ORIGINAL ARTICLE

Health risk factors as predictors of workers' compensation claim occurrence and cost

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ABSTRACT

Objective The objective of this study was to examine the predictive relationships between employee health risk factors (HRFs) and workers' compensation (WC) claim occurrence and costs.

Methods Logistic regression and generalised linear models were used to estimate the predictive association between HRFs and claim occurrence and cost among a cohort of 16 926 employees from 314 large, medium and small businesses across multiple industries. First, unadjusted (HRFs only) models were estimated, and second, adjusted (HRFs plus demographic and work organisation variables) were estimated.

Results Unadjusted models demonstrated that several HRFs were predictive of WC claim occurrence and cost. After adjusting for demographic and work organisation differences between employees, many of the relationships previously established did not achieve statistical significance. Stress was the only HRF to display a consistent relationship with claim occurrence, though the type of stress mattered. Stress at work was marginally predictive of a higher odds of incurring a WC claim ($p<0.10$). Stress at home and stress over finances were predictive of higher and lower costs of claims, respectively ($p<0.05$).

Conclusions The unadjusted model results indicate that HRFs are predictive of future WC claims. However, the disparate findings between unadjusted and adjusted models indicate that future research is needed to examine the multilevel relationship between employee demographics, organisational factors, HRFs and WC claims.

What this paper adds

- Little is known about how health risk factors (HRFs) are related to the frequency and cost of the occupational injuries, illnesses and fatalities that result in workers' compensation (WC) claims. Previously, researchers focused on large, single-company sample populations to examine this relationship.
- Using a diverse sample of workers and worksites, the researchers demonstrated that some HRFs are more common among those workers who subsequently experience a work-related injury that results in a WC claim. However, the analyses suggest that HRFs, demographic and work organisation factors may interact to predict the occurrence and cost of WC claims.
- These findings reinforce the value of introducing a Total Worker Health approach whereby employers optimise the work environment to prevent and mitigate work-related injuries and poor health, especially with the goal of mitigating sources of stress, while also serving as a platform for empowering employees to adopt and practice behaviours for better personal health *and* safety.

INTRODUCTION

Parallel trends can be observed between the rise in direct and indirect costs of healthcare and work-related injury and illness. In 2013, the US Bureau of Labor Statistics reported over 3 000 000 non-fatal workplace injuries[1] and over 4000 fatal work injuries.[2] Of the non-fatal injuries, approximately one-third resulted in lost work time with a median of 8 days away from work per case.[3] While the frequency of occupational injuries and illnesses has declined over the past two decades, the cost per workers' compensation (WC) claim has risen.[4] Occupational injuries cost US employers almost $250 billion dollars annually.[5]

At the same time, workers' health and the risk factors leading to poor health have also been shown to influence employer costs and employee productivity. Ward and Schiller[6] estimated that a quarter of US adults have at least one chronic health condition, and another quarter has two or more. Many adults also experience depression, anxiety and other types of mental distress.[7] Chronic conditions result in significant out-of-pocket healthcare costs.[8] Personal health risk factors (HRFs), as assessed by an employer-sponsored health promotion programme using health risk assessments (HRAs), have previously been associated with higher healthcare and lost productivity costs. Goetzel *et al*[9 10] found that depression, high stress, high glucose levels, high blood pressure, obesity, high cholesterol and lack of exercise were associated with high healthcare costs. Goetzel *et al*[11] also found that factors related to high biometric laboratory values (eg, blood pressure), alcohol/tobacco use and emotional problems

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were associated with higher presenteeism (ie, poor job performance). Frey *et al*[12] found that some psychosocial factors (eg, poor sleep) were associated with higher presenteeism.

On a broader scale, in 2011, total US healthcare costs exceeded $2.7 trillion with ~84% of the costs attributable to personal healthcare and 10% attributable to prescription drug costs.[13] Identifying modifiable HRFs via early detection and facilitating necessary treatment and/or behaviour change can reduce direct and indirect costs associated with chronic conditions and other preventable illnesses, and improve worker productivity.[14]

Organisations adopting a Total Worker Health (TWH) strategy seek to understand the relationships between health promotion and health protection and how a more holistic approach can positively influence employee health, safety and well-being.[15] One way in which to understand the interplay between worker health and safety is to examine how HRFs are related to occupational injury. Although there is emerging evidence of an association between employee health and occupational injury,[16] little is known about how HRFs are related to the frequency and severity of injuries, illnesses and fatalities that result in WC claims.

Previously, researchers focused on the relationship between employees' comorbid HRFs and WC based on samples from single, large companies (ie, >1000 employees).[17–20] Some studies focused on evaluating the relationship between overall health risk level and WC claims by summing the number of HRFs or examining individual HRFs.[18–20] Their findings have been inconsistent regarding the relationship between HRFs and WC claims,[17–20] and only one study[17] examined whether HRFs predict subsequent injury and cost. This study is a continuation of the Pinnacol Assurance Health Risk Management (HRM) research programme.[21] The purpose of the HRM programme is to understand the impact of a worksite wellness programme offered by a WC insurer on the health, safety and productivity of covered employees. As part of this research, the present study examines the prospective relationship between individual HRFs, as defined by self-reported HRA responses, and WC occurrence and cost among a diverse sample of employees from multiple employers (see table 1). We hypothesised that HRFs related to lifestyle, psychosocial conditions and health conditions are predictive of (1) a higher odds of filing a WC claim and (2) higher medical and total costs of WC claims.

METHODS

Sample

The present study draws on a cohort of Colorado employees (N=16 926) from 314 companies who participated in a prospective longitudinal study from 1 May 2010 to 31 December 2014. The HRM programme included annual HRAs, feedback reports, action plans for improving wellness and reducing health risks, unlimited telephonic coaching and access to educational resources for employees. Employers with more than 50 participating employees received annual risk and recommendation reports with *aggregated* employee HRF data to highlight employee needs, ongoing feedback on participation and progress, educational content to distribute to employees and advice on programme enhancements. If employers had fewer than 50 employees, they were given an aggregated report based on their industry average to benchmark across HRFs. Pinnacol Assurance supported an external evaluation of the HRM programme by partnering with researchers from several academic institutions.[21 22] For the purposes of this study, the unit of analysis was an employee who completed a baseline HRA questionnaire during the study period.

The data analysed in this study were subjected to a robust data linkage process to insure worker privacy. The HRA data were transferred from the wellness vendor, and the WC claims data were transferred from Pinnacol Assurance to the Integrated Benefits Institute for de-identification and then transferred to the Center for Health, Work and Environment at the Colorado School of Public Health for analysis. The Colorado Multiple Institutional Review Board determined the study to be exempt from human subjects research.

Measures

An online, self-administered, English and Spanish HRA was offered to employees. The Wellsource HRA[23] used was provided by Trotter Wellness and certified by the National Committee for Quality Assurance. The HRA included validated questions in the following categories: biographical information, health history, medical care, physical activity, nutrition, substance use, mental/social health, injury prevention practices in one's personal life and readiness to change. The HRA was supplemented with 58 additional selected questions from the WHO's Health and Work Performance Questionnaire (HPQ)[24] and a shortened version of the validated HPQ, the HPQ Select,[25] including demographic, health and productivity information. All responses were self-reported. For this study, the HRFs of interest were related to lifestyle, psychosocial and health condition factors. The HRFs were chosen based on their association with healthcare costs in previous literature.[9 10] The variables, their descriptions and operational definitions of high risk can be found in online supplementary table S1. HRFs were considered present if employees indicated that they had the condition, and absent if employees indicated that they did not have the condition or if they left the question blank.

WC claims were included if they were initially filed within 1 year *from* the date when the employee completed a baseline HRA and occurred at the same company in which the HRA was taken. On average, employees filed a claim 160 days (SD=105) after their baseline HRA. We excluded claims (3.0%) that had not closed within 18 months of the date of injury. For the purpose of this study, we only included compensable non-zero-cost claims (66%). Employees with a zero-cost WC claim were categorised the same way as employees without a claim because zero-cost claims do not represent compensable injuries, illnesses or fatalities. The WC variables of interest were (1) a dichotomous variable representing whether or not there was at least one compensable claim filed, (2) medical cost and (3) the total cost of the claim(s) that were filed. Total cost included all medical, indemnity and expenses (eg, legal fees) associated with the claim. Medical costs included all direct medical care costs (eg, clinical care, hospitalisation and prescriptions). All cost data were inflation-adjusted to 2013 dollars using the Consumer Price Index. Pinnacol Assurance provided all claims data.

Finally, employee demographic and work organisation variables were included as control variables in all adjusted analyses. Employee demographic variables included age, gender and education level. Work organisation variables included employment type (full time vs part time), pay scheme (hourly vs salary), occupation, income, company size (number of employees) and industry (Standard Industry Codes (SIC)). Results for all variables were derived from the HRA, except for company size and industry, which were provided by Pinnacol Assurance.

Table 1 Demographic and work organisation characteristics of employees with and without a WC claim

			Claim (n=533)		
	Overall (N=16 926)	No claim (n=16 393)		Total claim cost ($)	
Characteristics	Per cent+ (%)	Per cent+ (%)	Per cent+ (%)	M	SD
Sex*					
Male	60	61	49	$3044	$8155
Female	40	39	51	$4847	$16 492
Age (years)					
18–24	8	8	9	$1516	$2677
25–34	26	26	25	$2492	$7169
35–44	24	24	24	$4723	$17 629
45–54	24	24	22	$5729	$16 255
55–64	16	16	18	$4216	$11 737
65+	3	3	2	$2163	$2947
Race/ethnicity					
White	84	84	80	$3778	$13 524
Black	1	1	1	$3298	$5136
Hispanic/Latino	12	11	15	$5008	$10 529
Other	3	4	4	$5447	$18 043
Education*					
At least a 4-year college degree	51	52	36	$4821	$10 909
Some college or 2-year degree	31	30	39	$3420	$9517
High school diploma or GED	16	16	19	$4396	$14 858
Did not complete high school	3	3	6	$3666	$13 154
Employment type*					
Full time	91	91	93	$3860	$13 716
Part time	9	9	7	$5752	$13 023
Pay scheme*					
Salary	51	52	33	$3396	$9770
Hourly	49	48	67	$4257	$14 530
Industry*					
Agriculture	0	0	1	$1951	$2100
Mining/construction	11	11	13	$4537	$12 037
Manufacturing	5	5	5	$2778	$5623
Transport/communication/electric/gas/sanitation	3	3	4	$4133	$10 189
Wholesale trade	3	3	4	$10 115	$39 680
Retail trade	10	10	8	$4481	$11 276
Finance	6	6	1	$2352	$2685
Services	51	52	48	$3429	$9907
Public administration	10	10	16	$4131	$16 855
Occupation*					
Executive	14	14	9	$2723	$4432
Professional	36	36	25	$4991	$16 912
Technical support	3	3	3	$1134	$1696
Sales	7	7	5	$3006	$8243
Clerical and administrative support	15	15	10	$2312	$5129
Service occupation	12	12	20	$5126	$18 189
Precision production and crafts worker	3	3	3	$961	$982
Chemical/production operator	1	1	1	$14 087	$28 130
Labourer	11	10	24	$3584	$8825
Annual income (in dollars)*					
<10 000	7	7	7	$3759	$8580
10 000–14 999	5	5	5	$3466	$13 569
15 000–19 999	5	5	7	$3253	$6866
20 000–24 999	15	15	21	$2872	$6385
25 000–34 999	11	11	11	$4689	$12 968
35 000–49 000	26	26	26	$4124	$15 035
50 000–74 999	19	19	16	$6328	$21 536
75 000+	12	12	7	$2887	$5689

Continued

Table 1 Continued

Characteristics	Overall (N=16 926) Per cent+ (%)	No claim (n=16 393) Per cent+ (%)	Claim (n=533) Per cent+ (%)	Total claim cost ($) M	SD
Company size (number of employees)*					
<100	35	35	39	$4648	$13 852
100–499	41	41	41	$3853	$14 750
500+	24	24	20	$2851	$6294

+Per cents are calculated based on the total sample size for each column. For example, among employees who filed a claim (n=533), 49% of them were male.
*χ^2 test p<0.05, Ho: Employee demographic factors are independent of prior WC status.
M, Mean.

Analysis

We generated descriptive statistics for the overall employee sample as well as for the bivariate relationship between HRFs and (1) employees who did and (2) employees who did not have a WC claim. A χ^2 test was used to determine if the proportion of employees who had a WC claim was independent of demographic and HRF variables.

For all multivariate analyses, unadjusted and adjusted models predicting WC claim occurrence and cost were estimated. Unadjusted models only included HRFs, whereas the adjusted models included HRFs and demographic and work organisation control variables. We estimated the odds of filing at least one WC claim 1 year after the employees' baseline HRA using logistic regression. A sensitivity analysis was performed to determine the impact of defining WC claim occurrence as having $0 and >$0 claims instead of only >$0 claims. Finally, we used a generalised linear model (GLM) analysis to estimate the relationship between HRFs and average WC costs among employees who had a claim. The generalised gamma distribution and log link function were used in the analysis. The generalised gamma regression allows for nested comparisons of the more frequently used distribution models and can provide more efficient estimators since it is less restrictive than the nested distributions.[26] Additionally, interpretation of the coefficients is not marred by re-transformation, as compared to ordinary least squares with a log-transformed dependent variable. These methods have been used previously when evaluating healthcare costs.[27] Discrete differences in average marginal effects and their 95% CIs were estimated in order to facilitate interpretation of the significant and marginally significant coefficients in the GLM models. The marginal effects represent the average WC claim cost difference for employees with the HRF, as compared to employees without the HRF. Effects were considered statistically significant if the p value was <0.05. Marginally significant effects with a p value of <0.10 were reported where the clinical researchers determined that the findings had practical significance. Data management and logistic modelling were performed using Stata V.12 (StataCorp, College Station, Texas, USA). The generalised linear modelling of cost data was performed using SAS V.9.4 (SAS Institute, Cary, North Carolina, USA).

RESULTS

A total of 16 926 employees completed an HRA. For a description of the study population, see table 1. Three per cent (n=533) of the employees who completed an HRA had at least 1 WC claim within 1 year of completing the HRA. Of these, 9% filed 2 or more claims in the same year. The most common claims were for contusion (26%), strain (25%), sprain (17%) and laceration (8%) injuries. Among employees who had a WC claim, the average total cost was $3971 (SD=$13 139) (median=$796, range=$19–$173 878). The average medical cost was $2413 (SD $5314) (median=$776, range=$0–$45 122).

The most common lifestyle HRFs were poor sleep (45%), the use of poor lifting practices (41%) and inadequate exercise (41%) (see table 2). The most common psychosocial HRFs were stress over finances (63%), stress at work (31%) and depression (21%). The most common health condition HRFs were abnormal body mass index (BMI) (59%), no dental examination in the past year (29%), severe headaches (25%) and no physical examination in the past 1–2 years (23%).

Unadjusted relationship between HRF and WC claims and costs

Bivariate analyses

A number of HRFs were significantly related to incurring a WC claim (p<0.05) (see table 2). For example, employees were more likely to file a claim within 1 year if they were smokers versus non-smokers (18% vs 13%), sick with diabetes (6% vs 4%), with abnormal BMI (63% vs 58%) and not wearing seat belts (26% vs 20%).

Three of the HRFs were statistically significantly predictive of higher mean total costs. Employees *with* diabetes incurred, on average, $12 074 (SD=$34 346) in total WC claim costs, whereas employees *without* diabetes incurred, on average, $3488 (SD=$10 519) in total WC claim costs (t=−3.51(531), p=0.00). Employees *with* arthritis incurred, on average, $6427 (SD=$21 302) in total WC claim costs, whereas employees *without* arthritis incurred, on average, $3458 (SD=$10 064) in total WC claim costs (t=−1.97(531), p=0.05). Finally, employees *with* chronic fatigue incurred, on average, $5758 (SD=$19 529) in total WC claim costs, whereas employees *without* chronic fatigue incurred, on average, $3479 (SD=$10 718) in total WC claim costs (t=−1.65(531), p=0.09).

Multivariate analyses

As shown in table 3, 4 HRFs were found to be significantly (p<0.05) predictive of the likelihood of having a WC claim in the unadjusted models. These included having digestive disorders (OR=1.28, 95% CI 1.00 to 1.63), poor seat belt use (OR=1.27, 95% CI 1.03 to 1.56) and exposure to secondhand smoke (OR=1.34, 95% CI 1.05 to 1.70). However, drinking and driving (OR=0.76, 95% CI 0.59 to 0.98) was predictive of a lower odds of filing a WC claim. A sensitivity analysis using $0 and >$0 claims instead of only >$0 claims for the WC claim occurrence variable revealed only two significant differences in the results of this logistic model. Safe lifting (OR=0.83, 95% CI 0.72 to 0.97) was a significant predictor, and exposure to secondhand smoke (OR=1.13, 95% CI 0.91 to 1.40) was a non-significant predictor.

Table 2 HRFs among employees with and without WC claims

HRF characteristics	Overall (N=16 926) Per cent+	No claim (n=16 393) Per cent+	Claim (n=533) Per cent+	With HRF Mean cost ($)	With HRF SD	Without HRF Mean cost ($)	Without HRF SD
Lifestyle factors							
Alcohol use, excessive	8	8	8	$6859	$24 261	$3737	$11 802
Drinking and driving, yes*	18	19	15	$6167	$19 801	$3583	$11 561
Exercise, inadequate	36	36	35	$4119	$11 964	$3891	$13 744
Fruits/vegetable intake, poor	33	33	33	$4085	$15 173	$3914	$12 023
Helmet use, poor	19	19	21	$4830	$16 480	$3740	$12 097
Lifting practices, poor	41	41	39	$3993	$10 850	$3957	$14 431
Seat belt use, poor*	21	20	26	$5235	$19 536	$3525	$9945
Secondhand smoke, yes*	15	14	21	$4474	$18 216	$3837	$11 441
Sleep, poor	45	45	49	$4121	$15 739	$3829	$10 112
Smoker, currently*	13	13	18	$5010	$19 090	$3743	$11 443
Psychosocial factors							
Anxiety, chronic	18	18	19	$5273	$18 870	$3666	$11 401
Depression, yes	21	20	22	$5617	$18 708	$3508	$11 068
Job health culture, excellent	37	37	35	$2828	$9297	$2743	$11.895
Job health culture, good	44	45	48	$3089	$13 476	$2473	$8352
Job health culture, fair	15	15	14	$2029	$7108	$2911	$11 729
Job health culture, poor	4	4	3	$1296	$2616	$2826	$11 317
Stress at home, yes	18	18	19	$3030	$7479	$4185	$14 114
Stress at work, yes	31	30	32	$4963	$17 306	$3494	$10 565
Stress over finances, yes*	63	63	67	$3726	$13 785	$4476	$11 715
Health condition factors							
Arthritis, yes†	15	15	17	$6427	$21 302	$3458	$10 647
Asthma, yes	11	11	11	$4723	$11 532	$3883	$13 323
Back pain, yes	22	22	25	$5096	$17 908	$3579	$11 114
Blood pressure, high	14	14	14	$3503	$10 438	$4049	$13 544
BMI, abnormal*	59	58	63	$4460	$15 081	$3122	$8786
Cancer, yes	3	3	3	$4322	$7595	$3961	$13 261
Cholesterol, high	16	16	16	$5206	$14 725	$3737	$12 821
Dental examination, no*	29	29	32	$3406	$9329	$4238	$14 601
Diabetes, yes*†	4	4	6	$12 074	$34 346	$3488	$10 519
Digestive disorder, yes*	15	15	19	$5329	$15 671	$3649	$12 464
Fatigue, chronic†	19	19	22	$5758	$19 529	$3479	$10 718
Headaches, severe	25	25	27	$5356	$17 634	$3453	$10 983
Heart disease, yes	1	1	2	$1709	$1346	$4010	$13 247
Irritable bowel disorder, yes	12	12	12	$2934	$6395	$4112	$13 805
Lung disease, yes	3	3	4	$2677	$5977	$4027	$13 362
Osteoporosis, yes	3	3	3	$8586	$18 336	$3855	$12 986
Overall health, excellent*	16	16	14	$2309	$6888	$2848	$11 686
Overall health, very good*	42	43	36	$2792	$11 347	$2757	$10 993
Overall health, good*	34	34	43	$3040	$12 748	$2591	$9905
Overall health, fair*	7	7	6	$2134	$6610	$2817	$11 383
Overall health, poor*	1	1	1	$1787	$3120	$2777	$11 156
Physical examination, no	23	23	24	$3908	$14 216	$3991	$12 082
Stroke, yes	1	1	1	$1838	$1636	$3991	$13 199

+Per cents are calculated based on the total sample size for each column. For example, among employees who filed a WC claim (n=533), 67% of them experienced stress over finances.
*χ^2 test p<0.05, Ho: Employee HRF status is independent of prior WC status.
†t-Test p<0.05, Ho: Mean total WC cost is not significantly different among claimants with and without HRF.
BMI, body mass index; HRF, health risk factor; WC, workers' compensation.

Ten HRFs were significantly predictive of subsequent WC medical claim costs (see table 4). For example, smoking (β=$179, 95% CI −$13 to $372) was significantly predictive of higher medical claim costs. On the other hand, stress over finances (β=$216, 95% CI −$438 to $7) was significantly predictive of lower medical claim costs.

Eleven HRFs were significantly predictive of total claim costs (see table 5). For example, pre-existing back pain (β=$150, 95% CI −$11 to $289) and heart disease (β=$634, 95% CI −$5 to $1274) were significantly predictive of higher total claim costs.

Adjusted relationship between HRF and WC claims and costs

Multivariate analyses

Three of the four HRFs shown in table 3 to be significantly predictive of the likelihood of a claim were no longer significant

Table 3 Unadjusted and adjusted multivariate logistic regression models of the ability of HRFs to predict the occurrence of a WC claim (N=16 926)

	Unadjusted model (n=16 985)			Adjusted model (n=15 322)		
	OR	95% CI	p Value	OR	95% CI	p Value
Lifestyle factors*						
Alcohol use, excessive	0.91	0.65 to 1.29	0.60	0.72	0.49 to 1.06	0.10
Drinking and driving, yes	0.76	0.59 to 0.98	0.03	0.84	0.65 to 1.10	0.21
Exercise, inadequate	0.90	0.74 to 1.09	0.27	1.00	0.81 to 1.22	0.97
Fruits/vegetable intake, poor	0.91	0.75 to 1.11	0.36	0.92	0.75 to 1.13	0.41
Helmet use, poor	1.07	0.86 to 1.33	0.53	0.96	0.76 to 1.21	0.74
Lifting practices, poor	0.88	0.73 to 1.05	0.16	0.97	0.80 to 1.18	0.79
Seat belt use, poor	1.27	1.03 to 1.56	0.02	1.14	0.91 to 1.42	0.25
Secondhand smoke, yes	1.34	1.05 to 1.70	0.02	1.04	0.80 to 1.35	0.77
Sleep, poor	1.05	0.88 to 1.26	0.56	0.98	0.81 to 1.18	0.80
Smoker, currently	1.23	0.95 to 1.60	0.11	1.16	0.88 to 1.52	0.30
Psychosocial factors*						
Anxiety, chronic	0.95	0.73 to 1.23	0.70	0.96	0.73 to 1.27	0.80
Depression, yes	1.00	0.78 to 1.28	0.99	0.99	0.76 to 1.29	0.95
Job health culture	0.99	0.88 to 1.10	0.82	0.98	0.87 to 1.10	0.76
Stress at home, yes	0.90	0.70 to 1.15	0.39	0.96	0.75 to 1.25	0.78
Stress at work, yes	1.07	0.88 to 1.31	0.51	1.22	0.98 to 1.52	0.07
Stress over finances, yes	1.15	0.95 to 1.40	0.16	1.14	0.93 to 1.40	0.22
Health condition factors*						
Arthritis, yes	1.07	0.83 to 1.37	0.62	1.00	0.77 to 1.31	0.98
Asthma, yes	0.93	0.69 to 1.24	0.60	0.99	0.73 to 1.33	0.93
Back pain, yes	1.10	0.88 to 1.37	0.40	1.03	0.82 to 1.30	0.78
Blood pressure, high	0.85	0.65 to 1.13	0.27	0.79	0.59 to 1.06	0.11
BMI, abnormal	1.14	0.94 to 1.38	0.18	1.00	0.82 to 1.23	0.99
Cancer, yes	0.78	0.45 to 1.34	0.36	0.80	0.45 to 1.42	0.45
Cholesterol, high	0.97	0.74 to 1.26	0.80	0.94	0.71 to 1.24	0.66
Dental examination, no	1.04	0.85 to 1.27	0.69	0.91	0.74 to 1.12	0.37
Diabetes, yes	1.35	0.91 to 2.02	0.14	1.32	0.88 to 1.99	0.18
Digestive disorder, yes	1.28	1.01 to 1.63	0.04	1.28	1.00 to 1.63	0.05
Fatigue, chronic	1.09	0.85 to 1.39	0.52	1.10	0.85 to 1.43	0.46
Headaches, severe	0.99	0.81 to 1.23	0.95	1.15	0.92 to 1.44	0.21
Heart disease, yes	1.33	0.66 to 2.67	0.43	1.21	0.59 to 2.46	0.60
Irritable bowel disorder, yes	0.92	0.69 to 1.23	0.58	0.92	0.68 to 1.25	0.60
Lung disease, yes	1.11	0.71 to 1.74	0.65	1.02	0.63 to 1.67	0.92
Osteoporosis, yes	0.89	0.50 to 1.59	0.70	0.95	0.52 to 1.71	0.86
Overall health rating	1.05	0.93 to 1.19	0.44	1.02	0.90 to 1.16	0.75
Physical examination, no	0.98	0.79 to 1.21	0.83	0.92	0.73 to 1.15	0.46
Stroke, yes	1.33	0.53 to 3.33	0.54	1.34	0.53 to 3.40	0.53

Adjusted model includes age, sex, race/ethnicity, education, pay scheme (salary/hourly), employment type (full time/part time), industry (SIC code), occupation, income and company size (number of employees).
*The reference group for each HRF is a worker who did not have the HRF.
BMI, body mass index; HRF, health risk factor; WC, workers' compensation.

after adjusting for demographic and work organisation factors: drinking and driving (OR=0.84, 95% CI 0.65 to 1.10), poor seat belt use (OR=1.14, 95% CI 0.91 to 1.42) and exposure to secondhand smoke (OR=1.04, 95% CI 0.80 to 1.35). Two of the HRFs became marginally significant after adjusting: excessive alcohol use (OR=0.72, 95% CI 0.49 to 1.06) and stress at work (OR=1.22, 95% CI 0.98 to 1.52). A sensitivity analysis using $0 and >$0 claims instead of only >$0 claims for the WC claim occurrence variable revealed only one significant difference in the results of this logistic model. Seat belt use (OR=1.21, 95% CI 1.01 to 1.46) was a significant predictor.

As shown in table 4, 8 of the 10 HRFs that were significantly predictive of medical claim costs were no longer significant after adjustment: poor sleep, smoking, high blood pressure, high cholesterol, heart disease, lung disease, osteoporosis and stroke (marginal effects for insignificant variables not shown). One HRF became significant after adjustment: stress at home (β=−$206, 95% CI −$109 to $521). Two HRFs became marginally significant after adjustment: severe headaches (β=$132, 95% CI −$67 to $331) and irritable bowel disorder (β=−$160, 95% CI −$421 to $101).

As shown in table 5, 9 of the 11 HRFs that were significantly predictive of total claim costs, no longer significant after adjustment: poor sleep, smoking, back pain, high blood pressure, high cholesterol, heart disease, irritable bowel disorder, lung disease and stroke (marginal effects for insignificant variables not

Table 4 Unadjusted and adjusted multivariate GLM regression models of ability of HRFs to predict WC claim *medical cost*

	Unadjusted model (n=533)			Adjusted model (n=493)		
HRF	**β***	**(95% CI)**	**p Value**	**β***	**(95% CI)**	**p Value**
Lifestyle factors†						
Alcohol use, excessive	−0.05	−0.46 to 0.36	0.80	−0.08	−0.78 to 0.61	0.81
Drinking and driving, yes	0.07	−0.19 to 0.32	0.60	0.04	−0.42 to 0.50	0.87
Exercise, inadequate	−0.03	−0.21 to 0.15	0.74	−0.14	−0.36 to 0.08	0.22
Fruits/vegetable intake, poor	−0.01	−0.18 to 0.15	0.90	0.04	−0.28 to 0.36	0.80
Helmet use, poor	−0.07	−0.28 to 0.14	0.49	−0.01	−0.36 to 0.34	0.97
Lifting practices, poor	0.06	−0.13 to 0.24	0.56	−0.02	−0.29 to 0.26	0.91
Seat belt use, poor	0.00	−0.20 to 0.20	0.99	−0.04	−0.41 to 0.32	0.81
Secondhand smoke, yes	−0.02	−0.23 to 0.19	0.86	0.14	−0.11 to 0.38	0.28
Sleep, poor	0.27	0.10 to 0.44	0.00	0.13	−0.25 to 0.52	0.50
Smoker, currently	0.28	0.03 to 0.53	0.03	0.23	−0.15 to 0.62	0.24
Psychosocial factors†						
Anxiety, chronic	−0.03	−0.28 to 0.22	0.84	0.08	−0.28 to 0.44	0.66
Depression, yes	0.10	−0.15 to 0.35	0.41	−0.08	−0.42 to 0.26	0.66
Job health culture, poor	0.00	−0.11 to 0.11	1.00	−0.08	−0.22 to 0.05	0.23
Stress at home, yes	0.09	−0.12 to 0.30	0.39	0.29	0.03 to 0.55	0.03
Stress at work, yes	−0.03	−0.22 to 0.16	0.73	0.07	−0.21 to 0.36	0.61
Stress over finances, yes	−0.35	−0.55 to −0.15	0.00	−0.39	−0.63 to −0.15	0.00
Health condition factors†						
Arthritis, yes	0.13	−0.10 to 0.37	0.27	−0.08	−0.51 to 0.35	0.73
Asthma, yes	0.19	−0.06 to 0.45	0.14	0.16	−0.24 to 0.57	0.43
Back pain, yes	0.15	−0.06 to 0.37	0.16	0.06	−0.21 to 0.33	0.66
Blood pressure, high	−0.41	−0.63 to −0.19	0.00	−0.15	−0.56 to 0.25	0.46
BMI, abnormal	0.00	−0.18 to 0.18	0.98	−0.12	−0.35 to 0.10	0.28
Cancer, yes	−0.12	−0.60 to 0.36	0.62	0.51	−0.42 to 1.44	0.28
Cholesterol, high	0.33	0.07 to 0.59	0.01	0.13	−0.26 to 0.53	0.50
Dental examination, no	0.13	−0.04 to 0.29	0.14	−0.02	−0.23 to 0.19	0.82
Diabetes, yes	0.00	−0.38 to 0.37	0.99	0.13	−0.53 to 0.78	0.71
Digestive issues, yes	0.15	−0.09 to 0.40	0.22	0.20	−0.14 to 0.55	0.25
Fatigue, chronic	−0.15	−0.45 to 0.16	0.34	0.22	−0.21 to 0.66	0.32
Headaches, severe	0.11	−0.10 to 0.31	0.30	0.26	−0.01 to 0.54	0.06
Heart disease, yes	0.74	0.21 to 1.27	0.01	−0.33	−2.08 to 1.42	0.71
Irritable bowel disorder, yes	−0.21	−0.49 to 0.07	0.15	−0.38	−0.77 to 0.00	0.05
Lung disease, yes	−1.14	−1.76 to −0.51	0.00	−0.35	−0.96 to 0.26	0.26
Osteoporosis, yes	0.94	0.02 to 1.85	0.04	0.58	−0.32 to 1.47	0.20
Overall health rating	−0.05	−0.17 to 0.07	0.43	−0.10	−0.30 to 0.10	0.33
Physical examination, no	−0.19	−0.34 to −0.04	0.02	−0.27	−0.50 to −0.04	0.02
Stroke, yes	1.35	0.86 to 1.84	<0.01	0.43	−0.78 to 1.63	0.49
κ*	−1.20	−1.48 to −0.91	<0.01	−1.28	−1.76 to −0.79	<0.01

Adjusted model includes age, sex, race/ethnicity, education, pay scheme (salary/hourly), employment type (full time/part time), industry (SIC code), occupation, income and company size (number of employees).
*κ is a shape parameter that is used to determine whether the data best fit a generalised gamma distribution or one of the special cases of a generalised gamma distribution (lognormal, Weibull or gamma distribution). Compared to the κs for the other distributions, the κ for the gamma distribution was significantly better (data not shown).
†The reference group for each HRF is a worker who did not have the HRF.
HRF, health risk factor.

shown). One HRF became significant after adjustment: stress at home (β=$156, 95% CI −$37 to $349). One HRF became marginally significant after adjustment: overall health (β=−$56, 95% CI −$117 to $4).

DISCUSSION

Using a diverse sample of 16 926 employees from 314 companies across a variety of industries, we found a number of HRFs that were predictive of the occurrence and/or increased cost of WC claims. In the unadjusted models, 4 HRFs were predictive of future WC claim occurrence, and 10 and 11 HRFs were predictive of future WC total and medical claim costs, respectively. However, after adjusting for demographic and work organisation factors, most HRFs were no longer predictive of future WC claim occurrence or cost. In the adjusted models, employee-reported stress was predictive of future WC claim occurrence and cost. Notably, the type of stress mattered. Stress at work predicted higher WC claim occurrence, whereas stress at home predicted higher WC claim costs and stress over finances predicted lower WC claim costs. These findings demonstrate a need to understand the interactive relationship between employee HRFs, demographic and work organisation factors, and WC claims.

Table 5 Unadjusted and adjusted multivariate GLM regression models of the ability of HRFs to predict WC claim *total cost*

	Unadjusted model (n=533)			Adjusted model (n=499)		
HRF	**β***	**(95% CI)**	**p Value**	**β***	**(95% CI)**	**p Value**
Lifestyle factors†						
Alcohol use, excessive	0.04	−0.43 to 0.51	0.85	−0.02	−0.57 to 0.53	0.93
Drinking and driving, yes	0.11	−0.16 to 0.38	0.43	0.11	−0.26 to 0.47	0.56
Exercise, inadequate	−0.06	−0.25 to 0.13	0.53	−0.14	−0.38 to 0.09	0.23
Fruits/vegetable intake, poor	0.00	−0.18 to 0.18	0.99	−0.03	−0.37 to 0.31	0.87
Helmet use, poor	−0.10	−0.32 to 0.11	0.35	−0.06	−0.31 to 0.20	0.66
Lifting practices, poor	0.03	−0.16 to 0.22	0.78	−0.01	−0.31 to 0.29	0.95
Seat belt use, poor	0.05	−0.17 to 0.26	0.67	−0.03	−0.35 to 0.29	0.85
Secondhand smoke, yes	−0.10	−0.32 to 0.12	0.40	0.16	−0.11 to 0.43	0.24
Sleep, poor	0.21	0.03 to 0.40	0.02	0.18	−0.12 to 0.47	0.24
Smoker, currently	0.42	0.15 to 0.69	0.00	0.17	−0.20 to 0.55	0.37
Psychosocial factors†						
Anxiety, chronic	0.00	−0.23 to 0.24	0.98	0.05	−0.30 to 0.39	0.79
Depression, yes	0.14	−0.11 to 0.39	0.29	−0.06	−0.45 to 0.34	0.78
Job health culture, poor	−0.01	−0.12 to 0.10	0.85	−0.03	−0.17 to 0.10	0.62
Stress at home, yes	0.11	−0.12 to 0.33	0.35	0.30	0.06 to 0.54	0.01
Stress at work, yes	0.03	−0.16 to 0.23	0.74	0.07	−0.24 to 0.38	0.65
Stress over finances, yes	−0.36	−0.55 to −0.17	0.00	−0.36	−0.57 to −0.14	0.00
Health condition factors†						
Arthritis, yes	0.13	−0.10 to 0.36	0.27	−0.04	−0.36 to 0.29	0.82
Asthma, yes	0.15	−0.12 to 0.42	0.28	0.05	−0.32 to 0.43	0.78
Back pain, yes	0.25	0.04 to 0.47	0.02	0.08	−0.21 to 0.36	0.60
Blood pressure, high	−0.35	−0.57 to −0.13	0.00	−0.17	−0.50 to 0.16	0.31
BMI, abnormal	0.05	−0.14 to 0.24	0.60	−0.07	−0.34 to 0.19	0.60
Cancer, yes	−0.17	−0.66 to 0.32	0.50	0.63	−0.13 to 1.38	0.10
Cholesterol, high	0.39	0.13 to 0.65	0.00	0.06	−0.39 to 0.50	0.81
Dental examination, no	0.13	−0.04 to 0.30	0.13	−0.01	−0.21 to 0.19	0.92
Diabetes, yes	0.04	−0.37 to 0.45	0.85	0.15	−0.40 to 0.70	0.59
Digestive issues, yes	0.13	−0.11 to 0.38	0.28	0.27	−0.02 to 0.56	0.07
Fatigue, chronic	−0.19	−0.47 to 0.08	0.16	0.17	−0.25 to 0.59	0.42
Headaches, severe	0.09	−0.13 to 0.31	0.42	0.20	−0.11 to 0.50	0.20
Heart disease, yes	0.77	0.32 to 1.22	0.00	−0.07	−1.36 to 1.23	0.92
Irritable bowel disorder, yes	−0.33	−0.62 to −0.03	0.03	−0.33	−0.76 to 0.09	0.12
Lung disease, yes	−0.88	−1.28 to −0.48	<0.01	−0.11	−0.87 to 0.65	0.77
Osteoporosis, yes	0.14	−1.78 to 2.06	0.89	0.30	−0.88 to 1.48	0.62
Overall health rating	−0.09	−0.22 to 0.03	0.15	−0.16	−0.34 to 0.02	0.07
Physical examination, no	−0.21	−0.37 to −0.05	0.01	−0.26	−0.49 to −0.03	0.03
Stroke, yes	1.21	0.82 to 1.60	<0.01	0.53	−0.81 to 1.87	0.44
κ*	−1.19	−1.37 to −0.79	<0.01	−1.50	−2.01 to −1.00.	<0.01

Adjusted model includes age, sex, race/ethnicity, education, pay scheme (salary/hourly), employment type (full time/part time), industry (SIC code), occupation, income and company size (number of employees).
*κ is a shape parameter that is used to determine whether the data best fit a generalised gamma distribution or one of the special cases of a generalised gamma distribution (lognormal, Weibull or gamma distribution). Compared to the κs for the other distributions, the κ for the gamma distribution was significantly better (data not shown).
†The reference group for each HRF is a worker who did not have the HRF.
HRF, health risk factor.

Opportunities for health promotion

In the bivariate analyses, we found that workers who subsequently experienced a WC claim were positively and significantly more likely to report smoking, exposure to secondhand smoke, an abnormal BMI, stress over finances, poor seat belt use, no dental examination in the past 2 years, diabetes, digestive disorder and overall health rating. In general, workers reporting being in better health incurred fewer claims. Previously, using a national database of WC claims, the National Council on Compensation Insurance (NCCI) found that the WC claims with comorbidity diagnoses are on the rise.[28] These findings demonstrate that there is an opportunity for professionals who interact with injured workers such as occupational medicine physicians, other healthcare providers, and safety and health managers to not only provide injury and illness care but also to offer health promotion interventions.

Predictive relationship between HRFs and WC claims

Turning to the relationships between HRFs and WC claims, this prospective study across a wide range of industries shows that several HRFs are predictive of WC claims. Previously, researchers reported contradictory results regarding the relationship between HRFs and WC claim occurrence and cost. Musich *et al*[18] found no significant relationship between HRFs and WC

claim occurrence, but Kuhnen *et al*[17] did. Kuhnen *et al*[17] and Wright *et al*[19] found no significant relationship between HRFs and WC claim cost,[17 19] but Henke *et al*[29] and Musich *et al*[18] did. For example, Henke *et al*[29] found that WC claim cost was significantly associated with obesity where WC costs were 46%, 59% and 135% higher for workers with Class I (BMI=30.0–34.9), Class II (BMI=35.0–39.9) and Class III (BMI=40.0+) obesity, respectively. In the present study, our unadjusted models demonstrated that HRFs were more predictive of WC claim cost, rather than WC claim occurrence. However, after adjusting for confounders, they became non-significant, suggesting that certain demographic and work organisational factors were more important predictors of subsequent claims and costs. The disparate findings among these studies may be due to a difference in HRAs, underlying sample, measurement or statistical methods.[26]

Stress was the only HRF to display a predictive relationship with WC claim occurrence and cost in our analysis. Similar to prior research that has demonstrated a relationship between stress and work-related injury,[30 31] we found that *stress at work* was marginally predictive of increased odds of filing a WC claim. Work-related stress can stem from poorly functioning aspects of the psychosocial and physical work environment such as poor supervisory safety leadership, among other factors.[32] We also found that *stress at home* predicted higher WC claims costs and, inversely, that *stress over finances* predicted lower WC claims costs. We speculate that workers who are experiencing stress over finances may return to work sooner to avoid lost wages or job loss.[33] On the other hand, workers who are experiencing stress at home may have low social support, an important predictor of return to work.[33] These findings support the need for employers to consider TWH strategies that reduce workplace and financial stress, and identify ways to assist workers in managing life stressors.[15]

Strengths and limitations

Our study used a large sample of employees with different occupations and employment types from multiple companies of varying size and industries. However, there are four main limitations to our analysis. First, the results of our study may not be generalisable because samples were drawn from a non-randomised self-selected employer and employee population willing to participate in the HRM programme. However, we consider our findings more broadly generalisable than much of the published literature on this subject, especially as compared to single-company studies. Furthermore, it is important to note that we consider our study reflective of employers and employees who would willingly participate in a WC insurer-sponsored HRM programme. This universe of employers interested in engaging in health promotion is of practical interest to researchers as well as practitioners, especially as the number of organisations offering comprehensive worksite wellness programmes grows in the USA and abroad.

Second, measurement error may have inhibited detection of significant effects. Many of the HRFs typically associated in prior research with increased healthcare costs were not significantly predictive of WC claims in our prospective study.[9] These disparate findings may stem from measurement issues when using a self-report HRA, as well as differences in HRAs being used. The HRF variables were self-reported and potentially subject to recall bias, which would have biased our results towards the null. This is supported by research showing that regardless of a good or bad health test result, individuals are more likely to recall a value as being better than it actually is.[34] Measuring HRFs with limited response scales may have limited our ability to detect HRFs and their relationship with WC claims. It may be useful for future research to investigate more subjective self-report symptom screening tools as well as objective records (eg, biometrics) of HRFs. Although it may be difficult to link WC and biometric data from healthcare data among small businesses due to issues of privacy and buy-in from all stakeholders involved, it may be an important next step.

Third, the claims represented in the present study are mostly reflective of acute injuries rather than chronic health conditions in a 1-year post-HRA timeframe. Furthermore, the claims are also likely to underestimate the true cost of injury including lost wages over a lifetime. Therefore, the WC data in this study likely underestimate the true occurrence and cost of work-related injuries and illnesses. Thus, we may have been unable to detect a relationship between the HRFs and latent occupational illnesses and injuries.

Finally, it should be noted that we performed multiple comparisons in our models and some significant findings may have arisen by chance. Indeed, the negative predictive relationship observed between no physical examination in the past 2 years and cost was counter intuitive.

While the intent of this paper is to focus on the relationship of HRFs to WC claims, our findings in relation to the control variables cannot be ignored. The adjusted models suggest that by and large, HRFs are not highly predictive of subsequent WC claims, after accounting for differences between employees and work organisation factors. However, it is likely that our adjusted models were over-adjusted, which may have obscured the true relationship. We hypothesise that the control variables do play an important role in the relationship between HRFs and WC claims; however, this relationship may only hold true in specific instances. For example, Ostbye *et al*[35] found that employees with a BMI of >30 who were employed in high-risk jobs had a relative risk of 7.04 (95% CI 5.95 to 8.33) for WC claims, compared to employees with normal BMIs and who worked in low-risk jobs.

CONCLUSIONS

Our study demonstrates that the aetiology of occupational injuries may involve organisational and individual risk factors. Work organisation factors such as industry-related as well as employee-related HRFs including employee-perceived stress were predictive of the occurrence and cost of WC claims in the present study. This study is a starting point for examining the interplay between employee demographics and work organisation, HRFs and WC claims, and how interventions involving employee and employer can be integrated to promote TWH. Future research should consider these multilevel relationships.

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