	0.61 – 1.59	
Very heavy	258	39	0.85	0.52 – 1.40	
Excessive amount of work (ref=strongly	871	134			0.21

disagree/disagree)					
Strongly agree/agree	218	40	1.12	0.94 – 1.32	
Enough time to do job (ref=Strongly agree/agree)	796	117			0.26
Strongly disagree/disagree	293	57	1.22	0.86 – 1.73	
Very hectic (ref=Strongly disagree/disagree)	313	39			0.60
Agree	494	85	1.30	0.86 – 1.96	
Strongly agree	279	49	1.12	0.70 – 1.78	
Supervisor listens to my work problems (ref=agree)	622	101			0.25
Strongly disagree/disagree	205	40	1.03	0.69 – 1.56	
Strongly agree	248	30	0.67	0.43 – 1.04	
Satisfaction with job (ref=Somewhat or very satisfied)	944	149			0.30
Not at all or not too satisfied	142	25	1.02	0.64 – 1.64	
Co-worker relations (0 – 10 scale, ref=10, get along extremely well)	570	90			0.87
8 – 9	394	67	1.07	0.75 – 1.51	
0 – 7	121	16	0.86	0.48 – 1.53	
Job type at time of injury (ref=full-time)	992	158			0.26
Part-time	97	15	0.71	0.39 – 1.29	
Seasonal job at injury (ref=no)	1020	167			0.35
Yes	68	7	0.68	0.30 – 1.52	
Temporary job at injury (ref=no)	1024	163			0.55
Yes	62	11	1.23	0.63 – 2.41	
Job duration ≥ 6 months	865	135			0.67
< 6 months	222	39	1.09	0.73 – 1.62	
Employer offered job accommodation (ref=Yes)	517	75			0.15
No	561	94	1.28	0.92 – 1.79	
Pain and function					
Number pain sites (ref=0-2 sites)	528	70			0.21
3 – 4 sites	403	74	1.37	0.96 – 1.97	
5 – 8 sites	158	30	1.29	0.80 – 2.09	
Pain intensity, past week (0= no pain, ref= 0–3)[40]	291	41			0.79
4 – 5	289	43	0.99	0.62 – 1.58	
6 – 7	286	48	1.07	0.68 – 1.68	
8 – 10	223	42	1.24	0.77 – 1.99	
Pain interference with work, past week (0=no interference, ref=0-3)[40]	405	52			0.32
4 – 5	189	29	1.20	0.74 – 1.97	
6 – 7	192	33	1.35	0.84 – 2.18	
8 – 10	300	59	1.52	1.00 – 2.29	
Roland questionnaire € (0=no disability) (ref=0-	326	47			0.23

8)[42]					
9 – 16	386	53	0.95	0.62 – 1.45	
17 – 24	377	74	1.30	0.87 – 1.95	
SF-36 v2 Physical Function ¶ (ref=>50)[39]	276	39			0.26
41 – 50	209	27	0.93	0.55 – 1.57	
30 – 40	279	42	1.03	0.64 – 1.66	
< 30	325	66	1.40	0.90 – 2.18	
SF-36 v2 Role Physical ¶ (ref=>50)[39]	239	37			0.11
30 – 50	469	63	0.82	0.53 – 1.28	
< 30	381	74	1.22	0.79 – 1.90	
Pain change since injury (ref=better)	762	111			0.49
Same	198	42	1.36	0.92 – 2.02	
Worse	120	19	1.00	0.59 – 1.71	
Clinical status					
Injury severity †† (ref=mild strain/sprain)[11]	594	91			0.31
Major strain/sprain with substantial immobility but no evidence of radiculopathy	215	36	1.07	0.70 – 1.63	
Evidence of radiculopathy or abnormalities	273	47	1.15	0.78 – 1.70	
Pain radiates below knee (ref=no)	791	119			0.27
Yes	298	55	1.22	0.86 – 1.74	
Previous similar back injury (ref=no)	568	101			0.73
Yes	521	73	0.94	0.67 – 1.32	
Previous injury (any type) with ≥ 1 month off work (ref=no)	791	128			0.49
Yes	295	46	1.14	0.78 – 1.67	
Number of self-reported worker's compensation claims before current injury (ref=0)	402	64			0.40
1	328	49	1.06	0.70 – 1.60	
2 – 3	236	40	1.31	0.84 – 2.04	
≥ 4	115	18	1.33	0.74 – 2.39	
Work days missed because of back, previous year (ref=0)	720	114			0.34
1 – 10	269	39	0.92	0.62 – 1.37	
> 10	87	16	1.31	0.73 – 2.33	
Work days missed because of other health problems, previous year (ref=0)	458	56			0.20
1 – 10	536	98	1.34	0.94 – 1.91	
> 10	78	14	1.26	0.66 – 2.40	
Number other major medical problems (ref=0)	906	147			0.99
≥ 1	182	27	1.00	0.63 – 1.60	
General health, year prior to injury (ref=excellent)	262	33			0.23
Very good	415	62	1.16	0.74 – 1.83	

Good	320	58	1.39	0.88 – 2.21	
Fair/poor	90	21	1.71	0.93 – 3.13	
Opioid Rx within 6 weeks of injury (ref=no)	703	109			0.64
Yes	359	59	1.07	0.76 – 1.52	
Health care					
Health care provider recommended exercise (ref=yes)	768	126			0.66
No	319	48	0.92	0.64 – 1.33	
Health insurance (ref=yes)	787	119			0.32
No	301	54	1.13	0.79 – 1.62	
Administrative/legal					
Time from injury to first medical visit for injury ◊ (ref=0-6 days)	845	123			0.12
7 – 13 days	119	26	1.66	1.03 – 2.66	
≥ 14 days	96	18	1.33	0.77 – 2.30	
Health behavior					
Tobacco use (ref=no)	591	92			0.63
Occasionally/frequently	166	23	0.90	0.55 – 1.48	
Daily	332	59	1.14	0.80 – 1.63	
Alcohol Use Disorder Identification Test-Consumption (AUDIT-C)^^ (ref=negative, AUDIT-C score of 0 – 3 for males, 0 – 2 for females)[41]	755	129			0.30
Positive (4 – 12 for males, 3 – 12 for females)	331	44	0.77	0.53 – 1.12	
Baseline Body Mass Index (BMI) (ref=<25)	318	57			0.89
25 – 29 (overweight)	443	63	0.92	0.62 – 1.37	
≥ 30 (obese)	328	54	1.00	0.67 – 1.51	
Psychological					
Blame for injury[39] (ref=work)	527	91			0.41
Self	230	27	0.72	0.45 – 1.14	
Someone/something else	151	30	1.11	0.70 – 1.75	
Nothing/no one	160	21	0.80	0.48 – 1.33	
Work fear-avoidance (ref= <3, very low) ◊◊	214	28			0.31
Low-moderate (>3 – <5)	358	51	1.11	0.68 – 1.82	
High (5 – 6)	517	95	1.37	0.87 – 2.15	

Missing, “don’t know,” and refusal responses for each variable were combined into one response for each variable (results not shown)

Ref indicates reference group.

All measures were obtained from worker baseline interviews except where noted

^ All odds ratios were adjusted for age and gender, except for age

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

‡ Derived from Standard Industrial Codes (SIC)

€ Roland-Morris Disability Questionnaire assesses overall back disability[42-44]

¶ Scores from the Short-Form-36 version 2 (SF-36v2) Physical Function and Role Physical scales; higher scores indicate better functioning[39]

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

◊ From worker's compensation database

^^ The AUDIT-C score is a screening test for problematic alcohol usage[41]

◊◊ Mean of responses to two questions from the Fear-Avoidance Beliefs Questionnaire work scale[46]

Early Predictors of Lumbar Spine Surgery after Occupational Back Injury

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 incidence and early predictors of lumbar spine surgery within 3 years among Washington State workers with new workers' compensation wage-replacement claims for back injuries. Baseline measures included worker-reported measures obtained approximately 3 weeks after claim submission. We 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 1,624 workers, 153 (9.4%) 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 chiropractor as first provider. The probability of having surgery when first seeing a surgeon was 0.43 while the probability of having surgery when first seeing a chiropractor was 0.015. The model's AUC was 0.93, indicating a very high ability to identify workers with surgeries.

Conclusion

Baseline variables in multiple domains predicted lumbar spine surgery. Identifying early predictors for surgery may help determine which patients are likely to have surgery after occupational back injury.

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, have faced increasing scrutiny regarding effectiveness and efficacy.[4,5] Spine surgeries are associated with little evidence for improved population outcomes,[4] yet spine surgery rates have increased dramatically since the 1990s.[6 – 9] Reducing unnecessary spine surgeries is important for patient safety and complication reduction, as well as for reducing health care costs and improving patient outcomes.[10,11] Comparative effectiveness research (CER) is needed to improve understanding of effectiveness of different spine surgeries for different back pain problems and to identify patient characteristics that influence success of surgery. 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] Knowledge of early predictors of lumbar spine surgery following occupational back injury could help identify workers likely to undergo surgery, which in turn has the potential to improve patient outcomes by targeting evidence-based care to such workers. Furthermore, such information is essential for CER studies so that factors associated with receipt of surgery can be assessed and included in adjustment or matching techniques used to treatment groups comparable.

The Washington State Workers' 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, was used 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. Variables were identified within seven domains of interest, including sociodemographic, employment-related, pain and function, clinical status, health care, health behavior, and psychological.[18–21] We used previous literature in the occupational injury, back injury, chronic disability due to back pain, and lumbar spine surgery fields to determine potential early predictors available in the existing D-RISC data. We hypothesized *a priori* that the following baseline measures would be associated with subsequent lumbar spine surgery: older age,[8,9] higher levels of pain,[16,18,22,23] prescription of opioid medication within the first 6 weeks after the first medical visit for the injury,[17,24] worker perception of a hectic job,[18] no job accommodation offer after the injury,[18] psychological factors,[15,16,18–21] worse injury severity,[4–5,17,18] and living in a rural area.[8,25] Additionally, we hypothesized that participants of Hispanic ethnicity,[9,16,26,27] non-white race,[8,9,16,27] and females[8,9,27] would have reduced odds of surgery.

Methods

Setting and Participants

The D-RISC study has been described previously.[18–21,24,28] D-RISC identified workers 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. Data on the other third, covered by about 350 large self-insured companies, were insufficient for inclusion. In Washington State, workers must be off work due to an injury at least four days in order to receive wage replacement. Workers who received some wage-replacement compensation for temporary total disability due to the injury were selected 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,[18] 1178 (27.1%) could not be contacted, 909 (20.9%) declined enrollment into the study, and 120 (2.8%) were ineligible. The remaining 2147 (49.3%) were enrolled in D-RISC and completed a telephone interview, which was conducted a median of 18 days after the claim was received by DLI. Study participants were excluded from the D-RISC analysis sample if they were not eligible for wage-replacement compensation in the first year of the claim (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,[18] 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).

Measures

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.[18–21,24,28] Information such as employer size, industry type, worker residence region, opioid prescription within 6 weeks, time from injury to first medical visit for the injury, and type of first provider seen for the back injury was obtained from administrative claims and medical bill data.[18] A measure of injury severity was developed for D-RISC, and as part of the D-RISC study, trained occupational health nurses reviewed medical records of visits for the injury and rated injury severity.[21] All other measures were obtained from the interview. See Table 2 and the Appendix for additional information about the baseline variables.

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 workers' compensation claims for all medical bills paid by DLI in the claim. We identified all lumbar spine surgery bills using the CPT codes shown in Appendix 1. Our *a priori* CPT codes vary slightly from a previous code list[29] for lumbar spine surgery; there were no differences in counts 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 (0 versus 1 or more), 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.[30] Prior to testing the multivariate model, we excluded variables if they were collinear or redundant with other variables. Analyses were conducted using Stata version IC10.[31] 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). Additionally, we used 10-fold cross validation to estimate the AUC in different sub-samples of the D-RISC data.[32] An AUC from 0.70 to 0.80 is considered acceptable and 0.80 to 0.90 is considered excellent.[18,30]

Results

Sample characteristics

Study participants (N=1624) were mostly white non-Hispanic (71%; Hispanic 15% and Other 14%) and male (68%). By 3 years after claim receipt, 153 (9.4%) of the workers underwent a lumbar spine operation covered by DLI under the same claim as the index back injury. Among the 153 workers with an operation, 119 (77.8%) had decompression only, 5 (3.3%) had fusion only, and 29 (19.0%) 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 2. All seven domains contained variables associated with lumbar spine surgery. All the variables from the pain and function, health care, and psychological domains were associated (P<0.10) 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. The employment-related domain had four variables associated with surgery: 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 within 6 weeks of the first clinic visit were associated with surgery. Using tobacco daily (health behavior domain) was also associated with surgery.

Multivariate Model

The multivariate model (Table 2) includes variables that were associated at a level of $P < 0.10$ 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 in the multivariate model the pain interference with daily activities rating,[45] pain interference with work rating,[45] SF-36 v2 Physical Function scores,[34] and SF-36 v2 Role Physical scores.[34] We did include the number of pain sites, the rating of pain intensity, the Roland-Morris Disability Questionnaire score,[33] and all of the variables in the psychological domain. Finally, we did not include self-report of radiating pain below the knee in the multivariate model due to its similarity to radiculopathy in the injury severity measure.[18]

Due to missing variables on some variables, the multivariate model included 1,624 (86.2%) workers that had full data. These workers, as compared to the 276 that were in D-RISC but not in the multivariate model, were less likely to be married or living with a partner (35% vs. 45%, P=0.02) and less likely to be on wage-replacement benefits 1 year after claim submission (13% vs. 20%, P=0.006). No other differences, including undergoing surgery, were identified. Variables with the most missing values were recovery expectations (3.4%) and region of worker residence (3.1%).

Six variables from 4 domains contributed independently ($P < 0.05$) to the prediction of lumbar spine surgery within 3 years of claim submission for an occupational back injury in the multivariate model. Baseline factors predictive of lumbar spine surgery, adjusted for the other variables in the model, included high RDQ scores (17–24) compared to low (0–8); greater injury severity; and surgeon as first provider seen for the injury. This provider category included orthopedic surgeons (n=104), 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 after adjusting for all other variables in the model.

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.[30] In the validation procedure, the AUC was also 0.93 (95% CI 0.92–0.95). In additional analyses, inclusion of only the RDQ 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 validation AUC of 0.89 (95% CI 0.86 – 0.91).

Discussion

In this sample, 9.4% 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%[26]). Little previous research has identified early predictors of lumbar spine surgery after occupational back injury. We investigated many potential risk factors for lumbar spine surgery from multiple sources. Measures in four domains predicted surgery: sociodemographic, pain and function, clinical status, and health care.

In a multivariate model that included measures of sociodemographic characteristics, injury severity, pain, function, and psychological characteristics, workers with baseline RDQ scores of 17 or higher on the 0 – 24 scale had 6 times the odds (OR=6.08, 95% CI=1.79–20.64) of surgery, as compared with those with scores of 0–8. The RDQ has been shown in longitudinal studies to be predictive of several occupational back outcomes, including chronic work disability after occupational back injury (in a previous study involving the D-RISC sample),[18] duration of sick leave,[35] chronic pain,[23] and other measures of function.[36] 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 RDQ was excluded from the model.[18] In our current analyses predicting surgery, several psychological variables were significant in bivariate analyses, but none were significant in the multivariate model, with or without inclusion of RDQ scores (results not shown).

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.[16,17,23,36] Lumbar spine surgery may be appropriate treatment for radiculopathy.[37] There was a substantial difference in odds of surgery between participants with symptomatic radiculopathy without reflex, sensory, or motor abnormalities (85 of 344, or 24.7%, received surgery) and participants with such abnormalities (19 of 58, or 32.8%, received surgery). In future studies investigating association of objective findings with lumbar spine surgery, it may be informative, if the number of cases is sufficient, to separate these categories.

After adjustment for the other measures in the multivariate model, workers with an initial visit for the injury to a surgeon had high odds of receiving lumbar spine surgery (OR 9.23, 95% CI=5.11–16.66) relative to those seeing primary care providers, whereas workers whose first visit for the injury was to a chiropractor had significantly lower odds of surgery (OR 0.21, 95% CI=0.08–0.51). The probability of having surgery when a participant first saw a surgeon was 0.43 (73 of 171) while the probability of surgery when a participant first saw a chiropractor was 0.015 (8 of 542). It is possible that these findings indicate that "who you see is what you get."[38] Previous studies have noted similar findings using provider surveys of hypothetical patients.[38,39] Persons with occupational back injuries who first saw a chiropractor had lower odds of chronic work disability and of early receipt of magnetic resonance imaging (MRIs) in previous reports of data from the D-RISC sample,[18,28] and higher rates of satisfaction with back care.[40] However, patients who see chiropractors may be different from patients who choose other provider types.[18,41] Washington State is a provider choice state; workers may choose their provider.

Perhaps future studies or other worker's compensation programs may wish to evaluate a gatekeeper approach to help ensure the need for lumbar spine surgery.

As we hypothesized, Hispanic participants had lower odds of surgery. Prior research has also observed lower rates of spine surgery among Hispanics.[8,9,26,27,42] In an earlier study, Spanish-speaking workers had significantly fewer occupational lumbar spine surgeries within two years of injury as compared with non-Hispanic white workers (7.4% vs. 11.0%).[26] These lower odds of surgery may reflect cultural barriers and less willingness to undergo surgeries;[9,43] lack of familiarity with or understanding of surgery;[9,44] fewer physician referrals to surgery;[27] 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 as closely as possible, early receipt of an opioid prescription was still not significant in the multivariate model (results not shown). We speculate that the difference may be due to the fact that in the previous study, a measure of worker-related function was not included, whereas in our study the RDQ was a highly significant predictor of surgery in the multivariate model and opioid prescription was no longer significant after adjusting for RDQ socres.[17]

The multivariate model had excellent ability to distinguish between workers who did or did not have surgery. Additionally, a smaller multivariate model that only consisted of the RDQ, 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. However, the ability of the model to predict surgery in other samples needs to be examined in future studies.

Our study has limitations. We had no ability to capture information on surgery covered outside the workers' compensation system, although it is reasonable to assume that most, if not all, surgeries for the index back injury would be covered by the workers' compensation insurance. Although our D-RISC sample only included workers with low back injuries,[28] some of our included CPT codes do not necessarily restrict to lumbar-specific spine surgeries. We do not know the extent to which findings from our study may generalize to workers with back injuries in other settings. However, a strength of our study is that it was based upon a large prospective sample of injured workers who provided detailed information shortly after injury on a wide range of factors that may be predictive of surgery, as well as the availability of baseline data from other sources that enabled us to examine injury severity, early receipt of an opioid prescription, and type of first provider seen for the injury. Another strength is that we had complete data for the entire sample on surgery for the injury that was covered by workers' compensation.

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

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Table 8. 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 (e.g., Harrington rod technique, pedicle fixation across 1 interspace, atlantoaxial transarticular screw fixation, sublaminar wiring at C1, facet screw fixation)
22842	Posterior segmental instrumentation (e.g., pedicle fixation, dual rods with multiple hooks and sublaminar wires); 3 to 6 vertebral segments
22843	Posterior segmental instrumentation (e.g., pedicle fixation, dual rods with multiple hooks and sublaminar wires); 7 to 12 vertebral segments
22844	Posterior segmental instrumentation (e.g., 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) (e.g., 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 (e.g., 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 (e.g., 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 (e.g., 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], [e.g., 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], [e.g., 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) (e.g., herniated intervertebral disc), single segment; lumbar (including transfacet, or lateral extraforaminal approach) (e.g., far lateral herniated intervertebral disc)
63057	Transpedicular approach with decompression of spinal cord, equina and/or nerve root(s) (e.g., 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) (e.g., 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) (e.g., 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

Table 9. 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	891	116	1.77	1.26 – 2.48	
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
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)[45]	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)[45]	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)[45]	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[33] € (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[34] ¶ (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[34] ¶ (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[21]†† (ref=mild strain/sprain)	991	38			<0.001
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[46] ‡‡ (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[47] (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	
Blame for injury[47] (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[48] ◊◊ (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[34] ¶ (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 for each variable as needed. They were not included in analyses. The following variables had missing responses: region of worker residence (n=59), fast pace (6), job duration (4), employer offered job accommodation (23), 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 10. 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	P-Value
Sociodemographics					
Age, years (ref= 35-44 years)					0.002
≤24 years	0.15	0.05 – 0.41	0.23	0.07 – 0.74	
25 – 34 years	0.42	0.26 – 0.66	0.50	0.27 – 0.93	
45 – 54 years	0.86	0.59 – 1.27	0.59	0.33 – 1.06	
≥ 55 years	1.00	0.61 – 1.66	1.60	0.78 – 3.29	
Gender (ref=male)					0.0002
Female	0.73	0.51 – 1.04	0.38	0.22 – 0.65	
Region of worker residence (ref=urban)					0.11
Suburban	1.77	1.16 – 2.69	2.00	1.13 – 3.53	
Large town	1.02	0.60 – 1.75	1.37	0.67 – 2.78	
Rural	1.15	0.65 – 2.03	1.01	0.50 – 2.08	
Race/ethnicity (ref=White non-Hispanic)					0.01
Hispanic	0.36	0.20 – 0.67	0.33	0.14 – 0.74	
Other	0.56	0.33 – 0.95	0.70	0.35 – 1.39	
Employment-related					
Fast pace (ref=strongly disagree/disagree)					0.10
Agree	1.21	0.78 – 1.88	1.61	0.85 – 3.04	
Strongly agree	1.78	1.16 – 2.74	1.96	1.04 – 3.70	
Job duration ≥ 6 months					0.45
< 6 months	1.38	0.95 – 1.98	1.22	0.73 – 2.04	
Employer offered job accommodation (ref=Yes)					0.09
No	1.77	1.26 – 2.48	1.60	0.93 – 2.76	
Returned to paid work by baseline interview (ref=Yes, same job)					0.50
Yes, light duty or different job	2.44	1.25 – 4.76	1.68	0.68 – 4.13	
No	8.28	4.72 – 14.56	1.48	0.66 – 3.30	
Pain and function					
Number pain sites (ref=0-2 sites)					0.60
3 – 4 sites	5.15	3.34 – 7.94	1.31	0.72 – 2.38	
5 – 8 sites	4.22	2.50 – 7.11	1.09	0.52 – 2.26	
Pain intensity, past week (0= no pain, ref= 0–3)[46]					0.15
4 – 5	5.50	2.42 – 12.48	2.82	0.99 – 8.01	

6 – 7	8.23	3.68 – 18.37	1.90	0.66 – 5.47	
8 – 10	15.26	6.90 – 33.72	2.57	0.87 – 7.59	
Roland-Morris Disability Questionnaire[31] € (0=no disability) (ref=0-8)					0.0004
9 – 16	8.55	3.02 – 24.19	2.37	0.72 – 7.75	
17 – 24	31.69	11.59 – 86.63	6.08	1.79 – 20.64	
Pain change since injury (ref=better)					0.43
Same	3.31	2.24 – 4.87	1.15	0.66 – 2.03	
Worse	6.72	4.46 – 10.12	1.55	0.80 – 3.00	
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	1.12	0.56 – 2.28	
Evidence of radiculopathy	7.80	5.21 – 11.68	5.42	3.10 – 9.45	
Reflex, sensory or motor abnormalities	11.57	6.19 – 21.65	7.67	3.31 – 17.79	
Previous injury (any type) with ≥ 1 month off work (ref=no)					0.22
Yes	1.83	1.32 – 2.54	1.26	0.89 – 1.79	
Opioid Rx within 6 weeks of injury (ref=no)					0.12
Yes	2.46	1.78 – 3.39	0.69	0.43 – 1.10	
Health care					
Specialty, first provider seen for injury (ref=primary care)					<0.0001
Surgeon	10.41	6.72 – 16.11	9.23	5.11 – 16.66	
Occupational medicine	2.09	1.13 – 3.87	1.58	0.73 – 3.42	
Chiropractor	0.21	0.10 – 0.45	0.21	0.08 – 0.51	
Other	1.36	0.84 – 2.19	1.45	0.78 – 2.68	
Time from injury to first medical visit for injury (ref=0-6 days)					0.46
7 – 13 days	1.08	0.65 – 1.79	0.81	0.42 – 1.57	
≥ 14 days	2.58	1.67 – 3.98	1.36	0.72 – 2.58	
Health behavior					
Tobacco use (ref=no)					
Occasionally/frequently	1.04	0.64 – 1.67	0.69	0.36 – 1.30	0.45
Daily	1.49	1.06 – 2.11	1.01	0.61 – 1.66	
Psychological					
Catastrophizing[47] ‡‡ (ref=0-1)					0.33
Low (>1 – <2)	3.02	1.55 – 5.90	1.65	0.67 – 4.07	

Moderate (2 – <3)	5.30	2.99 – 9.42	2.04	0.93 – 4.50	
High (3 – 4)	6.39	3.57 – 11.43	1.94	0.83 – 4.54	
Recovery expectations[48] (0-10 scale, 10 = extremely certain will be working in 6 months, ref=10)					0.71
High (7 – 9)	3.04	2.10 – 4.40	0.89	0.50 – 1.56	
Low (0 – 6)	1.86	1.22 – 2.84	1.15	0.65 – 2.03	
Blame for injury[48] (ref=work)					0.48
Self	0.52	0.31 – 0.85	0.64	0.33 – 1.26	
Someone/something else	1.25	0.81 – 1.92	1.15	0.63 – 2.11	
Nothing/no one	0.91	0.58 – 1.42	0.85	0.44 – 1.64	
Work fear-avoidance[49] ◊◊ (ref= <3, very low)					0.69
Low-moderate (>3 – <5)	1.71	0.93 – 3.16	0.97	0.43 – 2.18	
High (5 – 6)	3.85	2.21 – 6.70	1.22	0.56 – 2.62	
SF-36 v2 Mental Health (ref=>50)					0.27
41 – 50	3.27	2.05 – 5.20	1.15	0.61 – 2.17	
≤ 40	3.53	2.29 – 5.45	0.75	0.40 – 1.40	

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

Table 11. Non-Significant Bivariate Associations (P ≥ 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	
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
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-Consumption (AUDIT-C)[49] ^^ (ref=negative, AUDIT-C score of 0 – 3 for males, 0 – 2 for females)	1220	124			0.56
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

Conclusion

This dissertation assessed the predictors and incidence for three major potential outcomes following occupational back injury: back re-injury while at work by 1 year, clinically significant weight gain by 1 year, and undergoing lumbar spine surgery by 3 years after claim submission. We identified predictors of each outcome in preceding chapters. Table 12 provides a brief summary of significant predictors across the three outcomes.

Summary

Approximately 26% of workers had a back re-injury within 1 year of claim submission after returning to work. Predictors included constant whole body vibration at work, a history of similar previous back injury, having more than 3 previous worker's compensation claims of any type, and reporting higher fear-avoidance scores; not having health insurance and obesity were associated with lower odds of re-injury.

Among workers who reported their weight during both telephone interviews, 14% had clinically significant weight gain (7% of baseline weight) 1 year after injury. Female gender was associated with weight gain. Individuals on time-loss compensation for more than six months in the year after injury were also associated with weight gain.

9% of the D-RISC sample of injured workers underwent a fusion or decompression lumbar spine surgery within 3 years of the claim submission date for the back injury. Early predictors of surgery included higher Roland Disability Questionnaire scores, evidence of radiculopathy or other abnormalities, and first seeing a surgeon for the injury. Lower odds of surgery were associated with age under 35 at time of injury, females, Hispanics, and initially seeing a chiropractor for the injury.

Across the three studies, only one variable was associated with the outcome of interest in more than one analysis. Female gender was the only predictor associated with clinically significant weight gain; it was also predictive of lower odds of re-injury and lumbar spine surgery. Table 12 identifies significant predictors by outcome and domain. All domains had at least one significant predictor across the analyses except for administrative legal; only the sociodemographics domain contained predictors across all analyses. Health care and clinical status domains contained predictors for both the re-injury and surgery studies.

Implications and future studies

This dissertation provides new information on outcomes following occupational back injury that may influence policymakers. Our re-injury analysis was the first large, multi-industry study across an entire state. As discussed in that chapter, previous incidences of re-injury ranged from 5-84% across substantially different populations and definitions of re-injury. Our paper indicates a self-reported benchmark of re-injury following occupational back re-injury and variables that may predict future re-injury. Unfortunately, several significant variables related to re-injury are not malleable (gender, history of back injury and occupational claims). However, physicians, employers and policymakers may be able to reduce fear-avoidance scores through education and constant whole-body vibration at work through targeted interventions for employees who report high baseline scores for these variables. Possible future studies may identify and evaluate these intervention approaches, such as therapies to reduce fear-avoidance behaviors after injury or reduce time spent doing whole-body vibration activities. Additionally, merging the D-RISC data with allowed payments from DLI claims data may allow future studies to evaluate the differences in medical and wage-replacement costs between workers who do and do not self-report re-injury.

Although no alterable predictors of weight gain after back injury were identified, our study was the first to determine that the incidence of clinically significant weight gain was higher in women and those receiving more than 180 days of wage-replacement benefits in the year after injury. The inability to identify additional predictors of weight is likely most related to the fact that important known predictors, such as dietary habits and more detailed markers of physical activity following injury, were not collected in the D-RISC cohort. This study also established that clinically significant weight gain among persons with occupational back injuries had a higher incidence at 1 year than that in the general American adult population. Future studies may compare occupational workers' compensation costs of participants with clinically significant weight gain compared to those who did not. Interventions that might induce greater calorie expenditure following injury, such as regular home exercise, should be investigated compared to the usual type of passive, modality-based physical therapy offered. Weight-loss and weight-maintenance interventions, such as gym memberships, group therapy, or other incentivized programs that are provided at discounted rates, are possible solutions to weight gain that can be evaluated.

We identified several early predictors of lumbar spine surgery after occupational back injury; the set of identified predictors resulted in a very strong predictive model. Predictors of obtaining lumbar spine surgery were little known prior to this study; our analysis has a very strong AUC value and can discriminate between people who did and did not undergo surgery. This may be of great value to workers, insurers, and policymakers. This study can be tested for validation in different populations, including workers in other states (Washington State has a conservative approach to occupational lumbar spine surgery), large self-insured companies, the SPORT surgical outcomes trial, different insurance types, general adult populations, and the elderly. (As of this writing, it may be possible to replicate this study at Dartmouth.) These predictors may also assist in matching patients in future studies, including comparative effectiveness studies comparing surgery to non-surgery interventions for back injury. Future comparisons can also be made between surgical specialties. Additionally, it may be useful to determine whether these predictors of surgery also predict higher costs among patients who undergo surgery.

Table 12. Significant variables in multivariate analyses in three outcomes of interest following occupational back injury

Domain	Variable	Category, Odds Ratio, 95% CI		
		Re-Injury	Weight Gain	Lumbar Spine Surgery
Sociodemographics	Age, years (ref= 35-44 years)			≤24, 0.23, 0.07-0.74 25–34, 0.50, 0.27-0.93
	Gender (ref=male)	Female, 0.68, 0.47-0.99	Female, 2.17, 1.54-3.07	Female, 0.38, 0.22-0.65
	Race/ethnicity (ref=White non-Hispanic)			Hispanic, 0.33, 0.14-0.74
Employment-related	Whole body vibration (ref=not at all/rarely/occasional)	Constant, 1.66, 1.02-2.69		
Pain and function	Roland score (0=no disability) (ref=0-8)			17–24, 6.08, 1.79-20.64
Clinical status	Injury severity (ref=mild strain/sprain)			Radiculopathy, 5.42, 3.10-9.45 Other abnormalities, 7.67, 3.31-17.79
	Previous similar back injury (ref=no)	Yes, 1.47, 1.06-2.02		
	# of prior claims, any type (ref=0)	>3, 2.29, 1.34-3.92		
Health care	Specialty, first provider seen for injury (ref=primary care)			Surgeon, 9.23, 5.11-16.66 Chiropractor, 0.21, 0.08-0.51

	Health insurance (ref=yes)	No, 0.62, 0.43-0.89
Health behavior	BMI (ref=<25)	≥ 30, 0.59, 0.40-0.88
Psychological	Fear-avoidance (ref=very low)	Low-moderate, 2.03, 1.27-3.23
		High, 1.84, 1.13-2.99

Technical Appendix

AUCs and ROCs

The area under the receiver operating characteristic curves (AUC) is a type of receiver operating characteristic (ROC) plot. ROCs are a process of measuring a model or test's ability to determine, discriminate or identify a binary outcome successfully; a visual display compares the sensitivity to the specificity and the AUC is a measure of the area under that curve.[1-3] In basic terms, the AUC averages accuracy of the model or term across all values.[3] This section gives a brief overview of the history of AUCs and ROCs, their classical use, and how they are used currently and in this dissertation.

ROCs were first used in the 1950s by engineers studying the detection of objects in radar fields.[4] By the late 1960s, the use of ROC expanded into aspects of medicine and clinical work, including binary outcomes related to Pap smears,[5] radiology diagnostics,[6] and medical decision making.[7] In current clinical practice, ROCs and AUCs are particularly common in epidemiology, investigations related to diagnostic and screenings tests such as radiology and laboratory testing, and bioinformatics.[3]

AUCs and ROCs are useful tools for evaluating the accuracy of a logistic regression predictive model.[3] The value of an AUC ranges between 0 and 1. A value of 0.5 is essentially random chance and indicates the model is not better than chance.[3] A value between 0.70 and 0.80 is considered to be acceptable while a value between 0.80 and 0.90 is good. A score over 0.90 is rare.[1,8] This dissertation used AUCs for two outcomes following occupational back injury: occupational back re-injury within 1 year and undergoing lumbar spine surgery within 3 years.

We did not use AUCs for the weight gain outcome because that analysis was exploratory in nature with minimal previous literature. Our AUC value for the re-injury analysis was 0.72, indicating that the model had an acceptable ability to discriminate between workers who reported re-injury and those that did not. This score may be lower due to the absence of a gold standard for the outcome of re-injury.[3,9] That measure was self-reported and there is no "gold standard" for either defining or confirming the re-injury occurrence. This differs from surgery: claims data and the costs involved in surgical procedures make it comparatively easier to determine definitively that surgery occurred. The AUC value for undergoing lumbar spine surgery was 0.93 for the general model and 0.91 using randomized training and validation sub-groups. Dividing the data into randomized training and validation subsets for calculating the AUC minimized possible verification bias, which can occur when only data with "known" outcomes are used to determine the score.[3,10] Of note, the inclusion of only 3 variables in the surgery model (Roland Disability Questionnaire score,[11] injury severity,[12] and first provider seen for the injury) had an AUC score of 0.89.

Omitted variable bias

Omitted variable bias is a common occurrence in observational studies.[13] In brief, if a key variable is missing from a dataset, its attributes may be directed to another included variable, which then has a biased coefficient.[14] In particular, omitted variable bias is problematic when running regression analyses as these assume the model is fully specified and includes all relevant variables.[15] For example, it is likely that our weight gain analysis may have omitted variable bias; it does not contain measures that have established associations with obesity and weight, including diet, exercise, and social support.[16-18] Thus, it is likely that our use of the D-RISC prospective cohort, which was not designed to assess weight change outcomes, suffered substantial omitted variable bias.

Although regressions require full models, an omitted variable does not always create statistical problems. The regression coefficients can only become biased if the omitted variable is relevant to both the outcome of interest and another variable remaining in the dataset.[15] If the omitted variable does not have a foreseen relationship with another variable, no bias exists; however, the model will not fit as well and may have larger error terms.[15] Omitted variable bias may hence become a serious problem if an unavailable variable has its effect or association placed on another variable in its absence. In our weight gain analysis, the absence of diet, exercise, and social support measures may have had their associations placed on female gender.[19]

Apart from including all variables that appear appropriate based on availability and previous literature, little can be done to prevent omitted variable bias. However, its importance depends also on how the model or its included variables are interpreted.[15] Additionally, it is never clear if there are more omitted variables for the outcome of interest. While finding a known omitted variable and adding it to the dataset helps attribute appropriate coefficients to each variable, authors can never know if “all” omitted variables have been found and included. If a variable indicated by previous literature is clearly relevant to the outcome and other variables, and is unavailable with the intended dataset, then this is a limitation and should be noted for publication as omitted variable bias. As a limitation, its seriousness is determined by the specific model and situation.[15]

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