

RESEARCH ARTICLE

The impact of industry and body part injured on repeat workers' compensation claims

Courtland Keteyian MD, MBA, MPH^{1,2,3}  | Natalie Schwatka PhD^{4,5}  |
Miranda Dally MS⁴ | Molly Tran MD, MPH, MA^{4,5} | Erin Shore MPH⁴ |
David Weitzenkamp PhD⁴ | Lee S. Newman MD, MA^{4,5,6,7}

¹Occupational Health, Henry Ford Allegiance Health, Henry Ford Health System, Jackson, MI

²Prevention and Community Health, Henry Ford Allegiance Health, Henry Ford Health System, Jackson, MI

³Jackson Health Network, Henry Ford Allegiance Health, Henry Ford Health System, Jackson, MI

⁴Center for Health, Work & Environment, Colorado School of Public Health, University of Colorado, Aurora, CO

⁵Department of Environmental and Occupational Health, Colorado School of Public Health, University of Colorado, Aurora, CO

⁶Department of Epidemiology, Colorado School of Public Health, University of Colorado, Aurora, CO

⁷Department of Medicine, School of Medicine, University of Colorado, Aurora, CO

Correspondence

Courtland Keteyian, Henry Ford Allegiance Health, Henry Ford Health System 205N East Avenue, Jackson, MI 49201.
Email: cketeyi1@hfhs.org

Funding information

National Institute for Occupational Safety and Health, Grant/Award Number: T42 OH009229; Pinnacol Assurance, Grant/Award Number: Pinnacol Assurance furnished the dataset and provided philanthropic support

Abstract

Background: Few studies investigate the influence of body part injured and industry on future workers' compensation claims.

Methods: Using claims incurred from 1 January 2005 to 31 July 2015 (n = 77 494) from the largest workers' compensation insurer in Colorado, we assessed associations between worker characteristics, second claims involving *any body part* and the *same body part*. We utilized Cox proportional hazards models to approximate the probability of a second claim.

Results: First claims represented 74.9% (n = 58 007) and second claims 25.2% (n = 19 487) of total claims. Sex, age, industry, and body part of the first claim were associated with the probability of second claims and the body part affected. The 5-year probabilities of second claims and same body part second claims were 27.0% (95% confidence interval [CI]: 26.6%-27.5%) and 6.2% (95% CI: 5.9%-6.5%) in males and 26.5% (95% CI: 26.0%-27.0%) and 6.7% (95% CI: 6.5%-7.0%) in females. Most second claims occurred within 3 years.

Conclusions: Most second claims occur within 3 years. Body part and industry-specific injury patterns suggest missed opportunities for prevention.

KEYWORDS

body part, industry, injury, repeat claims, workers' compensation

1 | INTRODUCTION

For many workers, their first injury at work will not be their last. Multiple studies estimate at least one-third of workers who experience an occupational injury will sustain a subsequent new

injury after returning to work.¹⁻⁷ In the United States, estimates of the economic burden of all workplace injuries and illnesses, including both direct medical expenses and indirect costs, exceed \$250 billion per year.^{8,9} The contribution of repeat claims to this figure is unknown but likely substantial. Compared to initial claims, repeat claims appear to result in significantly higher costs and longer periods of work disability.^{6,7,10} The impact of injuries on workers and

The work was performed at Colorado School of Public Health, University of Colorado.

their families is also significant. Injured workers experience a range of psychosocial consequences, including anxiety, depression, and strained family relationships.¹¹⁻¹³ In addition, lost earnings reduce household assets and perpetuate income inequality.^{14,15} Despite the substantial burden of repeat claims, both in terms of cost to the system and impact on individual workers, we do not fully understand the nature of repeat claims and why they occur. Therefore, repeat claims represent an important target for additional research, attention in clinical practice, and intervention in the workplace.

Several previous studies have described the features of workers who experienced repeat claims. Cherry et al⁴ characterized claims of workers using data from the Alberta Workers' Compensation Board in Canada and found that 49.2% of 490 230 workers experienced at least two claims from 1994 to 2004. Reduced time to second claim was associated with male sex, younger age, and certain industry and accident types.⁴ Using a similar methodological approach, Ruseckaite et al⁵ characterized claims of 178,630 workers from Victoria, Australia, of which 36.9% experienced at least two claims from 1996 to 2009. Reduced time to the second claim was also associated with male sex, younger age, and employment in the manufacturing industry.⁵ Gross and Battié¹⁶ analyzed workers' compensation board data from Alberta, Canada to predict outcomes in patients with low back injuries enrolled in intensive rehabilitation programs. The number of preadmission healthcare visits consistently predicted outcomes in low back injuries. However, sex, days between injury, physical job demands, performance on a physical test, and previous back-related claims were not consistent predictors of future injury.¹⁶

In our review of the repeat claims literature, we observed a number of research gaps, including an understanding of the relationship between the body part affected in a worker's first injury and the body part affected in their second injury. The majority of research conducted on repeat claims focuses almost exclusively on low back injuries. Past analyses of low back injuries suggest significant rates of recurrence.^{10,12,17} From a clinical perspective, it is useful for practitioners to understand the anatomical location, rate, and timeframe in which new injuries occur. Ruseckaite and Collie explored body parts involved in 170 148 claims from Victoria, Australia from 1996 to 2000, and determined the same anatomical location was involved in 34.3% of repeat claims, while a different body part was involved in 65.7% of repeat claims.⁶ Relying only on self-reports, Galizzi determined that 7% of injuries occurred subsequently to the same body part (mainly eyes, backs, and hands), and 2% involved the same type of injury to the same body part, suggesting a sequence of relatively different injuries.¹⁸ Both the apparent rates of reinjury and potential disparity in findings underscore the need for more detailed investigation.

The goal of this study was to improve our understanding of the natural history and risk factors for subsequent injuries. We hypothesized that injury to a given body part may influence both the occurrence of subsequent injuries overall and of future repeat injuries to the same body part and that these effects may vary across industries. As a second objective, to understand the probability of repeat claims, we examined both the timeframe in which repeat

claims occurred and the association between subsequent injury and workers' sex, age, industry, and body part of the initial claim.

2 | METHODS

2.1 | Sample

The largest workers' compensation insurer in the state of Colorado, Pinnacol Assurance, provided a deidentified database of all workers' compensation claims from 552 companies included in the Pinnacol Health Risk Management Study.¹⁹ The database included claims filed during a 10½-year period (126 months), covering 1 January 2005 through 31 July 2015. Variables of interest included claimant age, sex, date of injury, standard industrial classification (SIC) codes, and body part of injury involved in a claim. The Colorado Multiple Institutional Review Board deemed this study non-human subjects research. Claimants included in the study had no missing data related to age, sex, date of the initial injury, SIC codes, or body part of injury involved in a claim. Available detail with respect to the body part of injury included only the primary diagnosis for the claim, and there was no information available regarding sidedness of an injury. Many claimants experienced multiple claims, but only the first two claims for an individual were used in this analysis. The dataset included both open and closed claims, and also denied claims. These denied claims were estimated to represent approximately 5% of the dataset. Pinnacol encourages reporting of all injuries regardless of severity and in cases where work-relatedness is in doubt, so there are claims with no associated time loss or expense incurred. The original dataset included 114 569 claims, of which 77 494 met criteria for analysis.

2.2 | Study variables

Our outcomes of interest were second claims involving any body part and second claims involving the same body part. Our main predictors of interest were industry and body part involved in the first claim. We defined "industry group" using standard division level SIC grouping codes, and then condensed observations by code into one of 11 categories. Categories included agriculture/forestry/fishing; finance/insurance/real estate; manufacturing; mining and construction; public administration; police; retail trade; services; transportation/communications/electric/gas/sanitary services; wholesale trade; and fire. Initially, police and fire were contained within the public administration category, but during analysis, we observed higher rates of both first claims and second claims within these populations when compared to most other groups. As a result, we excluded police and fire from the public administration group and analyzed them as standalone categories.

We defined "body part" using anatomical location of injury, and then condensed observations by location of injury into one of 10 categories—head, neck, eye, lung, upper back, lower back (lumbosacral, sacrum, and coccyx), proximal upper extremity (elbow, shoulder, upper arm including clavicle and scapula), distal upper extremity (finger[s], hand, lower arm, thumb, and wrist), proximal

lower extremity (hip, knee, and upper leg), and distal lower extremity (ankle, foot, and lower leg). Ultimately, we focused our analysis on body parts with the highest frequencies due to sample size considerations. The most common injuries were lower back ($n = 10\,059$), proximal upper extremity ($n = 7\,022$), distal upper extremity ($n = 23\,240$), and proximal lower extremity ($n = 8\,579$). We classified the remaining observations ($n = 28\,594$) as “other.”

2.3 | Data analysis

Chi-squared tests were used to assess univariate associations between sex, age group, industry, and body part of injury and the two outcomes of interest—second claims involving any body part and second claims involving the same body part. In the analysis of sex, the variable had two categories—male and female. In the analysis of age, the variable had six categories—18 to 24, 25 to 34, 35 to 44, 45 to 54, 55 to 64, and 65+. In the analysis of industry, the variable had 11 categories—agriculture/forestry/fishing; finance/insurance/real estate; manufacturing; mining and construction; public administration; police; retail trade; services; transportation/communications/electric/gas/sanitary services; wholesale trade; and fire. In the analysis of body part, the variable had five categories—low back, proximal upper extremity, distal upper extremity, proximal lower extremity, and other. Each Chi-square test yielded an indicator of association between the variables described and the characteristic of second claims involving any body part or the same body part.

We developed Cox proportional hazards models, adjusted for age and sex, to estimate industry-specific time-to-event (survival) curves for a second claim within 5 years for both second claims involving any body part and the same body part. The Cox proportional hazards model is analogous to a multiple regression model and is commonly used to analyze survival time data when it is necessary to assess the effect of multiple covariates. The model assumes the covariates to be time-independent. The survival function and hazard function are fundamental to survival analysis, and being closely related can easily be converted to one another.²⁰ The survival function describes the probability of surviving past a given point in time, or more generally, the probability that the event of interest has not yet occurred. Therefore, the probability of an event, or claim in this instance, is the complement of the probability of event-free survival. All analyses were performed using SAS version 9.4 (2012; SAS Institute Inc., Cary, NC).

3 | RESULTS

3.1 | Sample description

Characteristics of the claims are presented in Table 1. There were 77 494 claims. Overall, claims in this study were equally distributed by sex. The claims predominately represented younger workers (under age 45). The most common industries were services (55.8%; $n = 43\,261$), retail trade (11.1%; $n = 8\,616$), and mining and construction (9.6%; 7419). First claims represented 74.9% ($n = 58\,007$) while

subsequent claims represented 25.2% ($n = 19,487$) of total claims. Most subsequent claims involved a new body part, with the same body part being affected in only 5.4% ($n = 4179$) of the total claims. It is important to note that the first claim is not necessarily the first claim for the worker; it is just the first claim observed in this dataset. In addition, the data do not distinguish whether a second claim involving the same body part included the same extremity or contralateral extremity as the first claim.

Chi-square tests were applied to sex, age, industry, and body part. With respect to sex, the distribution between males and females was not significantly different ($P = .972$), however, women were more likely to experience a second claim for the same body part (females 52.5%; $n = 2196$ vs males 47.5%; $n = 1983$, $P = .003$).

Across age groups, there were significant associations between age categories and future claims activity (any: $P < .001$; same: $P < .001$). The youngest age category (18-24 years) represented 17.4% ($n = 10\,073$) of first claims, but only 9.7% ($n = 1889$) of second claims and 11.9% ($n = 496$) of same body part second claims. The representation of claims increased most in the 45 to 54 years and 55 to 64 years age groups. The distribution of claims in the 45 to 54 years age group rose from 20.1% ($n = 11\,637$) of first claims to 24.0% ($n = 4681$) of second claims and 21.1% ($n = 880$) of same body part second claims. The distribution of claims in the 55 to 64 years age group rose from 12.4% ($n = 7193$) of first claims to 16.7% ($n = 3245$) of second claims and 15.2% ($n = 637$) of same body part second claims.

Industry categories also demonstrated significant associations with future claims (any: $P < .001$; same: $P < .001$). Police, fire, and agriculture had the most significant relative increases between first claims (0.8% [$n = 446$], 0.6% [$n = 343$], and 1.9% [$n = 1086$]) and second claims (any: 1.9% [$n = 368$], 1.0% [$n = 189$], and 2.9% [$n = 561$]; same: 1.8% [$n = 76$], 0.8% [$n = 35$], and 4.8% [$n = 202$]). Retail, finance/insurance/real estate, and mining and construction had the most significant relative decreases between first claims (12.5% [$n = 7231$], 2.2% [$n = 1271$], and 10.0% [$n = 5820$]) and second claims (any: 7.1% [$n = 1385$], 1.7% [$n = 332$], and 8.2% [$n = 1599$]; same: 7.7% [$n = 320$], 1.8% [$n = 74$], and 7.2% [$n = 299$]).

Regarding body part, there were significant associations between first body part injured and the second injury, involving both any body part ($P < .001$) and same body part ($P < .001$). As shown in Table 1, the distal upper extremity was the most commonly affected body part among the four designated categories (30.0%; $n = 23\,240$). Distal upper extremity also was the most common of first claims (30.0%; $n = 17\,386$), second claims (28.9%; $n = 5628$), and same body part second claims (52.2%; $n = 2182$). Low back claims were the second most common overall (13.0%; $n = 10\,059$). Low back claims comprised 13.2% ($n = 7645$) of first claims, 13.4% ($n = 2616$) of second claims, and 14.5% ($n = 605$) of same body part second claims.

Within second claims, patterns of injury emerged with respect to body part and industry (Table 2). Except for fire, distal upper extremity was the most common second claim and same body part second claim. Distal upper extremity claims represented over 22% of all second claims and over 35% of all same body part second claims in

TABLE 1 Characteristics of total worker population: sex, age, industry, and body part involved

Characteristics at first claim	Claims overall [1]	%	First claims [2]	%	Second claims any body part [3]	%	Second claims same body part [4]	%
Sex								
Male	38 646	49.9	28 930	49.9	9716	49.9	1983	47.5
Female	38 848	50.1	29 077	50.1	9771	50.1	2196	52.5
Total	77 494		58 007		19 487		4179	
Age								
18-24	11 962	15.4	10 073	17.4	1889	9.7	496	11.9
25-34	20 058	25.9	15 306	26.4	4752	24.4	1124	26.9
35-44	16 782	21.7	12 413	21.4	4369	22.4	943	22.6
45-54	16 318	21.1	11 637	20.1	4681	24.0	880	21.1
55-64	10 438	13.5	7193	12.4	3245	16.7	637	15.2
65+	1936	2.5	1385	2.4	551	2.8	99	2.4
Total	77 494		58 007		19 487		4179	
Industry								
Police	814	1.1	446	0.8	368	1.9	76	1.8
Fire	532	0.7	343	0.6	189	1.0	35	0.8
Public administration (police and fire excluded)	4119	5.3	2,753	4.7	1,366	7.0	229	5.5
Agriculture, forestry, and fishing	1647	2.1	1086	1.9	561	2.9	202	4.8
Mining and construction	7419	9.6	5820	10.0	1599	8.2	299	7.2
Manufacturing	4295	5.5	3145	5.4	1150	5.9	285	6.8
Transportation, communications, electric, gas, and sanitary services	2427	3.1	1690	2.9	737	3.8	140	3.4
Wholesale trade	2761	3.6	2117	3.6	644	3.3	126	3.0
Retail trade	8616	11.1	7231	12.5	1385	7.1	320	7.7
Finance, insurance, and real estate	1603	2.1	1271	2.2	332	1.7	74	1.8
Services	43 261	55.8	32 105	55.3	11 156	57.2	2393	57.3
Total	77 494		58 007		19 487		4179	
Body part								
Low back	10 059	13.0	7645	13.2	2616	13.4	605	14.5
Proximal upper extremity*	7022	9.1	5150	8.9	2084	10.7	313	7.5
Distal upper extremity**	23 240	30.0	17 386	30.0	5628	28.9	2182	52.2
Proximal lower extremity***	8579	11.1	6344	10.9	2279	11.7	433	10.4
Other	28 594	36.9	21 482	37.0	6880	35.3	646	15.5
Total	77 494		58 007		19 487		4179	
	Chi-square (P values)			Sex	Age	Industry	Body part	
	First claims/second claims any body part			.972	<.001	<.001	<.001	
	First claims/second claims same body part			.003	<.001	<.001	<.001	

The number of claims overall [column 1] includes the number of first claims [column 2] and second claims: any body part [column 3]. Second claims: same body part [column 4] is a subset of second claims: any body part [column 3].

Chi-square analysis tests the relationship between characteristics (sex, age, industry, body part) and claims (first claims [column 2] and second claims: any body part [column 3]; and first claims [column 2] and second claims: same body part [column 4]).

*Proximal upper extremity: elbow, shoulder, upper arm, scapula/clavicle.

**Finger(s), hand, lower arm, thumb, wrist.

***Hip, knee, upper leg.

TABLE 2 Distribution of second claims by industry and body part injured

Distribution of second claims, any body part	Low back		Proximal upper extremity		Distal upper extremity		Proximal lower extremity		Other		Total
	N	%	N	%	N	%	N	%	N	%	
Industry	N	%	N	%	N	%	N	%	N	%	N
Police	53	14.4	50	13.6	86	23.4	53	14.4	126	34.2	368
Fire	35	18.5	12	6.3	25	13.2	23	12.2	94	49.7	189
Agriculture, forestry, and fishing	41	7.3	40	7.1	280	49.9	42	7.5	158	28.2	561
Public administration (police and fire excluded)	155	11.3	148	10.8	335	24.5	201	14.7	527	38.6	1366
Transportation, communications, electric, gas, and sanitary services	102	13.8	83	11.3	164	22.3	91	12.3	297	40.3	737
Finance, insurance, and real estate	47	14.2	40	12.0	107	32.2	33	9.9	105	31.6	332
Manufacturing	151	13.1	131	11.4	389	33.8	93	8.1	386	33.6	1150
Services	1477	13.2	1197	10.7	3191	28.6	1389	12.5	3901	35.0	11 156
Wholesale trade	115	17.9	67	10.4	181	28.1	71	11.0	210	32.6	644
Mining and construction	230	14.4	164	10.3	446	27.9	144	9.0	615	38.5	1599
Retail trade	210	15.2	152	11.0	424	30.6	139	10.0	459	33.1	1385
Total	2616		2084		5628		2279		6878		19 487
Distribution of second claims, same body part	Low back		Proximal upper extremity		Distal upper extremity		Proximal lower extremity		Other		Total
Industry	N	%	N	%	N	%	N	%	N	%	
Police	11	14.5	10	13.2	33	43.4	10	13.2	12	15.8	76
Fire	6	17.1	1	2.9	6	17.1	4	11.4	18	51.4	35
Agriculture, forestry, and fishing	6	3.0	4	2.0	171	84.7	5	2.5	16	7.9	202
Public administration (police and fire excluded)	36	15.7	18	7.9	96	41.9	32	14.0	47	20.5	229
Transportation, communications, electric, gas, and sanitary services	23	16.4	20	14.3	50	35.7	19	13.6	28	20.0	140
Finance, insurance, and real estate	11	14.9	7	9.5	44	59.5	5	6.8	7	9.5	74
Manufacturing	33	11.6	22	7.7	161	56.5	13	4.6	56	19.6	285
Services	349	14.6	179	7.5	1243	51.9	285	11.9	337	14.1	2393
Wholesale trade	30	23.8	10	7.9	60	47.6	9	7.1	17	13.5	126
Mining and construction	50	16.7	21	7.0	141	47.2	23	7.7	64	21.4	299
Retail trade	50	15.6	21	6.6	177	55.3	28	8.8	44	13.8	320
Total	605		313		2182		433		646		4179

every industry except Fire (13.2%; $n = 25$ and 17.1%; $n = 6$). The proportion of distal upper extremity claims was most significant in agriculture/forestry/fishing, where these injuries comprised 49.9% ($n = 280$) of second claims and 84.7% ($n = 171$) of same body part second claims.

3.2 | Time-to-event analysis

As shown in Figure 1, the overall five-year probability of second claims was 27.0% (26.6%-27.5%) in males and 26.5% (26.0%-27.0%) in females, while the 5-year probability of same body part second claims was 6.2% (5.9%-6.5%) in males and 6.7% (6.5%-7.0%) in females. Table S1

specifies 95% confidence intervals (CI) by industry and provides a comparison of survival probabilities derived by the Kaplan-Meier method and Cox proportional hazards models. The models in this analysis violated the proportionality assumption, which is considered central to the Cox model. The importance of proportionality is debated, however, because the hazard ratio can still be viewed as an average effect when the assumption is not met.²¹ In addition, the objective was to obtain adjusted survival probabilities rather than between-group comparisons, and the Kaplan-Meier method and Cox proportional hazards models yielded similar results. We, therefore, favored use of Cox proportional hazards models despite the violation of the proportionality assumption.

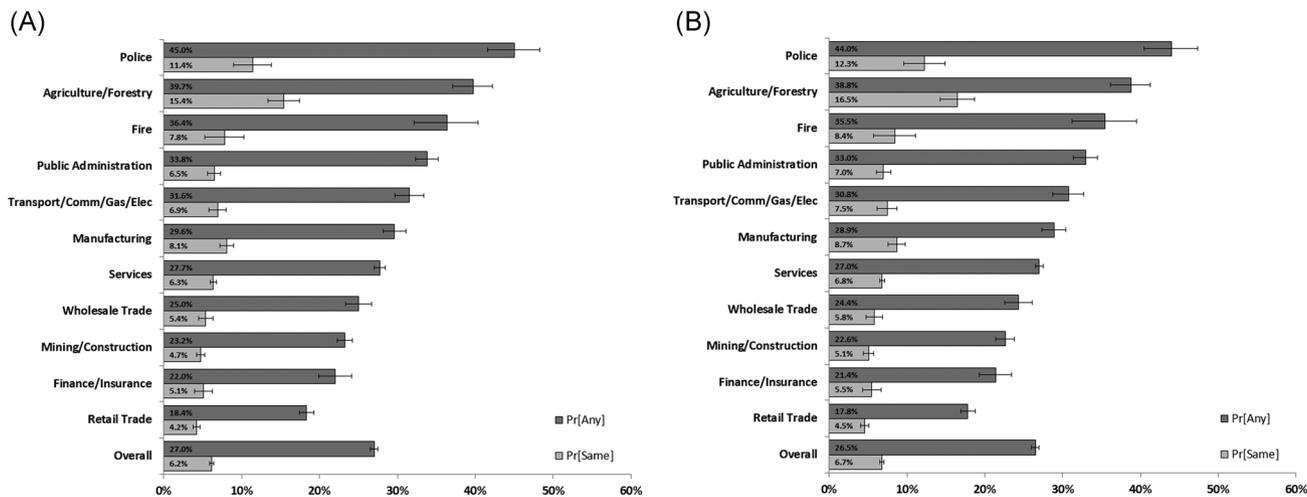


FIGURE 1 Five-year probability of a second claim by industry for males (A) and females (B), including second claims at any body part and second claims at the same body part

The 5-year probability of second claims was highest for police (45.0% [41.6%-48.3%]; 44.0% [40.5%-47.3%]) and lowest for retail trade (18.4% [17.4%-19.3%]; 17.8% [16.9%-18.7%]). Multiple other industries had 5-year risks of second claims in excess of 30%. The

five-year probability of same body part second claims was highest for agriculture/forestry/fishing (15.4% [13.4%-17.4%]; 16.5% [14.3%-18.6%]), and lowest for retail trade (4.2% [3.7%-4.7%]; 4.5% [4.0%-5.1%]). Police and Fire also had high five-year probabilities of same

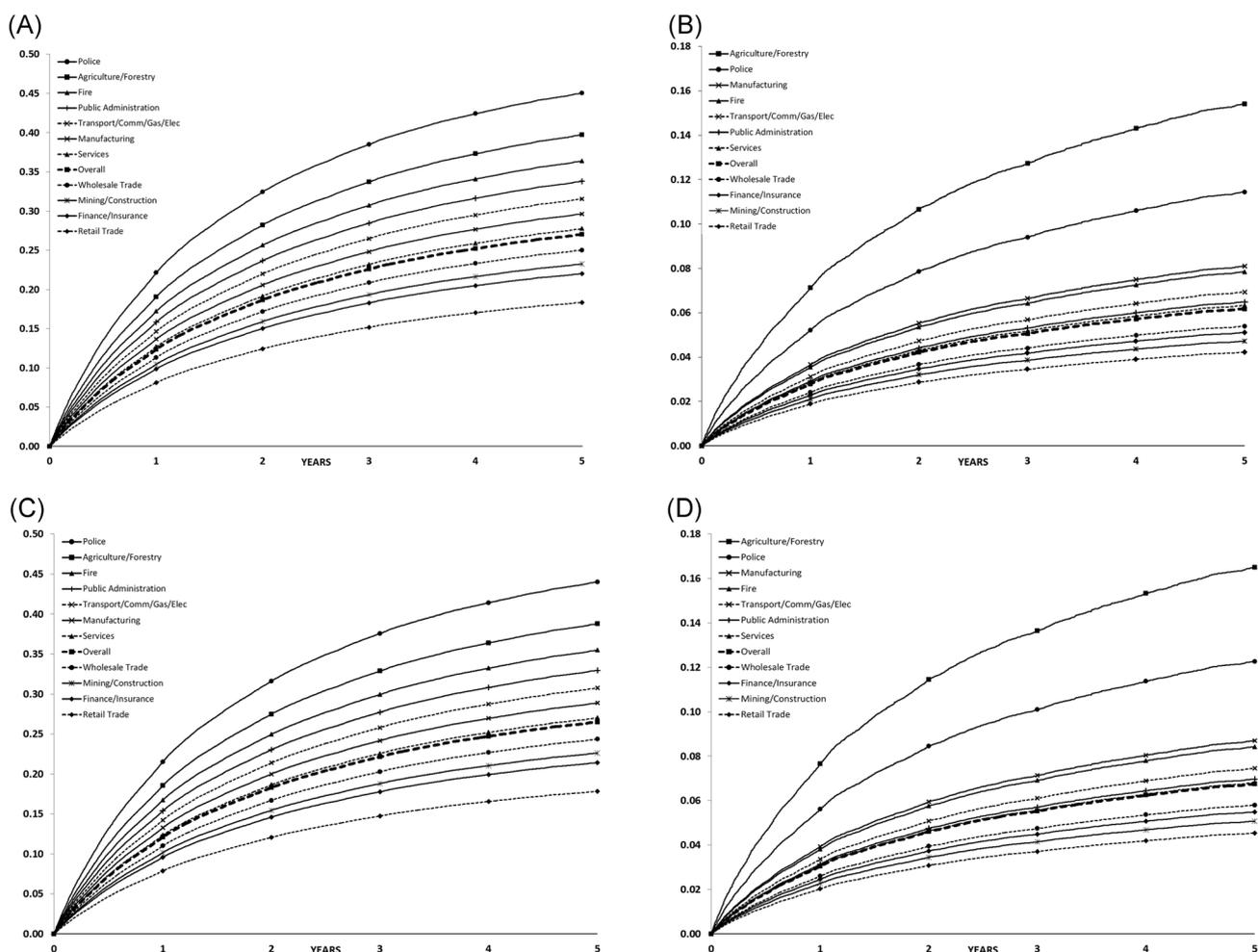


FIGURE 2 The trend of the probability of second claims by industry for males—second claim at any body part (A) and second claim at same body part (B), and for females—second claim at any body part (C) and second claim at same body part (D)

body part second claims (11.4% [9.0%-13.8%]; 12.3% [9.6%-14.9%]), (7.8% [5.3%-10.3%]; 8.4% [5.7%-11.1%]).

Figure 2 presents time-to-event injury probabilities up to 5 years. The slopes of the event lines rise most rapidly within the first 2 years, before becoming nearly asymptotic to the eventual 5-year probabilities of a second claim by the third year. For any body part claims, police experienced the highest overall probability of the second claim regardless of sex, followed by agriculture/forestry/fishing and fire. For same body part claims, agriculture/forestry/fishing experienced the highest overall probability of second claims regardless of sex.

Five-year probabilities of second claims also varied by industry and body part of interest—low back, proximal upper extremity, distal upper extremity, and proximal lower extremity (Figures 3 and 4). Specific values for 95% CI by industry are provided in Table S2, and the anatomical composition of the categories of body parts analyzed is provided in Table S3. Overall, when industry is not considered, the probability of a second claim was similar for each category of a body part, ranging from 26.0%-28.3% in males to 24.3%-27.9% in females. The probability of repeat claims involving the same body part ranged from 5.4%-9.9% in males to 4.9%-11.9% in females.

Patterns of injury emerged for certain body parts within specific industries. For example, police stood apart with exceedingly high probabilities of repeat claims. This group had the highest 5-year probabilities of second claims and same body part second claims for both males and females with respect to injuries involving the low back, proximal upper extremity, and proximal lower extremity. The same is true for fire, which experienced the second highest 5-year probabilities of both overall and same body part second claims for low back and proximal lower extremity claims in males and females. By comparison, retail trade generally had low probabilities of repeat claims regardless of body part or sex.

Mining and Construction, both considered high-hazard environments, experienced some of the lowest rates of repeat claims when comparing across industries (Figures 3 and 4). These unexpectedly low rates may be due to the fact that inclusion in this dataset is tied to employment, and employees in these industries often move between employers. Agriculture/forestry/fishing is remarkable as the only industry with a higher 5-year probability of second claims than police in any category of body part. Following a first distal upper extremity claim, the agriculture/forestry/fishing industry 5-year

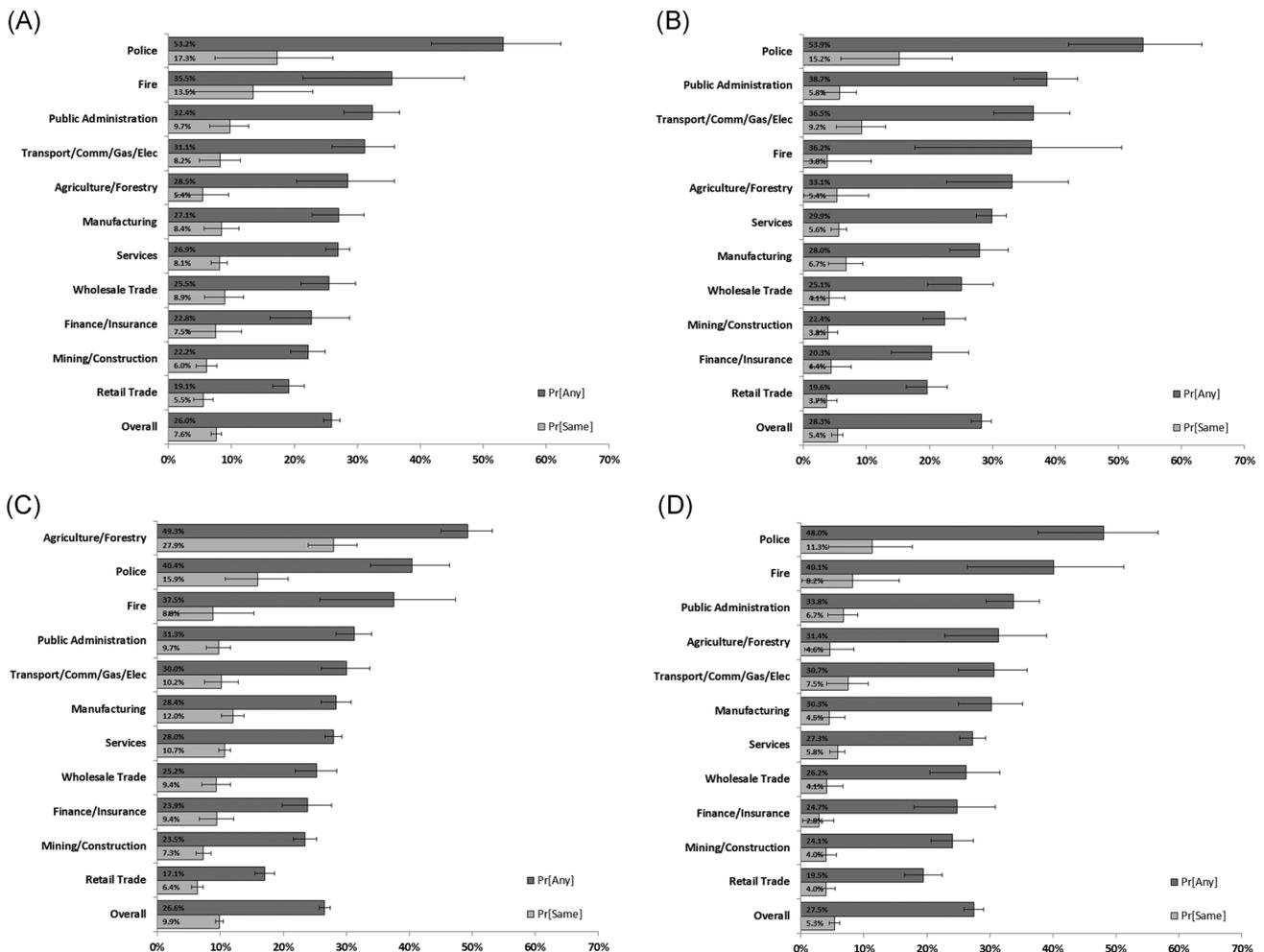


FIGURE 3 Five-year probability of a second claim for males by industry for body parts involved in the initial injury, including second claims at any body part and second claims at the same body part. Body parts shown are low back (A), proximal upper extremity (B), distal upper extremity (C), and proximal lower extremity (D)

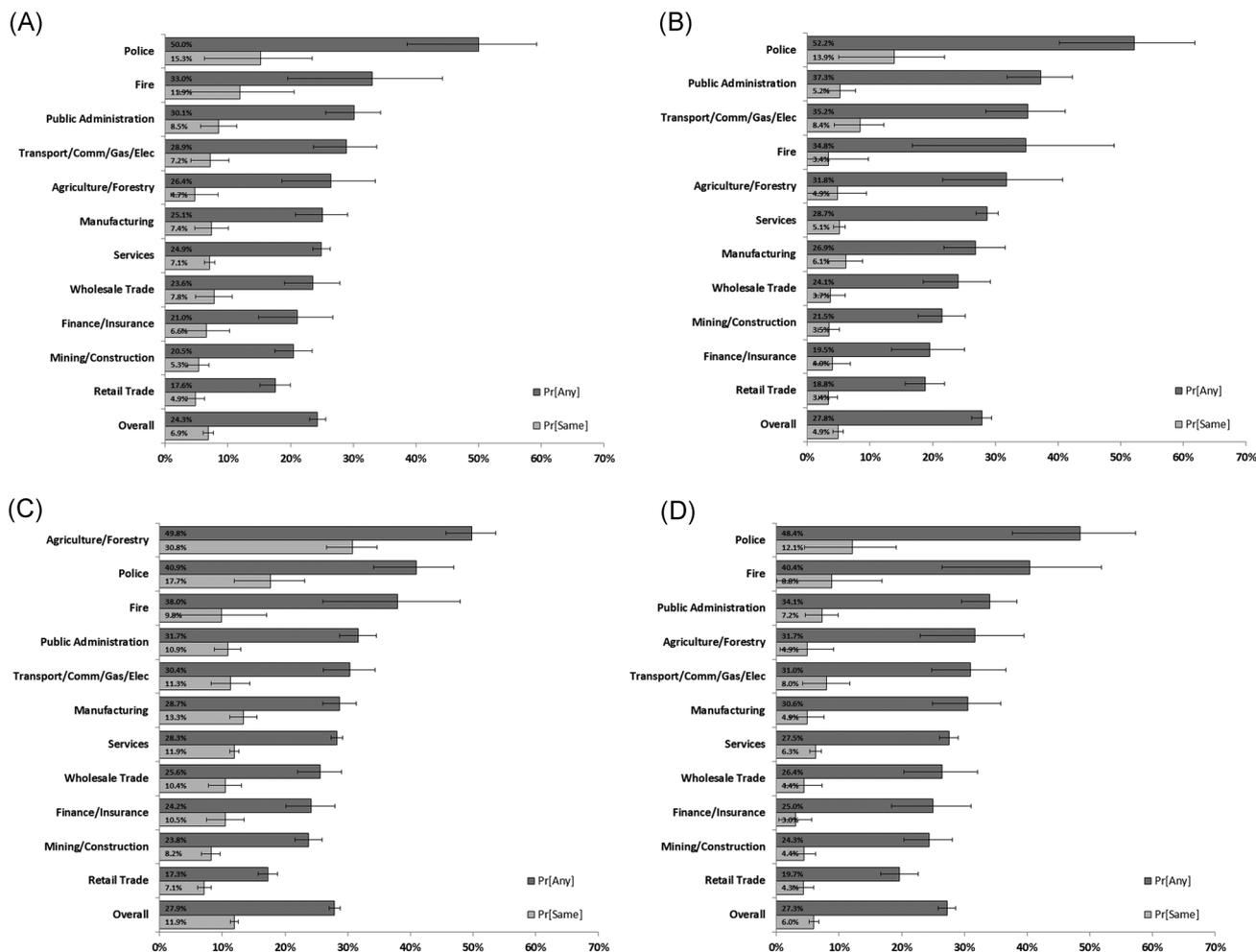


FIGURE 4 Five-year probability of a second claim for females by industry for body parts involved in the initial injury, including second claims at any body part and second claims at the same body part. Body parts shown are low back (A), proximal upper extremity (B), distal upper extremity (C), and proximal lower extremity (D)

probability of a second claim was 49.3% (45.1%-53.2%) in males and 49.8% (45.6%-53.6%) in females, while the probability of same body part second claim was 27.9% (24.0%-31.7%) in males and 30.8% (26.7%-34.7%) in females. This was the highest probability of same body part second claims regardless of the body part and statistically distinguishable from all other industries, suggesting a pattern of relatively similar injuries in this group.

4 | DISCUSSION

This study yielded several important findings related to the body part of injury and industry involved in repeat workers' compensation claims. Foremost, it supports the idea that body part of initial injury influences the anatomical site of subsequent injuries. Previous studies of the relationship between repeat claims and body part injured focused on recurrence of low back injuries,^{10,12,17,22} and did not explore the impact on other body parts in detail. It is clinically plausible that body part is an important predictor of future claims. Injury to one part of the anatomy, for example back injury, may

predispose to injury of other body parts, or weaken tissues making them more prone to repeat injury in the future. We observed significant associations between body parts involved in first and second claims.

Second, this study demonstrated that second claims happen quickly, most often within the initial 3 years following the first claim. This finding was industry agnostic and occurred for both any body part and same body part second claims. Ruseckaite et al^{5,6} report means of 1104 days (±1063) and 1088 days (±1057) between first and second claims, while Cherry et al⁴ report a mean of 744 days (±687). Our data generally confirm their findings. The speed of subsequent injury is troubling, and the relatively brief timeframe between first and second claims suggests missed opportunities to mitigate workplace hazards.

Finally, the relationship between body part injured and claims activity varied depending upon the industry, with surprisingly high probabilities (>30%) of second claims in certain industries. Claims activity varied across industries, both overall and for different body parts, with some industries exhibiting very high probabilities of subsequent claims. In agriculture/forestry/fishing, distal upper

extremity injuries represented 49.9% of second claims and 84.7% of same body part second claims. The 5-year probability of second distal upper extremity claims in this industry was 27.9% (24.0%-31.7%) in males and 30.8% in females (26.7%-34.7%). For same body part second claims, no other industry experienced a relative proportion of injuries near this level. This pattern suggests a relatively heterogeneous distribution of injuries in second claims across all industries while underscoring the significance of distal upper extremity injuries in agriculture/forestry/fishing.

The findings in agriculture/forestry/fishing correlate with previous studies, where farmers and farm workers experienced high rates of low back, shoulder, and upper extremity disorders,^{23,24} in particular sprains and strains.^{25,26} The rate of arthritis, considered a repetitive motion and overuse injury, was also greater in a study of a farm cohort (147.3 per 1000 people, age adjusted) compared to a nonfarm cohort (141.2 per 1000 people, age adjusted).²⁷ These findings may not be surprising given the hands-on nature of job tasks in these professions. Existing evidence also suggests that conditions of work, such as poor ergonomics and awkward postures,^{28,29} increase the risk of injury in agricultural workers.

The police and fire groups had high probabilities of repeat claims regardless of the body part involved. This finding is consistent with 2016 U.S. Bureau of Labor Statistics data, which rank police and fire in the top five of all industries in terms of annual nonfatal occupational injury rates—9.1 and 8.6 injuries per 100 workers respectively.³⁰ The consistent finding of elevated injury probabilities in the police group supports the premise that their work environment is inherently hazardous. Most media attention focuses on fatalities rather than occupational injuries. On average, 115 police and sheriff's patrol officers suffered fatal work injuries each year from 2003 to 2014.³¹ In 2014, this translated to a rate of 13.5 per 100 000 full-time equivalent workers, compared to 3.4 for all occupations.³¹ There is a general paucity of descriptive research investigating the nature and course of both occupational fatalities and occupational injuries in this population.

Similar to the police group, the fire group experienced extremely high probabilities of repeat claims. Unlike police, most second claims for firefighters fell into the "other" category, suggesting a more heterogeneous nature of subsequent injuries. A study by the Rand Corporation Center for Health and Safety in the Workplace found firefighters are 3.5 times more likely to suffer a workplace injury, and 3.8 times more likely to suffer a work-related musculoskeletal disorder than a private-sector worker.³² Firefighters also take twice as long to return to work after a musculoskeletal injury.³² The National Fire Protection Association (NFPA) estimates that overexertion (27.1%) and falls-slips-trips (21.0%) are the most common causes of occupational injuries in this population.³³ Overexertion alone may account for over one-third of all injuries, and, in one estimate, over 80% of overexertion injuries resulted in strains and sprains to the firefighters.³⁴ Fatalities are also common, with an average of 31 firefighters killed each year in the United States from 2008 to 2011.³⁵ Of interest, only 39% of injuries to firefighters occur on the fireground; the remainder occur during nonfire emergencies

(21%), other on-duty activities (18%), training (14%), and responding to/returning from incidents (8%).³³ Given the findings of this study and patterns described by the NFPA, there appears to be an opportunity for future research examining circumstances surrounding firefighter injuries.

The collection of findings in this study provides an opportunity to better focus on prevention opportunities. Given the high probability of repeat claims, the initial presentation of an injury provides an opportunity to counsel patients related to specific risks associated with their work, and discuss strategies to mitigate the possibility of future injuries. We highlighted agriculture, police, and fire as industries at particularly high risk. In general, while there are patterns of repeat injuries to the same body part, subsequent claims usually involve injuries to different areas of the body. This finding suggests that it may be less an issue of overly aggressive return to work policies or lack of modifiable job options, but rather the persistence of hazards in the work environment that presents the greatest risk.

There are several limitations to our analysis. First, individuals included in this dataset may have claims that occurred outside the study time period, or previously worked for other employers. Thus, first claims in this dataset actually may be subsequent claims, and some subsequent claims may not be captured, resulting in censored observations. In either case, the omission of claims would bias the analysis toward the null, thereby underestimating the true effect. Second, this analysis excluded future claims beyond the second claim. This exclusion of subsequent claims was necessary to perform time-to-event analysis, but admittedly ignores a portion of the available data. Including this information may demonstrate that certain professions experience greater/fewer claims on average, or that injuries to certain body parts may predispose to greater/fewer claims on average. Third, limitations in detail of available data such as lack of body part involved beyond the primary diagnosis and lack of sidedness of injury prevented a deeper analysis. Fourth, this study included worker's compensation claims only in the state of Colorado which may affect generalizability. Fifth, because inclusion in this dataset is predicated on being able to work, it does not include individuals that leave the workforce, thereby potentially underestimating the number and severity of future injuries. Sixth, misclassification of claims was possible in the original dataset and we estimate that approximately 5% of claims in the dataset were ultimately rejected. Finally, inclusion in the dataset was tied to the employer. We believe this may help explain why Mining and Construction, where work is often project-based, had fewer occurrences of repeat claims than one might expect. Likewise, a typical long duration of employment for Police and Fire likely help this study reflect a more realistic picture of these industries.

Many opportunities exist for additional research on this subject. First, investigating characteristics of multiple claims both within industries and affecting specific body parts would be valuable for various stakeholders. Police, fire, and the agriculture/forestry/fishing industries specifically had high probabilities of future claims. Ideally, future analyses would account for movement between employers.

Second, this study did not look beyond the first two claims, so there is an opportunity to understand the complete pattern of workers' injuries over a lifetime of work in each industry. Third, this study suggests there is an important relationship between body parts involved in the first claim and future claims. To guide prevention strategies, more research is needed to better understand the natural course of injuries and the relationship between these claims. Fourth, a desirable next step would be to refine predictive models using datasets with more information related work conditions, work schedules, and worker characteristics. Finally, although beyond the scope of this study, it would be important for future research to examine the economic, social, and personal impacts of repeat claims. If initial injuries are treated as sentinel health events that result in changes to work practices, the human and economic burden of subsequent injuries may be greatly reduced.

In conclusion, this was the first study to specifically investigate the relationship between body part and industry involved in the first claim and its role with respect to second claims. Specific industries and specific types of injuries deserve more attention. Occupational medicine providers should use the findings of this study to guide conversations and advise patients. Workplaces should use these findings to target safety programs that help prevent subsequent injuries and promote a healthier, more productive workforce.

ACKNOWLEDGMENTS

The authors would like to thank NIOSH (Grant number: T42 OH009229) for their support. Pinnacol Assurance furnished the dataset and provided philanthropic support to the Occupational and Environmental Medicine Fellowship Program at Colorado School of Public Health.

CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

DISCLOSURE BY AJIM EDITOR OF RECORD

John Meyer declares that he has no conflict of interest in the review and publication decision regarding this article.

AUTHOR CONTRIBUTIONS

All authors participated in the study design, data analysis, drafting and revision of the work, final approval of the version to be published, and agree to be accountable for all aspects of the content of this manuscript.

INSTITUTION AND ETHICS APPROVAL AND INFORMED CONSENT

The Colorado Multiple Institutional Review Board deemed this study non-human subjects research.

ORCID

Courtland Keteyian  <http://orcid.org/0000-0003-4252-776X>

Natalie Schwatka  <http://orcid.org/0000-0002-3768-9572>

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

How to cite this article: Keteyian C, Schwatka N, Dally M, et al. The impact of industry and body part injured on repeat workers' compensation claims. *Am J Ind Med*. 2019;62: 680-690. <https://doi.org/10.1002/ajim.22994>