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## Burden of Work-Related Knee Disorders in Washington State, 1999 to 2007

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### Abstract

**Objective**—To describe the burden of knee work-related musculoskeletal disorders (WMSDs).

**Methods**—Knee WMSDs were identified using Washington State Fund workers' compensation data from 1999 to 2007 and analyzed by cost, industry, occupation, and claims incidence rates.

**Results**—Knee WMSDs accounted for 7% of WMSD claims and 10% of WMSD costs. The rate of decline in claims incidence rates for knee WMSDs was similar to the rate of decline for all other WMSDs. Industries at highest risk for knee WMSDs included construction and building contractors. Occupations of concern included carpenters and truck drivers in men and nursing aides and housekeepers in women.

**Conclusions**—Between 1999 and 2007, Washington State Fund knee WMSDs were widespread and associated with a large cost. Identification of specific occupational knee WMSD risk factors in high-risk industries is needed to guide prevention efforts.

The prevalence of knee symptoms in the general population has been reported to be between about 10% and 60%.<sup>1–6</sup> Prevalence estimates of knee symptoms in certain occupational groups, including drivers,<sup>7,8</sup> manual material handlers,<sup>9</sup> farmers,<sup>10</sup> carpenters, floor-layers and carpet menders,<sup>5,11–15</sup> postal workers,<sup>16,17</sup> foresters,<sup>18</sup> athletes,<sup>19</sup> and iron foundry workers,<sup>20</sup> range from about 10% to 50%. Work-related knee disorders are associated with substantial direct and indirect costs,<sup>21</sup> and occupational knee symptoms have been implicated as a risk factor for premature exclusion from knee demanding trades and disability.<sup>5,6,22,23</sup>

Knee symptoms may reflect a variety of knee disorders, including acute traumatic injuries (eg, from sudden direct external trauma to the knee) and work-related musculoskeletal disorders (WMSDs), or nontraumatic soft tissue disorders caused or aggravated by work activities (eg, from exposures to frequent or heavy manual handling, awkward postures, or forceful or repetitive exertions). Potential knee WMSDs have been described in a limited number of occupational groups consisting primarily of miners, and floor and carpet-layers. Studies of knee bursitis, particularly prepatellar bursitis (“housemaid’s knee”), have generally reported an increased prevalence of bursitis<sup>5,12,20,24–27</sup> and overlying cellulitis (“beat knee”)<sup>25,28</sup> in workers who engage in frequent kneeling work compared with those who do not. Meniscal disorders have been described in coal miners working in low coal seams<sup>29,30</sup> and in floor layers.<sup>14,31</sup> Studies of chondromalacia patellae in floor-layers have

reported relationships between exertion testing, self-reported history of knee injuries, and pain on compression of the patella.<sup>32</sup>

Potential knee WMSDs may be preventable, although few large intervention studies with rigorous methodology have been published. Knee kickers (devices used by carpet and floor layers to stretch wall-to-wall carpet) have been implicated as risk factors for knee symptoms,<sup>25</sup> and use of alternative mechanical stretching devices has been reported to be associated with fewer self-reported knee problems in floor-layers.<sup>33</sup> Iranian carpet menders have reported improvement in knee symptoms after implementation of ergonomic workstations designed to prevent kneeling.<sup>13</sup> Certain types of knee pads may be helpful in the prevention of bursitis in miners.<sup>24</sup> Training in new floor-laying methods was reported to be associated with a decrease in self-reported knee complaints in a controlled study of floor-layers.<sup>34</sup> Multifaceted interventions addressing job-related psychosocial factors and work organizational factors have been proposed for floor layers,<sup>35</sup> but studies evaluating such interventions are scarce.

Prevention of knee WMSDs is especially important, as workers' compensation patients may fare worse than nonworkers' compensation patients in a variety of postsurgical outcomes for knee-related conditions.<sup>36-41</sup> However, information necessary to guide prevention efforts, including the current burden of knee WMSDs and industries and occupations at highest risk for knee WMSDs, is limited. The aim of this descriptive study was to determine the burden of knee WMSDs overall and by age, sex, and diagnosis group, and to identify industries and occupations at highest risk for knee WMSDs using Washington State workers' compensation data. We also assessed trends in incidence rates of knee WMSDs over time.

## MATERIALS AND METHODS

### Data Source

Workers' compensation claims and employment data for the years 1999 to 2007 were obtained from the Washington State Department of Labor and Industries' (L&I) files. In Washington State, employers (with several exceptions, including the self-employed, federal government, those covered under other workers' compensation systems, and household employers with one employee) are required to obtain workers' compensation insurance through the L&I industrial insurance system unless they are able to self-insure. L&I's State Fund covers approximately two-thirds of workers in Washington State.

### Case Definition

The coding scheme used to define work-related knee disorders is outlined in the Appendix. Included case claims were accepted state fund claims with predefined injury nature, accident type, body part, and international classification of diseases, version 9 (ICD-9) codes. Approximately 92% of the state fund-filed claims were accepted for the 1999 to 2007 period. Injury nature, accident type, and body part coding systems changed on July 1, 2005, and were defined by the American National Standards Institute z16.2 system for claims filed up to July 1, 2005, and by the Occupational Injury and Illness Classification System for claims filed after July 1, 2005. As our focus was on WMSDs, injury nature and accident type codes were chosen to be consistent with the definition of WMSD (nontraumatic soft tissue knee disorders caused or aggravated by work activities, including exposures to frequent or heavy manual handling, awkward postures, or forceful or repetitive exertions). For a case claim to be included, nontraumatic claims had to have a knee body part code in addition to general ICD-9 codes that were relevant to knee disorders (eg, occupational bursitis). To improve the sensitivity of our coding scheme for detecting nontraumatic knee disorders, we also included nontraumatic disorders that had codes for body parts near the

knee (eg, leg), or the knee itself, in addition to knee-specific ICD-9 codes (eg, patellar tendinitis). The validity of the coding scheme was evaluated in a medical records abstraction exercise. One investigator (J.T.S) reviewed the medical records of a random sample of 100 Washington State Fund knee WMSD claims, as defined in the Appendix. The assessment provided by the claimant's health care provider was consistent with the case definition in approximately 89% of these claims.

### Data Abstraction

Data on claims were extracted from L&I databases on August 10, 2009. The L&I claims management database consists of two main data processing systems: the Medical Information and Payment System, which receives all billing information generated by provider bills, and the L&I Industrial Insurance System, which contains data necessary for the administration of state fund claims. Extracted information included date of injury, sex, date of birth, height and weight (self-reported at claim opening and available for 86% of the state fund compensable claims), 4-digit Washington Industrial Codes, 6-digit North American Industrial Classification System codes, six digit Standard Occupational Classification codes, procedure (Current Procedural Terminology) codes, claim status (compensable lost time claim [four or more days of time loss] versus medical treatment only claim codes), lost time days for compensable claims (mean from 1999 to 2007), total costs of claims, time loss payments, dollar amount of medical aid payments, and payroll hours (self-reported by state fund employers).

Number of employees per year was calculated assuming each full-time employee works 2000 hours per year (40 hours per week for 50 weeks per year). Hours were converted to full time equivalent workers (FTEs) as total hours reported/2,000. Body mass index was calculated as (weight [kg]/height [m]<sup>2</sup>). Obesity was defined as a body mass index of 30 or greater.<sup>42</sup> Total costs of claims reflected actual totals for closed claims. For state fund claims that were not closed, costs reflected actual totals plus the additional case reserve, as estimated by agency staff. For work-related knee disorder claims, approximately 2.7% and 5.5% of accepted and compensable claims, respectively, were still open, compared with 2.3% and 5.7% of WMSD claims and 1.4% and 5.1% of all claims. All bills were adjusted using the Consumer Price Index for Urban Wage Earners and Clerical Workers for Seattle-Tacoma-Bremerton, Washington. Bills were adjusted on a simplified basis using the date of injury as the "payment date" for all bills. Incurred Medical costs were adjusted using the Medical Care Series (ID CWURA423SAM, CWUSA423SAM) while all other costs were adjusted using all items except Medical Care Series (ID CWURA423SA0L5, CWUSA423SA0L5). Time loss days are paid on a 7-day workweek. While the initial pension reserve is included as part of the total incurred costs, L&I stops counting time loss days as of the date a worker is moved to the pension rolls. Lost workdays are not reflected as time loss days when an employee is kept on salary. All costs and payments were in dollar amounts.

Claims incidence rates (CIRs) were calculated by year and industry class and are expressed as number of claims per 10,000 FTEs. To eliminate unstable rates, only those North American Industrial Classification System codes with a mean of 50 FTEs per year or more and those Washington Industrial Codes with a mean of 50 employees per year over the 9-year period were included in the industry analysis. Incidence rates were estimated by age and sex using the Quarterly Workforce Indicators from the US Census Bureau to determine the number of employees (rather than FTEs). Each industry code-specific rate was compared with the industry-wide rate, and a crude incidence rate ratio was calculated. A prevention index was calculated for each industry by adding the frequency rank (rank order number of the frequency of claims) and incidence rank (rank order of incidence rates) and dividing the sum by 2.

## Diagnosis Groups and Procedures

The percentage of knee WMSD claims with any ICD-9 codes corresponding to the following a priori diagnosis groups was examined: “meniscal/ligamentous disruption” (ICD-9 717, 717.0 to 717.4, 717.40 to 717.43, 717.49, 717.5 to 6, 717.8, 717.81 to 717.85, 717.89, 836.0 to 836.2), “sprain/strain” (ICD-9 844, 844.0 to 3, 844.8 to 9), “tendinitis/bursitis/enthesopathy” (ICD-9 726.6, 726.60 to 65, or 726.69), “chondromalacia patellae” (ICD-9 717.7), “ganglion/cyst” (ICD-9 727.4, 727.40 to 43, 727.49, 727.51), and “synovitis” (ICD-9 727, 727.0, 727.00, 727.01, 727.09, 727.83). An additional subset of knee WMSD case claims, designed to be most consistent with the existing ergonomic principle of cumulative trauma,<sup>43</sup> was also examined. The cases in this subset were defined as those with ICD-9 codes for tendinitis, bursitis, or enthesopathy (726.6, 726.60 to 65, or 726.69) that did not have secondary ICD-9 codes that reflected ligamentous, tendinous, or meniscal disruptions (717, 717.0 to 717.4, 717.40 to 717.43, 717.49, 717.5 to 6, 717.8, 717.81 to .85, 717.89, 727.6, 727.60, 727.66, 727.69, 836.0 to 836.2). Diagnosis codes corresponding to degenerative arthritis were not considered, because arthritis is rarely deemed to be a work-related condition in Washington State. Knee arthroscopic surgery procedures were identified by current procedural terminology codes (29866 to 29887).

## Statistical Analyses

To obtain estimates of yearly changes in CIRs, Poisson regression models of log counts of claims were fit using the log of the denominator (10,000 FTEs) as an offset variable with year as a continuous variable. The coefficient for year in the Poisson models was exponentiated, to obtain the factor of expected yearly decrease in CIR, and then subtracted from one, to obtain the percent of yearly decline in CIRs. Corresponding *P* values from the Wald Chi-Square test were reported.

To compare differences in CIRs in different case groups, Poisson models of log counts of claims were fit with year as a continuous variable, case group as a categorical variable, an interaction term for year and group (year × group), and the log of the denominator as the offset variable. Two models were run: one comparing the “cumulative trauma knee WMSDs” case group with the “remaining knee WMSDs” case group and another comparing the “cumulative trauma knee WMSDs” case group with the “all other WMSDs” case group. Wald Chi-Square *P* values for year × group interaction coefficients were reported. Standard errors were adjusted for over-dispersion as a ratio of the Pearson Chi-Square to its associated degrees of freedom.

The odds of arthroscopic surgery was estimated using logistic regression models adjusted for age, sex, and obesity status (obese/nonobese). Pearson and deviance goodness-of-fit tests were used. All analyses were performed using SAS Software (SAS Proprietary Software Version 9.1, SAS Institute Inc., Cary, NC).

## RESULTS

### Burden of Knee WMSDs

There were 24,490 total knee WMSD Washington State Fund claims costing about \$494 million between 1999 and 2007 (Table 1). Knee WMSD claims represented about 2% of all state fund accepted claims, 7% of all WMSD claims, and about 10% of WMSD costs. Knee WMSDs in the cumulative trauma subset were responsible for 8% of total knee WMSD claims and \$11.9 million (2.4%) of total knee WMSD direct costs. Of all accepted knee WMSD claims, about half were medical only and half were compensable, and about two-thirds of cumulative trauma knee WMSDs were medical only. The percentage of total direct costs attributable to compensable knee WMSD versus medical only knee WMSD claims

was 96.6%. The mean number of state fund knee WMSD claims was 2721 per year, averaging \$20,222 per claim. The mean number of cumulative trauma knee WMSD claims was 212 per year, averaging \$6252 per claim. The median cost per knee WMSD claim, however, was \$1900, consistent with a right-skewed cost distribution. The mean total direct cost per knee WMSD claim was about 30 times higher for compensable versus medical only claims. The mean (median) compensable lost workdays for knee WMSDs was 212.7 (54). This is in comparison to 198.2 (36) for all claims, 232.5 (47) for all WMSD claims, and 116.0 (22) for all cumulative trauma knee WMSD claims.

The mean yearly CIR was 18.2 per 10,000 FTEs for all knee WMSDs and 1.4 per 10,000 FTEs for cumulative trauma knee WMSDs. There was a decrease in compensable CIRs for knee WMSDs between 1999 and 2007 (Fig. 1). The yearly rate of decline of CIRs for cumulative trauma knee WMSDs was 5.7% ( $P < 0.0001$ ). There was no significant difference in the rate of decline for cumulative trauma knee WMSDs compared with the remaining knee WMSDs ( $P = 0.84$ ) or cumulative trauma knee WMSDs compared with all other WMSDs ( $P = 0.81$ ).

### Claimant Characteristics

Approximately 27% of all knee WMSD claimants, 37% of all WMSD claimants, and 15.6% of cumulative trauma knee WMSD claimants were female. Median ages of claimants in different categories of knee WMSDs were similar (range = 39 to 42). The median BMI was similar for compensable and medical only knee WMSD claims (range = 28.2 to 28.7). The median number of months on the job was 18 for compensable and 21 for medical only knee WMSD claims.

### Diagnosis Groups and Procedures

The vast majority (about 86%) of knee WMSD claims fell into the “sprain” diagnosis group, followed by about 42% in the “meniscal/ligamentous disruption” group. About 12% of claims fell into the “chondromalacia patellae” group, and 11%, 3%, and 1% were “tendinitis/bursitis/enthesopathy,” “synovitis,” and “ganglion/cyst” claims, respectively. Of note, percentages do not sum to 100 because diagnosis groups are not mutually exclusive. In cumulative trauma claimants, female sex, but not obesity or age, was associated with an increased odds of having arthroscopic knee surgery (odds ratio 3.48, 95% confidence interval 1.75 to 6.91).

### Industry and Occupation

For all accepted state fund knee WMSD and compensable knee WMSD claims, building and finishing contractors and foundation, structure, and building exterior contractors were the top-two industries of concern by prevention index (Tables 2A and 2B). For *cumulative trauma* state fund compensable knee WMSD claims, ship and boat building was the second industry of concern followed by foundation, structure, and building exterior contractors (Tables 2C and 2D). Other top industries of concern by prevention index for all knee WMSDs were: logging; justice, public order, and safety; nursing care; waste collection; trucking; scenic and sightseeing transportation; and leather and hide tanning and finishing (Tables 2A and 2B). For cumulative trauma state fund claims, additional industries of concern by prevention index were: goods repair and maintenance; automotive stores; animal slaughtering and processing; and spectator sports (Tables 2C and 2D).

Incidence rates of state fund compensable cumulative trauma knee WMSDs by age and industry sector for males and females are shown in Figs. 2a and 2c, respectively. The compensable claims rate peaked for men at age 45 to 54 in the mining sector and at age 25 to 44 in the construction sector (Fig. 2a). For women, incidence rates peaked at age 25 to 34



in administrative support, 45 to 54 in utilities, 65 and over in accommodation/food services, and 35 to 44 in real estate (Fig. 2c). Bimodal peaks in incidence rates occurred in women in the construction (ages 19 to 24 and 45 to 54) and transportation and warehouse (19 to 24 and 55 to 64) sectors.

Incidence rates of state fund claims for all other knee WMSDs by age and industry sector for males and females are shown in Figs. 2b and 2d, respectively. The compensable claims rate peaked for men at age 14 to 18 in the mining sector and at age 35 to 44 in the construction sector (Fig. 2b). For women, incidence rates peaked at age 45 to 54 in accommodation/food services and construction and at age 55 to 64 in real estate, wholesale, transportation & warehouse, health care, retail, and utilities (Fig. 2d).

The top-15 classifiable occupations by percent of compensable knee WMSD state fund claims are listed in Table 3. About 20% of occupations were coded as nonclassifiable. The top-two occupations for men were carpenters and truck drivers and for women were nursing aides and housekeepers (Table 3A). A similar distribution of occupations by sex was seen for all accepted knee WMSD claims. Carpet installers and floor layers were ranked among the top-15 occupations (No. 8 and No. 15, respectively) for cumulative trauma knee WMSD claims (Table 3B) but not for all WMSD knee claims. Carpenters were the most represented occupation for knee WMSDs and cumulative trauma knee WMSDs.

## DISCUSSION

In this descriptive study of knee WMSDs using Washington workers' compensation state fund data between 1999 and 2007, knee WMSDs were associated with substantial costs and morbidity. Knee WMSDs accounted for 7% of all WMSD claims and 10% of WMSD costs. Although CIRs of knee WMSDs have declined between 1999 and 2007, the rate of decline was not significantly different comparing cumulative trauma knee WMSDs with the remaining knee WMSDs or all other WMSDs. The majority of knee WMSD claims fell into diagnosis groups representing "sprains" or "meniscal/ligamentous disruptions." Knee WMSD claims most consistent with the traditional ergonomic definition of cumulative trauma (tendinitis, bursitis, or enthesopathy without ligamentous, tendinous, or meniscal disruptions) were responsible for a minority of knee WMSD claims and costs. Industries at highest risk for knee WMSDs by prevention index included construction and building contractors. In general, mining and construction industries had high knee WMSD incidence rates in men, and peak incidence rates appeared to be distributed over a larger group of industry sectors by age group in women. Occupations of greatest concern included carpenters and truck drivers in men, and nursing aides and housekeepers in women.

Our findings are consistent with other published WMSD reports. A 2008 U.S. Bureau of Labor Statistics report indicates that about 30% of nonfatal occupational injuries and illnesses involving any days away from work were musculoskeletal disorders, about 8.5% involved the knee, and approximately 80% of these required 3 or more days away from work.<sup>44</sup> This is roughly comparable to the 1% of compensable knee WMSD claims, relative to all claims, observed in our study. Many industries and occupations found to be at risk in our study were similar to those reported in previous studies. Male miners, floor and carpet-layers, and carpenters have been previously described as groups at high risk for knee WMSDs.<sup>5,14,15,24-32</sup> Similarly, our results indicate that peak compensable cumulative trauma knee WMSD CIRs for middle-aged men and for other knee WMSDs in young men were in the mining sector. Carpenters and floor layers were ranked among the top-15 occupations for all knee and cumulative trauma knee WMSD claims, respectively, in men in our study. Knee disorders have also been previously described in nursing aides,<sup>21</sup> an occupation that we found to be at potentially high risk for knee WMSDs.

This study also identified new areas of concern that have not previously been reported. The spectator sport industry, which includes athletes, owners of racing animals, and establishments that support sports participants, was identified as one of the top industries at risk for cumulative trauma knee WMSDs by prevention index. Although numbers of claims were small, a post-hoc investigation revealed that standard occupational classification codes with the majority of knee WMSD claims within this industry included athletes, dancers, fitness trainers and aerobics instructors, installation and maintenance, and laborers. The construction and logging industries were identified as top industries of concern for knee WMSDs in our study, yet previous studies of knee disorders in these industries have focused primarily on knee arthritis<sup>45,46</sup> rather than soft tissue WMSDs. Similarly, knee arthritis in custodians has been studied,<sup>46,47</sup> but few studies have been published on soft tissue knee WMSDs in custodians or housekeepers. Several other industries and occupations identified in our study as being at potentially high risk for knee WMSDs have not been described extensively in the literature. These include the building contractor and ship-building industries and electricians, where musculoskeletal hazards may be similar to those in the construction industry. Trucking, real estate (which includes property management), administrative support (which includes janitorial services), and accommodation/food services were also industries of concern.

The large proportion of knee WMSD claims that did not fall into the cumulative trauma category raises important questions about the scope of cumulative trauma knee disorders and the mechanism of development of certain knee WMSDs. For example, meniscal disruptions are not included in the traditional definition of cumulative trauma.<sup>43</sup> The degree to which certain meniscal disruptions result from repeated trauma over time, a single traumatic exposure, an underlying degenerative disease process, or a combination of factors is often difficult to determine. The pattern of meniscal tears may provide insight into the mechanism of the tear (eg, vertical longitudinal tears often result from a single traumatic exposure), but tears can also be consistent with multiple potential mechanisms, including degenerative disease.<sup>48</sup> On the basis of findings reported in the biomechanical literature, it is plausible that repetitive knee bending, kneeling, squatting, and twisting may lead to substantial stress on the menisci over time.<sup>49-51</sup> Recent studies of floor-layers, who frequently kneel, compared with controls, have reported an increased odds of positive McMurray tests<sup>14</sup> and magnetic resonance imaging-diagnosed tears of the medial meniscus<sup>31</sup> after adjustment for age, body mass index, and knee straining sports.

Several strengths of this study are notable. First, we were able to analyze a large number of knee WMSD claims by cost, North American Industrial Classification System industry coding, standard occupational classification occupation coding, and claims incidence rates and trends over time. Second, use of injury nature, accident type, body part coding, and ICD-9 diagnostic codes to define knee WMSDs allowed for a case definition that was largely consistent with the health care providers' assessments.

Our study has several important limitations. First, temporary workers were not included in our analysis. However, in a post-hoc analysis of temporary service agencies using Washington Industrial Codes, construction, machine operation, and assembly were among the highest risk industries for knee WMSDs by prevention index. Second, misclassification of injury type was not completely avoided. The majority of the 11% of claims that were not consistent with health care providers' assessments were acute and traumatic in nature. Prior reports of Washington State workers' compensation data suggest that initial reporting may be biased toward acute, traumatic disorders, which tend to gain more ready acceptance in the workers' compensation system.<sup>52</sup> Third, misclassification of diagnoses is possible. More general ICD-9 diagnosis codes (eg, sprain or strain) may be used early in the life cycle of a claim before a more specific diagnosis can be made. However, we included any ICD-9 code

throughout the claim's life cycle as long as it met our case definition. Our analysis of the risk of surgery by obesity status is also likely limited by potential misclassification of obesity, as weight and height were self-reported by claimants. Fourth, we did not include arthritis claims in our case definition, because arthritis is rarely deemed to be a work-related condition in Washington State. Yet there have been multiple recent studies that have suggested that there is an association between certain occupational activities and osteoarthritis.<sup>45,46,53-67</sup> It is difficult for us to compare our results with recent studies that have included arthritis in the case definition.<sup>68</sup>

The results of this study may not be generalizable to other populations and settings. Self-insured claims represent about one-third of Washington State workers' compensation claims. Self-insured claims were not included in this study because diagnosis codes and billing information were rarely available for these claims. In Washington State, self-insured employers tend to be large employers who may have a greater capacity to return employees to work.<sup>52</sup> Exclusion of self-insured claims may have therefore led to overestimates of knee WMSD costs. Underreporting of knee WMSDs is also possible, and underreporting has been hypothesized to lead to underestimates of the magnitude and costs of other WMSDs.<sup>52</sup>

The results of this study should be used to guide further investigation, with the eventual aim of knee WMSD prevention. Further study of common characteristics of knee WMSD claims that are associated with especially high morbidity and cost is warranted. Longitudinal studies with accurate exposure assessment are needed to better quantify the contribution of specific occupational factors to the development of meniscal disorders and other potential knee WMSDs.

## CONCLUSIONS

Between 1999 and 2007, Washington State Fund knee WMSDs were widespread and associated with a large cost. Industries at highest risk for knee WMSDs included construction and building contractors. Occupations at highest risk included carpenters and truck drivers in men, and nursing aides and housekeepers in women. Identification of specific occupational knee WMSD risk factors in high-risk industries and occupations is needed. Further study to better define the contribution of occupational factors to the development certain knee WMSDs is warranted. Data from such studies should be used to guide knee WMSD prevention efforts.

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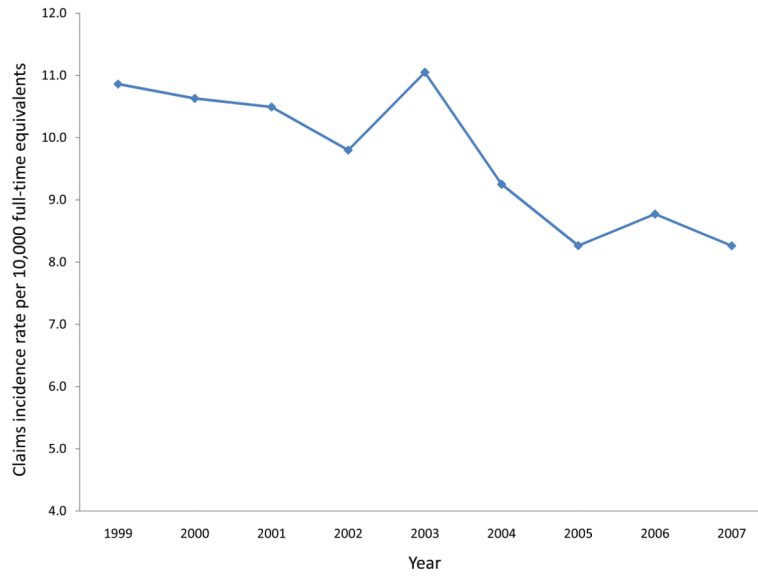
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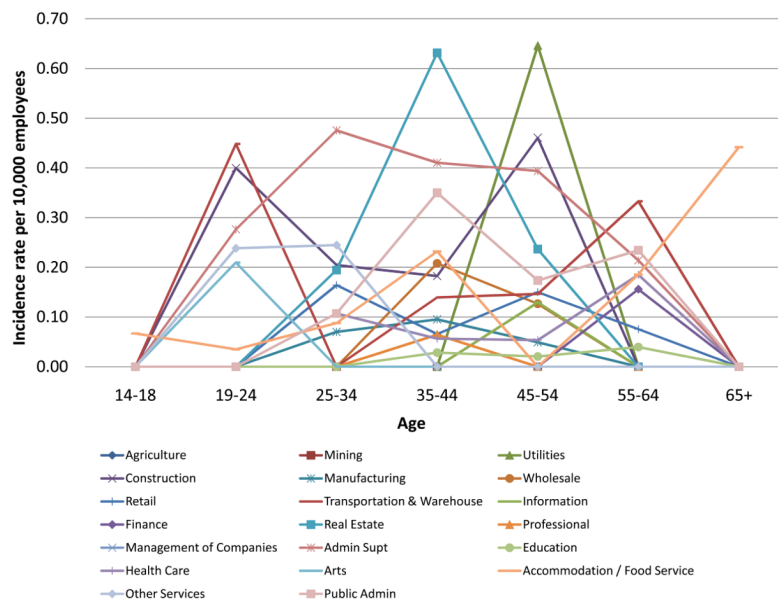
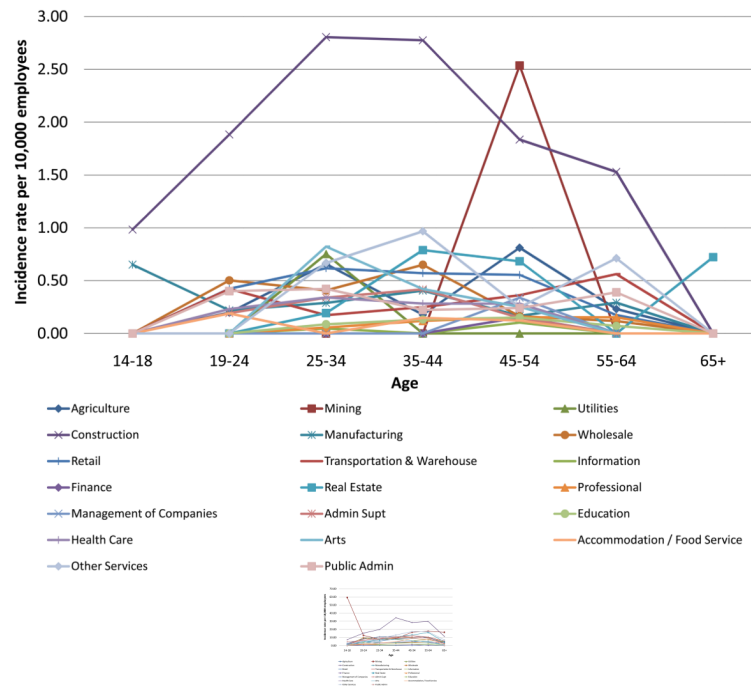
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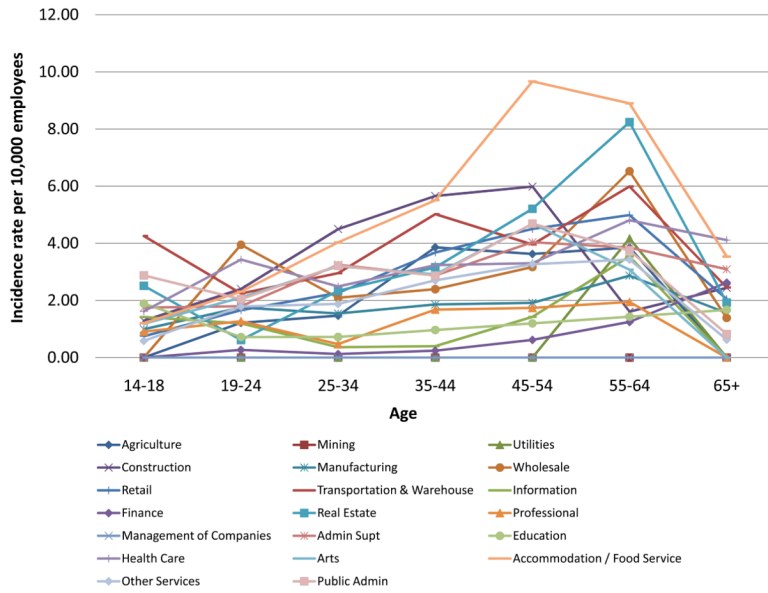
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**FIGURE 1.** State fund compensable claims incidence rates by year for all knee work-related musculoskeletal disorders.







**FIGURE 2.**  
 FIGURE 2a. State fund compensable *cumulative trauma* knee work-related musculoskeletal disorder claims incidence rates for males by age and industry sector.  
 FIGURE 2b. State fund compensable *non-cumulative trauma* knee work-related musculoskeletal disorder claims incidence rates for males by age and industry sector.  
 FIGURE 2c. State fund compensable *cumulative trauma* knee work-related musculoskeletal disorder claims incidence rates for females by age and industry sector.  
 FIGURE 2d. State fund compensable *non-cumulative trauma* knee work-related musculoskeletal disorder claims incidence rates for females by age and industry sector.

**Table 1**  
Knee work-related musculoskeletal disorder workers' compensation claims, 1999–2007

	All Claims		Total work-related musculoskeletal disorder		Knee work-related musculoskeletal disorder		
	TOTAL	Compensable	Medical Aid Only	Total	Compensable	Medical Aid Only	Total
Total claims, 1999–2007	1,168,618	124,211	219,478	343,689	11,976	12,514	24,490
Percent of all claims	100.0%	10.6%	18.8%	29.4%	1.0%	1.1%	2.1%
Percent of accepted claims		36.1%	63.9%	100.0%	48.9%	51.1%	100.0%
Total direct cost (millions of dollars), 1999–2007	\$10,990.7	\$4,833.2	\$286.0	\$5,119.2	\$477.8	\$16.6	\$494.4
Mean total number of claims per year	129,846	13,801	24,386	38,188	1,331	1,390	2,721
Percent female	33.0%	35.6%	37.2%	36.9%	24.5%	28.1%	26.5%
Median age	36	40	36	38	42	39	41
Median body mass index (kg/m <sup>2</sup> )	26.9	27.4	27.1	27.3	28.7	28.2	28.4
Median months on the job	12	18	18	18	18	21	19
Mean yearly claim rate per 10,000 full-time equivalents	861.9	91.9	162.6	254.4	8.9	9.3	18.2
Mean time loss (days)	198.2	232.5			212.7		
Median time loss (days)	36	47			54		
Mean total direct cost per claim (dollars)	\$9,508	\$38,950	\$1,361	\$15,313	\$39,901	\$1,333	\$20,222
Median total direct cost per claim (dollars)	\$539	\$8,778	\$522	\$1,145	\$12,744	\$487	\$1,900

**Table 2a**  
Top 10 industries for knee WMSDs by prevention index, accepted State Fund claims, 1999–2007

NAICS code/descriptor	hours	count	lost days	incidence rate*	rate ratio	severity rate*	rate rank	count rank	prevention index
2381 FOUNDATION, STRUCTURE, AND BUILDING EXTERIOR CONTRACTORS	448080678	1315	159243	58.7	2.76	7107.8	15	2	8.5
2383 BUILDING FINISHING CONTRACTORS	258391446	782	101830	60.5	2.85	7881.8	13	4	8.5
2382 BUILDING EQUIPMENT CONTRACTORS	624936450	1718	395722	55.0	2.58	12664.4	21	1	11
2361 RESIDENTIAL BUILDING CONSTRUCTION	323788612	822	96646	50.8	2.39	5969.7	26	3	14.5
1133 LOGGING	62461165	256	40786	82.0	3.85	13059.6	5	26	15.5
9221 JUSTICE, PUBLIC ORDER, AND SAFETY ACTIVITIES	302747864	677	43359	44.7	2.10	2864.4	38	6	22
6231 NURSING CARE FACILITIES	182268689	424	30798	46.5	2.19	3379.4	33	12	22.5
5621 WASTE COLLECTION	38129686	152	12189	79.7	3.75	6393.4	7	41	24
4841 GENERAL FREIGHT TRUCKING	163825837	382	49944	46.6	2.19	6097.2	32	17	24.5
2362 NONRESIDENTIAL BUILDING CONSTRUCTION	165059747	379	52094	45.9	2.16	6312.1	34	18	26
†4872 SCENIC AND SIGHTSEEING TRANSPORTATION, WAITER	1371706	9	388	131.2	6.17	5657.2	2	232	117
†3161 LEATHER AND HIDE TANNING AND FINISHING	469374	2	0	85.2	4.01	0.0	3	279	141

WMSD, Work-related musculoskeletal disorder; NAICS, North American Industrial Classification System

\* Incidence rates and severity rates (lost days) are per 10,000 full-time equivalents.

† Because the prevention index is an average of two ranks, it is possible that a very small industry with a high claims incidence rate or an industry with a large population but a low incidence rate would not have a high prevention index. We therefore included the top three industries by either count or rate below each table (gray) unless the industry was already within the body of the table.

**Table 2b**  
Top 10 industries for knee WMSDs by prevention index, compensable State Fund claims, 1999–2007

NAICS code/descriptor	hours	count	lost days	incidence rate*	rate ratio	severity rate*	rate rank	count rank	prevention index
2383 BUILDING FINISHING CONTRACTORS	258391446.4	434	101826	34	3.515773	7881.53	10	4	7
2381 FOUNDATION, STRUCTURE, AND BUILDING EXTERIOR CONTRACTORS	448080677.5	712	159234	32	3.326082	7107.381	13	2	7.5
2382 BUILDING EQUIPMENT CONTRACTORS	624936450.3	904	395711	29	3.027902	12664.04	17	1	9
2361 RESIDENTIAL BUILDING CONSTRUCTION	323788611.9	461	96581	28	2.980222	5965.682	18	3	10.5
1133 LOGGING	62461165.1	168	40786	54	5.63	13059.63	3	19	11
4841 GENERAL FREIGHT TRUCKING	163825837	228	49944	28	2.913142	6097.207	21	9	15
9221 JUSTICE, PUBLIC ORDER, AND SAFETY ACTIVITIES	302747864	361	43338	24	2.495947	2862.976	29	5	17
2389 OTHER SPECIALTY TRADE CONTRACTORS	167571108.2	214	36809	26	2.673153	4393.239	25	11	18
4842 SPECIALIZED FREIGHT TRUCKING	95582075	142	36645	30	3.109719	7667.756	16	25	20.5
5621 WASTE COLLECTION	38129686.44	73	12188	38	4.007456	6392.919	6	39	22.5
†4872 SCENIC AND SIGHTSEEING TRANSPORTATION, WATER	1371706	4	388	58	6.10391	5657.189	2	227	114.5

WMSD, Work-related musculoskeletal disorder; NAICS, North American Industrial Classification System

\* Incidence rates and severity rates (lost days) are per 10,000 full-time equivalents.

† Because the prevention index is an average of two ranks, it is possible that a very small industry with a high claims incidence rate or an industry with a large population but a low incidence rate would not have a high prevention index. We therefore included the top three industries by either count or rate below each table (gray) unless the industry was already within the body of the table.

Table 2c

Top 10 industries for *cumulative trauma* knee WMSDs by prevention index, accepted State Fund claims, 1999–2007

NAICS code/descriptor	hours	count	lost days	incidence rate*	rate ratio	severity rate*	rate rank	count rank	prevention index
2383 BUILDING FINISHING CONTRACTORS	258391446.4	161	4387	12.46171	7.891521	339.5623	3	3	3
2381 FOUNDATION, STRUCTURE, AND BUILDING EXTERIOR CONTRACTORS	448080677.5	207	7041	9.239408	5.850959	314.2738	6	2	4
2382 BUILDING EQUIPMENT CONTRACTORS	624936450.3	256	5067	8.192833	5.188204	162.1605	10	1	5.5
2361 RESIDENTIAL BUILDING CONSTRUCTION	323788611.9	113	1343	6.979863	4.420077	82.95536	14	4	9
3366 SHIP AND BOAT BUILDING	33854903	19	2059	11.22437	7.10796	1216.367	4	21	12.5
4422 HOME FURNISHINGS STORES	72582069	27	317	7.439854	4.711372	87.3494	11	16	13.5
7112 SPECTATOR SPORTS	8052875	12	0	29.80302	18.8731	0	1	37	19
8114 PERSONAL AND HOUSEHOLD GOODS REPAIR AND MAINTENANCE	30670238.05	13	305	8.477274	5.368329	198.8899	9	33	21
4413 AUTOMOTIVE PARTS, ACCESSORIES, AND TIRE STORES	119735860	28	77	4.676961	2.961739	12.86164	28	15	21.5
1133 LOGGING	62461165.1	18	1276	5.763581	3.649853	408.5739	20	24	22
74871 SCENIC AND SIGHTSEEING TRANSPORTATION, LAND	1540676	1	0	12.98131	8.220564	0	2	171	86.5

WMSD, Work-related musculoskeletal disorder; NAICS, North American Industrial Classification System

\* Incidence rates and severity rates (lost days) are per 10,000 full-time equivalents.

† Because the prevention index is an average of two ranks, it is possible that a very small industry with a high claims incidence rate or an industry with a large population but a low incidence rate would not have a high prevention index. We therefore included the top three industries by either count or rate below each table (gray) unless the industry was already within the body of the table.



Table 2d

Top 10 industries for *cumulative trauma* knee WMSDs by prevention index, compensable State Fund claims, 1999–2007

NAICS code/descriptor	hours	count	lost days	incidence rate*	rate ratio	severity rate*	rate rank	count rank	prevention index
2383 BUILDING FINISHING CONTRACTORS	258391446.4	60	4387	4.6441	9.470001	339.562	4	3	3.5
3366 SHIP AND BOAT BUILDING	33854903	9	2059	5.3168	10.84171	1216.37	2	10	6
2381 FOUNDATION, STRUCTURE, AND BUILDING EXTERIOR CONTRACTORS	448080677.5	69	7041	3.0798	6.280146	314.274	10	2	6
2382 BUILDING EQUIPMENT CONTRACTORS	624936450.3	80	5057	2.5603	5.220728	161.84	15	1	8
4422 HOME FURNISHINGS STORES	72582069	10	317	2.7555	5.618852	87.3494	12	9	10.5
2361 RESIDENTIAL BUILDING CONSTRUCTION	323788611.9	40	1343	2.4707	5.038199	82.9554	18	4	11
1133 LOGGING	62461165.1	8	1276	2.5616	5.223442	408.574	14	14	14
5617 SERVICES TO BUILDINGS AND DWELLINGS	315071074	24	4530	1.5235	3.106559	287.554	30	5	17.5
3116 ANIMAL SLAUGHTERING AND PROCESSING	25896636	4	469	3.0892	6.299318	362.209	9	30	19.5
8114 PERSONAL AND HOUSEHOLD GOODS REPAIR AND MAINTENANCE	30670238.05	4	305	2.6084	5.318874	198.89	13	30	21.5

WMSD, Work-related musculoskeletal disorder; NAICS, North American Industrial Classification System

\* Incidence rates and severity rates (lost days) are per 10,000 full-time equivalents.

† Because the prevention index is an average of two ranks, it is possible that a very small industry with a high claims incidence rate or an industry with a large population but a low incidence rate would not have a high prevention index. We therefore included the top three industries by either count or rate below each table (gray) unless the industry was already within the body of the table.

**Table 3a**  
 tions for State Fund compensable knee WMSDs, 1999–2007.

	Men			Women						
	Number of Claims	% of Claims	Occupation	Number of Claims	% of Claims	% Men	SOC Code	Number of Claims	% of Claims	% Women
ht	497	4.4%	472031 Carpenters	495	4.4%	5.8%	311012 Nursing Aides, Orderlies	239	2.1%	8.8%
ht	453	4.0%	533032 Truck Drivers, Heavy	403	3.6%	4.8%	372012 Maids and Housekeeping	107	1.0%	3.9%
vy	428	3.8%	537062 Laborers and Freight	375	3.3%	4.4%	412031 Retail Salespersons	86	0.8%	3.2%
at	318	2.8%	472061 Construction Craft	305	2.7%	3.6%	412011 Cashiers	79	0.7%	2.9%
ors	291	2.6%	533033 Truck Drivers, Light	266	2.4%	3.1%	537062 Laborers and Freight	78	0.7%	2.9%
erlies	273	2.4%	471011 First-Line Supervisors	266	2.4%	3.1%	399021 Personal & Home Care Aides	76	0.7%	2.8%
erlies	262	2.3%	499099 Installation, Maintenance	212	1.9%	2.5%	119199 Managers, All Other	70	0.6%	2.6%
s	248	2.2%	472111 Electricians	205	1.8%	2.4%	372011 Janitors and Cleaners	67	0.6%	2.5%
enance	224	2.0%	519199 Production Workers	194	1.7%	2.3%	353031 Waiters and Waitresses	60	0.5%	2.2%
er	214	1.9%	472152 Plumbers, Pipefitters	165	1.5%	1.9%	519199 Production Workers	54	0.5%	2.0%
s	208	1.9%	119199 Managers, All Other	138	1.2%	1.6%	411011 First-Line Supervisors	53	0.5%	1.9%
ers	193	1.7%	373011 Landscaping	133	1.2%	1.6%	291111 Registered Nurses	52	0.5%	1.9%
ers	167	1.5%	493023 Automotive Mechanics	132	1.2%	1.6%	351012 First-Line Supervisors	41	0.4%	1.5%
ers	162	1.4%	514121 Welders, Cutters, Solderer	117	1.0%	1.4%	311011 Home Health Aides	39	0.3%	1.4%
ers	142	1.3%	412031 Retail Salespersons	107	1.0%	1.3%	353021 Combined Food Preparation	34	0.3%	1.2%

etal disorder; SOC, Standard Occupational Classification

**Table 3b**

Top 15 classifiable occupations for State Fund compensable cumulative trauma knee WMSDs, 1999–2007.

SOC Code	Occupation	Number of Claims	% of Claims
472031	Carpenters	49	7.3%
471011	First-Line Supervisors/Managers	26	3.9%
472111	Electricians	26	3.9%
472152	Plumbers, Pipefitters	24	3.6%
472061	Construction Craft Laborer	20	3.0%
537062	Laborers and Freight	19	2.8%
499099	Installation, Maintenance	19	2.8%
472041	Carpet Installers	15	2.2%
499021	Heating, Air Conditioning	15	2.2%
372012	Maid and Housekeeping	13	1.9%
472181	Roofers	13	1.9%
519199	Production Workers	12	1.8%
533032	Truck Drivers, Heavy and T	11	1.6%
372011	Janitors and Cleaners	11	1.6%
472042	Floor Layers	11	1.6%

WMSD, Work-related musculoskeletal disorder. SOC, Standard Occupational Classification