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RESEARCH ARTICLE

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Work-related musculoskeletal disorder surveillance using the Washington state workers' compensation system: Recent declines and patterns by industry, 1999-2013

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Background: Work-related musculoskeletal disorders (WMSDs) are common and place large economic and social burdens on workers and their communities. We describe recent WMSD trends and patterns of WMSD incidence among the Washington worker population by industry.
Methods: We used Washington State's workers' compensation compensable claims from 1999 to 2013 to describe incidence and cost of WMSD claims by body part and diagnosis, and to identify high-risk industries.
Results: WMSD claim rates declined by an estimated annual 5.4% (95% CI: 5.0–5.9%) in Washington State from 1999 to 2013, but WMSDs continue to account for over 40% of all compensable claims. High risk industries identified were Construction; Transportation and Warehousing; Health Care and Social Assistance; and Manufacturing.
Conclusions: As documented in other North American contexts, this study describes an important decline in the incidence of WMSDs. The Washington State workers' compensation system provides a rich data source for the surveillance of WMSDs.

KEYWORDS
carpal tunnel syndrome, rotator cuff syndrome, sciatica, workers' compensation, work-related musculoskeletal disorders

1 | INTRODUCTION

Work-related musculoskeletal disorders (WMSDs) are common among workers, with often painful and long-lasting effects. The Bureau of Labor Statistics (BLS) reports that WMSDs account for close to one-third (32%) of all injuries and illnesses requiring days away from work.[1] There were 1000 cases of WMSDs each day on average during 2014, at a rate of 34 cases per 10 000 full-time workers.[1]

WMSDs place a large economic and social burden on workers and their communities. In addition to direct workers' compensation costs, WMSDs have indirect economic burden such as lost productivity, lost wages, lost tax revenues, other personal losses such as household services, and social security replacement benefits.[2] Conservative figures estimate that WMSDs cost the US a total $45 to $54 billion annually.[2] WMSDs are also thought to be an important contributor to the recent staggering increase in Americans out of work due to disability— a 75% increase in number of people collecting disabled worker benefits between 2000 and 2012.[3]

Outcomes related to WMSDs are often more severe and longer-lasting than other non-fatal injuries sustained at work. Workers with WMSDs require more time to recuperate before returning to work compared to other work-related injuries and illnesses.[1] Studies have also documented greater loss of earning power and likelihood of drawing from savings, more work time lost, significant household role displacement, increased probability of divorce, and elevated anxiety over risk of job loss among workers with claims for a specific WMSD, carpal tunnel syndrome, compared to workers with acute conditions.[4–6]

WMSDs affect the soft tissues of the body such as the muscles, the tendons that connect muscles to bones, ligaments that connect bone to bone, nerves, and blood vessels. These conditions have also been referred to as repetitive motion injuries or repetitive strain injuries (RSIs), cumulative trauma disorders (CTDs), and occupational overuse syndrome (OOS).[7] Trauma to soft tissues that result from an acute exposure, such as a fall, is not considered to be WMSDs.[7] Some examples of identified work conditions that may cause or worsen WMSDs include awkward

postures, performing repetitive forceful tasks, heavy physical work and lifting, and vibration.[8,9]

WMSDs are preventable. Prevention involves assessing tasks for risk and applying ergonomic principles to fit the job to the individual. WMSD risk is not uniform across all workers, and this has been demonstrated in previous work showing differing levels of risk for WMSDs by industry.[10,11] It is important to identify and track high risk populations to prioritize intervention efforts. The Washington State workers' compensation system provides a uniquely complete and rich data source to characterize WMSDs.[2] Thus, we take advantage of this important data source to describe recent trends and patterns of WMSD incidence among the Washington worker population by industry.

2 | METHODS

2.1 | Washington's workers' compensation system

All Washington State employers are required to obtain workers' compensation insurance unless workers are covered by an alternative workers' compensation system, such as the federal government, employers of railroad and long-shore workers, or are specifically exempted in Washington statute from mandatory workers' compensation insurance requirements, such as the self-employed.[12] Approximately, 174 000 employers and 2.7 million workers (75% of employees not named in the above exemption) are insured through the Washington State Department of Labor and Industries (WA L&I) industrial insurance system, referred to as the State Fund.[12] The remaining 25% of Washington State workers are employed by approximately 351 employers that self-insure for workers' compensation.[12]

Washington State L&I maintain workers' compensation claims data and employment records for both State Fund and self-insured employers. The State Fund includes medical billing information for all health care delivery, employer-reported total hours worked by industry classification, and data associated with the administration of claims including claim costs, accepted work and medical information on the claimant and injury, and communications regarding the claim with the injured worker's employer. Data on self-insured claims are limited, missing complete medical billing and diagnosis, cost, and time loss information. In July 2015, we abstracted data from the WA L&I claims management system for accepted State Fund and self-insured claims in which the date of injury occurred from 1999 to 2013. The Washington State Institutional Review Board (IRB) determined that this work did not involve human subjects because all data used in analyses were de-identified, and therefore exempt from further IRB review.

2.2 | Classification of claims

Accepted claims may be "medical aid only" for which only medical costs are paid or "compensable claims" for which medical and non-medical costs—including time-loss compensation, permanent disability awards, survivors' benefits, funeral expenses, and/or pension benefits—are paid. To qualify for time-loss compensation (i.e., a compensable claim), the injured worker must be medically certified as unable to perform normal work duties beyond a three calendar day waiting period not including the day of injury. All State Fund claims and compensable self-insured claims are coded for the nature, source, body part, and type of exposure/ injury event from information on the Report of Industrial Injury or Occupational Disease (RIIOD), a form filed by the health care provider and injured or ill worker to initiate a workers' compensation claim. Injury and illness characteristics are coded using the American National Standards Institute (ANSI) z16.2 codes for claims pre-July 2005. The coding system changed in July 2005 to the Occupational Injury and Illness Classification System (OIICS) codes and was used for claims for July 2005 and after. Given the completeness of the recording of injury and illness characteristics on compensable claims, all analyses here were restricted to compensable claims.

A claim was defined as a WMSD if it had a combination of nature of injury or illness, type of exposure/injury event, AND body part affected codes (ANSI z16.2 or OIICS) consistent with WMSDs. Details on this case definition and an evaluation of the validity of the codes used have been published previously.[9,11,13] Alternatively, a case could be defined if the medical bills associated with the claim included one or more International Classification of Diseases, 9th revision, Clinical Modification (ICD-9-CM) diagnosis or procedure codes consistent with the following WMSD diagnoses: carpal tunnel syndrome, rotator cuff syndrome, hand/wrist tendonitis, epicondylitis, sciatica, or knee bursitis. Assignment of body part affected was based on ANSI z16.2/OIICS codes and/or ICD-9-CM codes, allowing for multiple affected body parts to be assigned per claim. Cases predominantly included the following: musculoskeletal system diseases or disorders, abnormal nerve or nervous system conditions, sprains, strains, or rheumatisms affecting the back, elbow, hand/wrist, shoulder, neck, or knee due to overexertions, repetitive motions, bodily reactions, and rubbed or abraded exposures. Specific WMSD diagnoses were defined using ICD-9-CM diagnosis and procedure codes only. Therefore, only State Fund claims are included when describing these cases. Non-MSD claims are all other claims for work-related conditions that did not meet the WMSD case definition described above.

We categorized claims by industry using the North American Industry Classification System (NAICS), the standard classification system used by Federal agencies to report business establishment statistics. Results are presented by the two-digit NAICS industry sectors (20 sectors), and by more detailed four-digit NAICS industry groups (317 groups).

2.3 | Data analysis

Data were analyzed using SAS® 9.4 analytic software. Descriptive statistics including counts, proportions, rates, and medians are presented to summarize the Washington State WMSD claim burden. Cost data are expressed in 2013 US dollars using the Consumer Price Urban Workers Index, and complete cost data are only available for

State Fund claims. Median days of time lost were calculated excluding all claims with zero time-loss days. Incidence rates are presented per 10 000 Full Time Equivalent (FTE) employees. For this study, FTEs were defined using employee hours worked reported by the employer and 1 FTE is defined as 2000 h annually.

Descriptive statistics are also presented to summarize characteristics of WMSDs. Data on the general Washington worker population presented here were obtained from the 1999-2013 American Community Survey. Trends were analyzed by negative binomial regression modeling to account for overdispersion of claim count data using the GENMOD procedure in SAS®. Estimated changes in claim rates in response to year are reported from the negative binomial modeling in which reported hours worked was used as the exposure variable via the offset statement. Statistical significance levels were set at $\alpha = 0.05$.

To prioritize industries for intervention purposes, claim frequency and incidence rate are both important considerations.[14,11] We combined, the rank orders of both frequency and rate to create the "Prevention Index" (PI), and then ranked industries by PI.[14,11] The PI is calculated by averaging the frequency rank and the incidence rate rank for each industry category:

$$\text{PI} = \frac{[\text{Frequency} + \text{Incident rate rank}]}{2}$$

Industry sectors (two-digit NAICS) and more detailed industry groups (four-digit NAICS) were ranked by PI. PI ranking was performed on industry groups with five or more WMSD claims per year on average and 100 FTE or more per year on average only. During the study period, 241 industry groups which contain 98.5% of reported FTE met these criteria.

3 | RESULTS

3.1 | Description of claims

From 1999 to 2013, there were over 45 000 compensable claims each year on average (208.7 claims per 10 000 FTE) in Washington State from all causes of work-related injury and illness (Table 1). Within this time period, 43% of all compensable claims (State Fund and self-insured accounts combined) were due to WMSDs, with a rate of 90.1 WMSD claims per 10 000 FTE. The remaining 57% of compensable claims (118.6 claims per 10 000 FTE) were due to acute injury, infectious disease, neoplasms, noise induced hearing loss, and other systemic diseases such as respiratory disease. Approximately 64% of all claims and 60% of WMSD claims during this time period were State Fund claims (data not shown).

Total workers' compensation direct costs (medical and non-medical costs) due to WMSD claims exceeded $8.5 billion dollars during the study period, which accounted for 44% of all compensable claim costs. Costs are described for State Fund claims only due to data limitations, and therefore are an underestimate of statewide total claim costs. Median total direct costs (medical and non-medical) per claim were higher for WMSD claims compared to non-MSD claims—$6,661 versus $4,731 and $3,415 versus $2,109 per claim, respectively. WMSD-related claims also resulted in a higher median number of days lost from work compared to non-MSD claims. Among claims with at least one day of time lost, the median days of time lost for WMSD claims was 49 days, and 34 days for non-MSD claims.

A summary of claims and associated costs by body part affected and specific WMSD diagnosis can be found in Supplementary Tables S1 and S2, respectively. The back was the most commonly affected body part for WMSDs, with 46% of all WMSD claims involving the back. The majority (82%) of back-related WMSDs were sprains, strains, and tears of the muscles, tendons, ligaments, and joints (data not shown). Claims for WMSDs affecting the neck and shoulder had the highest median costs and median days of time lost per claim compared to other affected body parts. Carpal tunnel syndrome and rotator cuff syndrome were diagnosed more than the other WMSD diagnoses defined in this work. Sciatica diagnoses were associated with the highest median costs per claim. Claims with a sciatica diagnosis had a median total direct cost of $51 205 and 300 days of lost work time per claim. State Fund claims with a rotator cuff syndrome diagnosis were also very costly with a median direct cost of $39 526 and 174 days of lost work time per claim.

3.2 | Description of claimants

From 1999 to 2013, 581 665 individual workers had at least one compensable claim (Table 2). On average, each claimant had 1.2 claims within the 15-year period. Females make up 46% of the Washington State workforce, and 36% of all claimants. A greater proportion of workers with WMSD claims were female compared to workers with non-MSD claims (41% vs 32%). Workers age 35–54 years comprise 43% of the general Washington worker population. This age group is over-represented among WMSD claimants, accounting for 57% of workers with a WMSD claim. A similar proportion (34%) of workers with WMSD claims and non-MSD were obese.

A description of WMSD claimants by body part affected and specific WMSD diagnosis can be found in Supplementary Tables S3 and S4, respectively. Overall, 41% of workers with WMSD claim(s) were female (Table 2), however, a greater proportion (56%) of those with WMSD claims for the hand/wrist were female (Supplementary Table S3). Alternatively, knee-related WMSD claimants were 71% male. The age distribution of claimants with WMSD claims was similar across different body parts affected, with a slightly higher proportion of younger claimants with back-related claims compared to other regions. Compared to claimants with WMSDs affecting other body areas, a greater proportion of claimants with knee-related WMSDs were obese (44%). Similar patterns were observed for claimant characteristics by specific WMSD diagnoses as they relate to the body areas described above. For example, claimants with hand/wrist WMSDs had the greatest proportion of females (56%) compared to other body areas as did claimants with carpal tunnel syndrome (60%) and tendonitis of the hand/wrist (61%).

3.3 | WMSD claims trends

From 1999 to 2013, compensable claim rates, for both WMSD and non-MSD, significantly decreased. Compensable claim rates by year and trend analysis results are presented in Fig. 1. Compensable claims

TABLE 1 Washington State workers' compensation compensable[a] claims, 1999-2013

	WMSD claims		non-MSD claims		All claims	
	n	%	*n*	%	*n*	%
Compensable[a] claims (SF and SI)						
Total claims 1999-2013	293 395	43	386 163	57	679 558	100
Average annual claims	19 560	43	25 744	57	45 304	100
Average claims rate per 10 000 FTE	90.1	-	118.6	-	208.7	-
Claim costs[b] (SF only)						
Medical costs (millions)	$3101	41	$4386	59	$7487	100
Non-medical costs (millions)	$5405	46	$6432	54	$11 836	100
Total direct costs (millions)	$8506	44	$10 818	56	$19 324	100
Median medical cost per claim	$6661	-	$4731	-	$5387	-
Median non-medical cost per claim	$3415	-	$2109	-	$2497	-
Median total direct cost per claim	$10 961	-	$7638	-	$8762	-
Lost work time[c] (SF only)						
Total work days lost (millions)	43.6	48	47.5	52	91.1	100
Median work days lost per claim	49	-	34	-	40	-

WMSD, work-related musculoskeletal disorder; MSD, musculoskeletal disorder; SF, State Fund; SI, self-insured; FTE, full time equivalent (2000 h annually)
[a]Injured/ill worker must be medically certified as unable to perform normal work duties beyond a three calendar day waiting period not including the date of injury.
[b]Costs are expressed in 2013 US dollars using the Consumer Price Index-Urban Workers index; data available for State Fund claims only.
[c]Among claims with wage replacement benefits; data available for State Fund claims only.

TABLE 2 Washington State workers' compensation claimant[a] characteristics, 1999-2013

	WMSD claimants		non-MSD claimants		All claimants[b]		General WA worker population[c]	
	n	%	*n*	%	*n*	%	*n*	%
Total claimants 1999-2013	248 930	-	332 735	-	581 665	-	-	-
Average annual claimants	16 595	-	22 182	-	38 778	-	-	-
Average claims per claimant	1.2	-	1.2		1.2			
Sex								
Female	101 155	41	107 785	32	192 115	36	1 625 341	46
Male	147 660	59	224 764	68	336 500	64	1 901 435	54
Age group								
16-24 years	24 089	8	44 003	11	68 092	10	499 737	14
25-34 years	59 883	21	79 409	21	139 292	21	785 334	22
35-44 years	83 190	29	94 883	25	178 073	26	751 709	21
45-54 years	82 673	28	98 335	26	181 008	27	790 184	22
55-64 years	37 998	13	56 851	15	94 849	14	565 925	16
65+ years	3688	1	9187	2	12 875	2	133 887	4
BMI[d] (SF only)								
Underweight	2028	1	2680	1	4380	1	-	-
Normal, healthy	55 900	27	72 876	27	118 449	28	-	-
Overweight	77 521	37	101 166	38	159 966	37	-	-
Obese	73 545	35	91 086	34	144 646	34	-	-

WMSD, work-related musculoskeletal disorder; MSD, musculoskeletal disorder; SF, State Fund; WA, Washington; BMI, body mass index
[a]Includes workers with at least one compensable claim (ie, in which they were medically certified as unable to perform normal work duties beyond a three calendar day waiting period not including the date of injury).
[b]All claimants is not the sum of WMSD and non-WMSD claimants, these are not mutually exclusive categories.
[c]General WA worker population: sex and age from 2009-2013 American Community Survey.
[d]BMI available for State Fund only; underweight: BMI < 18.5, normal, healthy: 18.5 ≤ BMI < 25.0, overweight: 25.0 ≤ BMI < 30.0, obese: BMI ≥ 30.0.

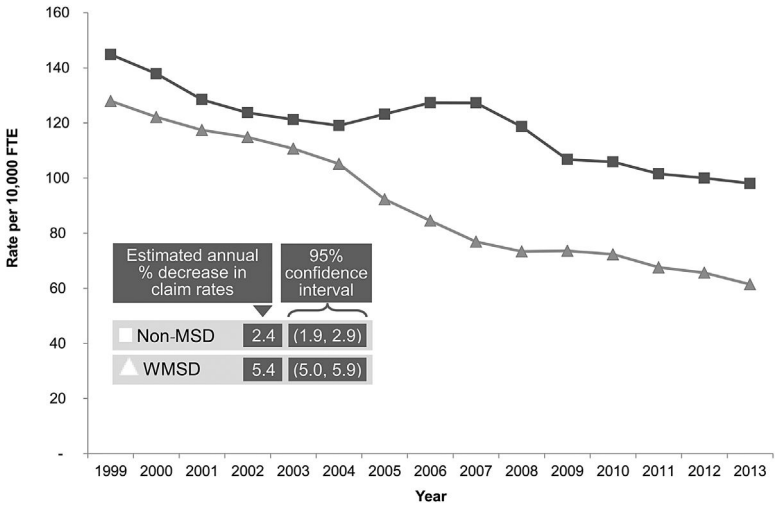

FIGURE 1 Trends in Washington State workers' compensation compensable claim rates by type and year, 1999-2013. MSD = musculoskeletal disorder; WMSD = work-related musculoskeletal disorder; Compensable claim = injured/ill worker must be medically certified as unable to perform normal work duties beyond a three calendar day waiting period not including the date of injury

due to WMSDs decreased an estimated 5.4% each year during the study period, while non-MSD claims decreased by an estimated 2.4% each year. Coding changes from ANSI to OIICS occurred in 2005 that may have influenced WMSD trends close to that time. However, similar significant results were obtained when restricting to claims after the coding change in 2005 (data not shown).

WMSD trend results by body part affected and specific diagnosis are presented in Figs. 2 and 3, respectively. Claim rates for WMSDs that affected the back were consistently higher than rates for WMSDs affecting other body parts throughout the study period. WMSD claims related to disorders of all body parts considered here significantly decreased over the study period. WMSD claims for the back and neck decreased at the fastest rates annually (7.2% and 6.2%, respectively), which is faster than the decline among WMSDs overall (5.4%).

Elbow and shoulder-related WMSD claims decreased more slowly at 1.5% annually. Similarly, State Fund claims for all considered WMSD-specific diagnoses significantly decreased during the study period. Knee bursitis and sciatica decreased the fastest at 7.8% and 7.7%, respectively, and rotator cuff syndrome decreased the slowest at 1.2% annually.

3.4 | WMSD claims by industry

Compensable claims due to WMSDs are presented by two-digit NAICS industry sector and rank ordered by the Prevention Index (PI) in Table 3. The top five industry sectors ranked by PI, a combination of rankings by frequency count and rate per FTE, were as follows: Construction; Transportation and Warehousing; Health Care and Social Assistance; Manufacturing; and Public Administration. The Mining, Quarrying, and Oil and Gas Extraction sector had a relatively high incidence rate, fourth highest when ranking by rate, but a relatively low claims frequency count. WMSD claims among all sectors, except Management of Companies and Enterprises, significantly, decreased during the study period. The largest annual decrease in WMSD claims was observed among those in Finance and Insurance

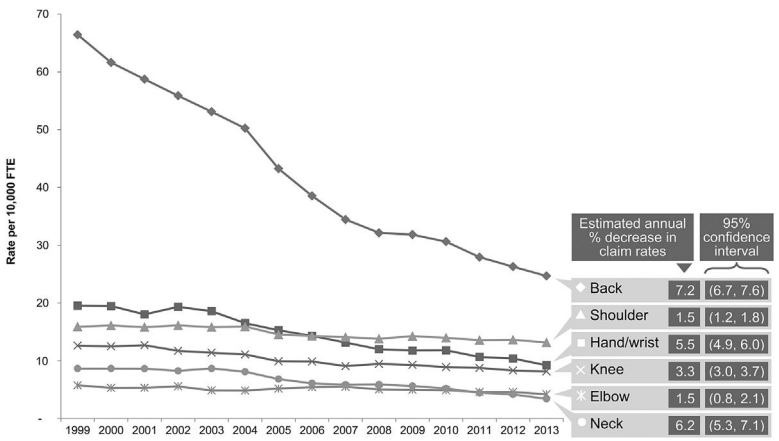

FIGURE 2 Trends in Washington State workers' compensation compensable claim rates due to WMSDs by body part and year, 1999-2013. WMSD = work-related musculoskeletal disorder; Compensable claim = injured/ill worker must be medically certified as unable to perform normal work duties beyond a three calendar day waitingperiod not including the date of injury

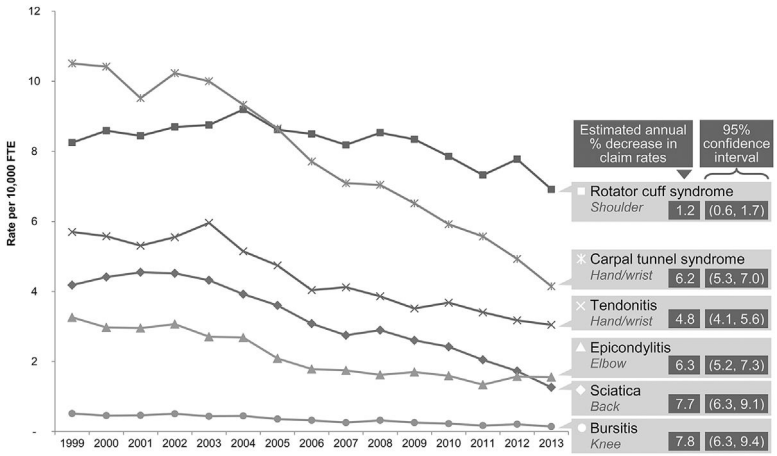

FIGURE 3 Trends in Washington State workers' compensation compensable claim rates for specific WMSDs by year, State Fund only, 1999-2013 WMSD = work-related musculoskeletal disorder; Compensable claim = Injured/ill worker must be medically certified as unable to perform normal work duties beyond a three calendar day waiting period not including the date of injury

(9.5% annually) and the smallest annual decrease among those in Public Administration (2.0% annually).

Ranking by PI was repeated for more detailed industry categories—NAICS four-digit industry groups. Details on the 20 industry groups with the highest PI ranking are presented in Table 4. The top industry groups when ranked by PI were as follows: Foundation, Structure, and Building Exterior Contractors; Scheduled Air Transport; Couriers and Express Delivery Services; General Freight Trucking; and Nursing Care Facilities. Three additional industry groups with lower PI ranks are displayed in Table 4 due to high count or rate ranks. WMSD claims among the top 20 PI-ranked industry groups all significantly decreased during the study period, with the largest annual decrease (11.0%) among those in waste collection and the smallest annual decrease (2.3%) among urban transit systems.

3.5 | WMSD claims by body part and diagnosis and industry

The proportion of WMSD claims by body part affected and two-digit industry sector may be found in Table 5. Close to half (42.9%) of all WMSD claims were specific to disorders of the back, with the remaining claims for WMSDs affecting the specified following areas: shoulder (13.7%), hand/wrist (13.4%), knee (11.1%), elbow (2.6%), neck (2.2%), and multiple areas (8.5%) (Table 5). Most industries had a similar distribution of WMSD claims by affected body part, with some notable exceptions described below. The back was the most commonly affected body part for all industries but Finance and Insurance. Those in Finance and Insurance had more hand/wrist claims (37.4%) than back claims (25.7%). The Health Care and Social Assistance industry had the largest proportion (48.6%) of back-related WMSD claims compared to all industries combined (42.9%). The proportion of knee-related WMSD claims among those in the Arts, Entertainment, and Recreation industry was double that observed for all industries combined (22.5% vs 11.1%).

Distribution of WMSD claims by selected diagnoses among State Fund accounts may be found in Table 6. Approximately, 34% of all State Fund claims due to WMSD had one of the following confirmed diagnoses: rotator cuff syndrome (10.9%), carpal tunnel syndrome (10.2%), hand/wrist tendonitis (5.8%), sciatica (4.2%), epicondylitis (2.8%), and knee bursitis (0.4%). Most industries' WMSD claims followed a similar distribution pattern by diagnosis (see Supplementary Table S4). Compared to other industries, a greater proportion of WMSD claims among those in the Finance and Insurance industry had a confirmed diagnosis of carpal tunnel syndrome (41.0%) and hand/wrist tendonitis (19.4%). A larger proportion (19.1%) of WMSD claims with a carpal tunnel syndrome was also observed among those in Professional, Scientific, and Technical services as compared to all industries.

3.6 | WMSD claims by type of exposure and industry

Lastly, we describe WMSD claims by description of the type of exposure (see Table 7). For all industries combined, close to three-quarters (74.4%) of all WMSD claims were caused by overexertion, with lifting being the most common single activity associated with the overexertion. The types of exposure associated with the remaining WMSD claims were as follows: bodily reaction (12.6%); repetitive motion (6.0%); bending, climbing, crawling, reaching, and twisting (4.6%); and other (2.3%). The highest proportion (81.7%) of overexertion claims was among those in Health Care and Social Assistance. Claims due to overexertion are broken down by type of overexertion event, such as overexertion due to lifting or pulling, and reveal further differences by industry sector. For example, those in Wholesale and Retail Trade had a greater proportion of claims related to overexertion due to lifting (36.4% and 34.5%, respectively, vs 26.8% overall) and the Transportation and Warehousing industry had a higher proportion of overexertion pulling claims (14.1% vs 8.8%, overall).

Supplementary Table I. Washington State workers' compensation compensable[a] claims due to WMSDs by body part[b], 1999–2013

Compensable[a] claims	**Back**	**Elbow**	**Hand/wrist**	**Knee**	**Neck**	**Shoulder**
Total claims 1999–2013	136,160	16,492	47,297	33,175	21,157	47,841
Average annual claims	9,077	1,099	3,153	2,212	1,410	3,189
Average claims rate per 10,000 FTE	41.8	5.1	14.5	10.2	6.5	14.7
Claim costs[c] (SF only)						
Medical costs (millions)	$1,549	$274	$476	$344	$763	$724
Non-medical costs (millions)	$2,741	$462	$832	$566	$1,451	$1,228
Total direct costs (millions)	$4,290	$737	$1,308	$909	$2,214	$1,953
Median medical cost per claim	$3,893	$10,271	$8,365	$8,338	$21,483	$14,871
Median non-medical cost per claim	$1,565	$7,075	$5,288	$5,452	$22,959	$12,586
Median direct cost per claim	$5,854	$18,226	$14,431	$14,718	$46,813	$28,563
Lost work time[d] (SF only)						
Total work days lost (millions)	21.8	4.3	7.5	4.2	11.3	9.9
Median work days lost per claim[d]	31	97	71	52	236	113

WMSD= work-related musculoskeletal disorder; SF= State Fund; FTE= full time equivalent (2,000 hours annually)

[a]Injured/ill worker must be medically certified as unable to perform normal work duties beyond a three calendar day waiting period not including the date of injury.

[b]Body part categories presented in this table are not mutually exclusive.

[c] Costs are expressed in 2013 US dollars using the Consumer Price Index-Urban Workers index; data available for State Fund claims only.

[d]Among claims with 1+ days of time loss; data available for State Fund claims only.

Supplementary Table II. Washington State workers' compensation compensable[a] claims due to WMSDs by diagnosis, SF only, 1999–2013

Compensable[a] claims	Sciatica (back)	Epicondylitis (elbow)	Carpal tunnel syndrome (hand/wrist)	Tendonitis (hand/wrist)	Rotator cuff syndrome (shoulder)	Bursitis (knee)
Total claims 1999–2013	7,380	4,991	18,020	10,255	19,174	779
Average annual claims	492	333	1,201	684	1,278	52
Average claims rate per 10,000 FTE	3.2	2.1	7.8	4.4	8.3	0.3
Claim costs[b]						
Medical costs (millions)	$345	$109	$338	$204	$573	$19
Non-medical costs (millions)	$646	$190	$619	$336	$1,003	$32
Total direct costs (millions)	$991	$295	$957	$540	$1,576	$52
Median medical cost per claim	$23,029	$10,565	$9,970	$9,310	$19,344	$8,979
Median non-medical cost per claim	$26,299	$8,235	$7,388	$5,587	$19,379	$4,784
Median direct cost per claim	$51,205	$19,467	$18,032	$15,775	$39,526	$14,348
Lost work time[c]						
Total work days lost (millions)	5.0	1.8	5.5	3.2	8.0	0.3
Median work days lost per claim[c]	300	112	92	83	174	63

WMSD= work-related musculoskeletal disorder; SF= State Fund; FTE= full time equivalent (2,000 hours annually)

[a]Injured/ill worker must be medically certified as unable to perform normal work duties beyond a three calendar day waiting period not including the date of injury.

[b]Costs adjusted to 2013 prices; data available for State Fund claims only.

[c]Among claims with 1+ days of time loss; data available for State Fund claims only.

Supplementary Table III. Description of Washington State workers' compensation WMSD claimants[a] by body part[b], 1999–2013

	Back		Elbow		Hand/wrist		Knee		Neck		Shoulder	
Claimant description	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Total claimants 1999–2013	123,046	--	15,960	--	44,773	--	31,588	--	20,484	--	45,031	--
Average annual claimants	8,203	--	1,064	--	2,985	--	2,106	--	1,366	--	3,002	--
Average claims per claimant	1.11	--	1.03	--	1.06	--	1.05	--	1.03	--	1.06	--
Sex												
Female	44,574	36%	7,051	44%	25,133	56%	9,059	29%	8,888	43%	17,656	39%
Male	78,445	64%	8,906	56%	19,607	44%	22,512	71%	11,593	57%	27,351	61%
Age group												
16-24 years	13,987	10%	908	6%	3,142	7%	2,350	7%	1,211	6%	2,961	6%
25-34 years	32,713	24%	3,109	19%	8,802	19%	5,712	17%	4,228	20%	7,737	16%
35-44 years	40,085	30%	5,434	33%	12,700	27%	8,553	26%	6,951	33%	13,021	27%
45-54 years	33,453	25%	5,097	31%	14,597	31%	10,167	31%	6,171	29%	15,133	32%
55-64 years	13,650	10%	1,735	11%	7,172	15%	5,629	17%	2,268	11%	7,810	16%
65-74 years	1,269	1%	84	1%	504	1%	502	2%	179	1%	842	2%
75+ years	119	0%	7	0%	31	0%	42	0%	16	0%	80	0%
BMI[c] (SF only)												
Underweight	1,069	1%	136	1%	390	1%	156	1%	194	1%	323	1%
Normal, healthy	28,458	28%	3,893	27%	10,242	26%	5,044	18%	5,528	30%	9,941	25%
Overweight	38,679	38%	5,171	36%	13,237	34%	10,193	37%	7,034	38%	15,269	38%
Obese	33,436	33%	4,999	35%	15,122	39%	12,008	44%	5,755	31%	14,265	36%

WMSD= work-related musculoskeletal disorder; SF= State Fund; BMI= body mass index

[a]Includes workers with at least one compensable claim (i.e., in which they were medically certified as unable to perform normal work duties beyond a three calendar day waiting period not including the date of injury).

[b]Body part categories presented in this table are not mutually exclusive.

[c]BMI available for State Fund only; underweight: BMI < 18.5, normal, healthy: 18.5 ≤ BMI < 25.0, overweight: 25.0 ≤ BMI < 30.0, obese: BMI ≥ 30.0.

Supplementary Table IV. Washington State workers' compensation claimants[a] by WMSD diagnosis, SF only, 1999–2013

	Sciatica (back)		Epicondylitis (elbow)		Carpal tunnel syndrome (hand/wrist)		Tendonitis (hand/wrist)		Rotator cuff syndrome (shoulder)		Bursitis (knee)	
Claimant description	**n**	**%****	**n**	**%****	**n**	**%****	**n**	**%****	**n**	**%****	**n**	**%****
Total claimants 1999–2013	7,261	--	4,856	--	17,217	--	9,864	--	18,280	--	770	--
Average annual claimants	484	--	324	--	1,148	--	658	--	1,219	--	51	--
Average claims per claimant	1.02	--	1.03	--	1.05	--	1.04	--	1.05	--	1.01	--
Sex												
Female	2,318	32%	2,144	44%	10,315	60%	6,062	61%	6,488	35%	152	20%
Male	4,943	68%	2,711	56%	6,902	40%	3,801	39%	11,791	65%	618	80%
Age group												
16-24 years	608	6%	194	3%	874	4%	1,167	8%	1,192	4%	68,092	10%
25-34 years	2,429	22%	1,124	15%	3,996	18%	3,241	23%	4,180	13%	139,292	21%
35-44 years	3,480	32%	2,827	38%	6,700	30%	3,730	26%	8,167	26%	178,073	26%
45-54 years	2,902	27%	2,583	35%	7,194	32%	4,058	29%	10,410	33%	181,008	27%
55-64 years	1,302	12%	703	9%	3,313	15%	1,826	13%	6,255	20%	94,849	14%
65-74 years	125	1%	39	1%	273	1%	129	1%	932	3%	11,593	2%
75+ years	14	0%	0	0%	16	0%	7	0%	84	0%	1,282	0%
BMI[b]												
Underweight	62	1%	44	1%	135	1%	125	1%	113	1%	4	1%
Normal, healthy weight	1,682	25%	1,272	28%	3,680	23%	2,684	30%	3,976	23%	144	21%
Overweight	2,630	40%	1,693	38%	5,284	33%	3,028	34%	6,658	39%	266	39%
Obese	2,255	34%	1,497	33%	6,963	43%	3,147	35%	6,189	37%	275	40%

WMSD= work-related musculoskeletal disorder; SF= State Fund; BMI= body mass index

[a]Includes workers with at least one compensable claim (i.e., in which they were medically certified as unable to perform normal work duties beyond a three calendar day waiting period not including the date of injury).

[b]underweight: BMI < 18.5, normal, healthy: 18.5 ≤ BMI < 25.0, overweight: 25.0 ≤ BMI < 30.0, obese: BMI ≥ 30.0.

TABLE 3 Washington State workers' compensation compensable[a] WMSD claims by NAICS industry sector ranked by Prevention Index (PI)[b], 1999-2013

PI rank[b]	NAICS 2-digit industry sector	Average annual FTE	Count rank	Average annual count	Rate rank	Rate per 10 000 FTE (95% CI)	Estimated annual % decrease in claim rates (95% CI)
1	Construction	133 881	4	2133	2	159.3 (157.5, 161.0)	6.8 (6.4, 7.2)
2	Transportation and warehousing	66 306	6	1327	1	200.1 (197.3, 202.9)	6.7 (6.0, 7.3)
2	Health care and social assistance	246 802	2	2819	5	114.2 (113.2, 115.3)	5.1 (4.4, 5.7)
2	Manufacturing	256 122	1	2850	6	111.3 (110.2, 112.3)	6.2 (5.4, 6.9)
5	Public administration	127 738	5	1620	3	126.8 (125.2, 128.4)	2.0 (1.0, 2.9)
6	Retail trade	264 430	3	2733	8	103.3 (102.3, 104.3)	4.2 (3.5, 4.9)
7	Administrative and support and waste management and remediation services	112 706	7	1073	9	95.2 (93.8, 96.7)	4.9 (4.3, 5.6)
8	Wholesale trade	104 861	8	978	10	93.3 (91.7, 94.8)	5.9 (5.3, 6.4)
9	Other services (except public administration)	81 499	11	544	11	66.7 (65.3, 68.2)	5.7 (5.2, 6.3)
10	Mining, quarrying, and oil, and gas extraction	3554	19	41	4	114.8 (105.7, 123.9)	7.7 (5.8, 9.5)
11	Agriculture, forestry, fishing, and hunting	74 039	12	481	12	65.0 (63.5, 66.5)	5.7 (5.1, 6.3)
11	Accommodation and food services	144 989	10	857	14	59.1 (58.1, 60.1)	6.4 (5.9, 7.0)
11	Educational services	165 511	9	949	15	57.3 (56.4, 58.3)	4.3 (3.6, 5.0)
14	Utilities	11 903	18	130	7	108.9 (104.0, 113.7)	5.6 (4.5, 6.8)
15	Real estate and rental and leasing	51 709	13	274	16	52.9 (51.3, 54.5)	5.1 (4.2, 6.0)
16	Arts, entertainment, and recreation	21 497	17	138	13	64.4 (61.6, 67.2)	4.1 (3.1, 5.1)
17	Information	83 135	15	220	18	26.5 (25.6, 27.4)	7.7 (6.5, 8.9)
17	Professional, scientific, and technical services	127 454	14	234	19	18.3 (17.7, 19.0)	7.7 (6.7, 8.6)
19	Finance and insurance	87 756	16	153	20	17.4 (16.7, 18.2)	9.5 (7.1, 11.8)
20	Management of companies and enterprises	1362	20	6	17	43.6 (34.5, 52.6)	1.2 (−6.1, 8.0)
-	All sectors	2 167 256	-	19 558	-	90.2 (89.9, 90.6)	5.4 (4.9, 5.9)

WMSD, work-related musculoskeletal disorder; NAICS, North American Industry Classification System; FTE, full time equivalent (2000 h annually); CI, confidence interval

[a]Injured/ill worker must be medically certified as unable to perform normal work duties beyond a three calendar day waiting period not including the date of injury.

[b]Prevention Index (PI) = [frequency rank + incidence rate rank]/2.

TABLE 4 Washington State workers' compensation compensable[a] claims for top 20 industry groups ranked by Prevention Index (PI)[b], 1999-2013

PI rank[b]	NAICS* 2-digit sector: 4-digit industry group	Average annual FTE	Count rank	Average annual count	Rate rank	Rate per 10 000 FTE (95% CI)	Estimated annual % decrease in claim rates (95% CI)
1	Construction: foundation, structure, and building exterior contractors	23 276	7	524	12	225.2 (220.2, 230.2)	5.5 (4.7, 6.4)
2	Transportation and warehousing: scheduled air transportation	8293	19	263	2	317.4 (307.5, 327.3)	7.3 (5.5, 9.1)
3	Transportation and warehousing: couriers and express delivery services	6941	22	223	1	321.9 (311.0, 332.8)	8.2 (6.8, 9.5)
4	Transportation and warehousing: general freight trucking	14 728	12	323	13	219.3 (213.1, 225.5)	5.1 (4.3, 5.8)
5	Health care and social assistance: nursing care facilities	15 746	13	322	16	204.7 (198.9, 210.4)	6.2 (5.5, 6.8)
6	Retail trade: grocery stores	39 588	5	670	28	169.4 (166.1, 172.7)	3.9 (3.0, 4.7)
7	Health care and social assistance: general medical and surgical hospitals	66 416	2	1107	32	166.7 (164.2, 169.3)	3.9 (2.9, 4.8)
8	Construction: building finishing contractors	15 748	17	297	21	188.3 (182.8, 193.8)	7.8 (7.0, 8.7)
8	Wholesale trade: grocery and related product merchant wholesalers	21 472	9	363	29	169.2 (164.7, 173.7)	6.1 (5.2, 7.0)
10	Construction: residential building construction	17 250	14	302	26	175.3 (170.2, 180.4)	6.8 (6.0, 7.6)
11	Health care and social assistance: community care facilities for the elderly	16 876	16	297	25	175.9 (170.7, 181.0)	5.7 (5.0, 6.5)
12	Public administration: executive, legislative, and other general government support	76 230	1	1175	44	154.1 (151.9, 156.4)	2.5 (1.4, 3.6)
13	Transportation and warehousing: specialized freight trucking	5638	33	120	15	212.1 (202.3, 222.0)	5.2 (4.1, 6.2)
14	Health care and social assistance: other ambulatory health care services	4243	42	103	8	242.9 (230.8, 255.0)	5.2 (3.5, 6.9)
14	Administrative and support and waste management and remediation services: waste collection	6449	32	128	18	199.1 (190.2, 208.0)	11.0 (9.3, 12.7)
14	Administrative and support and waste management and remediation services: services to buildings and dwellings	22 898	10	358	40	156.2 (152.0, 160.4)	5.3 (4.6, 6.0)
17	Health care and social assistance: residential mental retardation, mental health and substance abuse facilities	3476	45	92	6	265.6 (251.6, 279.6)	6.1 (4.2, 8.0)
18	Retail trade: department stores	38 967	6	564	51	144.9 (141.8, 148.0)	5.6 (3.8, 7.4)
19	Health care and social assistance: psychiatric and substance abuse hospitals	2637	58	71	5	270.0 (253.8, 286.1)	6.0 (4.2, 7.8)
20	Transportation and warehousing: urban transit systems	2347	64	68	3	287.7 (270.0, 305.5)	2.3 (0.9, 3.7)
30	Manufacturing: aerospace product and parts manufacturing	78 380	3	960	75	122.5 (120.5, 124.5)	6.8 (5.1, 8.5)
45	Transportation and warehousing: interurban and rural bus transportation	972	136	28	4	286.1 (258.7, 313.6)	7.6 (5.4, 9.8)
67	Educational services: elementary and secondary schools	98 026	4	709	150	72.3 (71.0, 73.7)	4.4 (3.6, 5.2)
-	All groups	2 167 256	-	19 558	-	90.2 (89.9, 90.6)	5.4 (4.9, 5.9)

WMSD, work-related musculoskeletal disorder; NAICS, North American Industry Classification System; FTE, full time equivalent (2000 h annually); CI, confidence interval.

[a]Injured/ill worker must be medically certified as unable to perform normal work duties beyond a three calendar day waiting period not including the date of injury.

[b]Prevention Index (PI) = [frequency rank + incidence rate rank]/2. Industry groups with less than five WMSD claims per year or less on average or 100 FTE per year on average were not included in the PI ranking.

TABLE 5 Washington State workers' compensation WMSD compensable[a] claims by NAICS industry sector and body part(s)[b], 1999-2013

NAICS 2-digit industry sector	Total (*n*)	Back (%)	Shoulder (%)	Hand/ wrist (%)	Knee (%)	Elbow (%)	Neck (%)	Multiple (%)	Other/ unknown (%)
Accommodation and food services	12 855	45.1	9.7	15.5	9.3	1.8	2.2	13.8	2.5
Administrative and support and waste management and remediation services	16 099	44.3	12.8	12.7	10.3	2.0	2.8	10.7	4.2
Agriculture, forestry, fishing and hunting	7220	43.4	13.2	11.6	13.2	1.5	2.1	11.2	3.7
Arts, entertainment, and recreation	2076	36.5	12.3	10.2	22.5	1.2	3.7	11.8	1.8
Construction	31 989	46.1	11.9	9.1	14.1	2.0	2.6	12.3	1.8
Educational services	14 230	40.9	14.7	12.9	13.6	2.3	2.7	4.9	8.0
Finance and insurance	2296	25.7	8.4	37.4	5.1	2.4	2.7	11.2	7.1
Health care and social assistance	42 292	48.6	12.6	12.0	7.2	2.5	1.8	8.1	7.2
Information	3301	35.5	11.1	22.1	12.5	2.4	3.0	6.1	7.3
Management of companies and enterprises	89	36.0	16.9	20.2	12.4	0	2.2	11.2	1.1
Manufacturing	42 746	36.0	15.2	18.3	10.8	2.0	3.2	6.7	7.8
Mining, quarrying, and oil and gas extraction	612	42.8	16.3	12.1	11.4	2.5	2.1	9.5	3.3
Other services (except public administration)	8155	37.8	12.1	16.6	11.9	2.4	2.0	14.7	2.6
Professional, scientific, and technical services	3508	36.7	9.6	20.0	10.9	2.5	2.5	16.2	1.7
Public administration	24 294	38.5	15.1	14.2	15.3	2.6	3.0	5.1	6.3
Real estate and rental and leasing	4105	47.6	11.5	9.5	11.5	2.0	2.3	13.7	1.9
Retail trade	40 989	44.2	13.7	14.6	9.9	2.0	2.6	6.4	6.7
Transportation and warehousing	19 901	45.2	15.8	9.0	11.9	2.7	2.8	6.1	6.6
Utilities	1944	37.4	15.7	16.4	15.2	2.0	2.5	4.9	5.9
Wholesale trade	14 668	48.1	13.6	11.3	9.9	2.0	2.4	9.6	3.1
All sectors	293 369	42.9	13.7	13.4	11.1	2.6	2.2	8.5	5.6

WMSD, work-related musculoskeletal disorder; NAICS, North American Industry Classification System.

[a]Injured/ill worker must be medically certified as unable to perform normal work duties beyond a three calendar day waiting period not including the date of injury.

[b]Body part categories presented in this table are mutually exclusive. Percentages reported for specified body parts indicate the claim was restricted to that body part only. Percentage of claims assigned to multiple body parts are presented in the "multiple" category.

4 | DISCUSSION

The Washington State workers' compensation system provides a rich data source for occupational health surveillance, with a well-defined population.[2] The system covers most of Washington's workers, including those covered by the State Fund and those working for self-insured employers. The system also contains exposure data by hours worked and industry, medical and billing record information allowing identification of specific WMSD diagnoses, and detailed claim outcome information. Using these data, we are able to calculate rates of WMSD by work exposure to monitor WMSD trends and patterns among Washington workers and identify high risk industries.

4.1 | Trends and burden

During the 15-year study period, we observed a steadily decreasing trend in the rate of compensable claims overall, with WMSD claims decreasing at a greater rate than non-MSD claims. Review of earlier publications reveals the decreasing trend in Washington WMSD compensable claims starting as early as 1990.[11] National data also reveal a decline in work-related injuries and illnesses, including WMSDs.[15,16] A similar decline in WMSDs has been reported with Canadian work-related injury and illness data.[17] It is not possible to determine the mechanism(s) causing the decline from the results of this study, but greater awareness of WMSD hazards over time leading to exposure reduction is a likely contributor. Of note, Washington State passed an ergonomics rule in 2000 to focus on primary prevention of WMSDs, and was subsequently, repealed in 2003. Reported exposures by employers among high hazard industries in Washington State decreased between 1998 and 2003, with a reversal of the progress after the appeal.[18] It is unclear if the ergonomics rule or the observed reported decrease in exposures had an effect on claim rates during that time period. The decline in claims was observed before the rule was implemented and continued after its repeal, even as reported exposures increased.

TABLE 6 Washington State workers' compensation WMSD compensable[a] claims by NAICS industry sector and diagnosis, SF only, 1999-2013

NAICS 2-digit industry sector	Total (*n*)	Rotator cuff syndrome (shoulder) (%)	Carpal tunnel syndrome (hand/wrist) (%)	Tendonitis (hand/wrist) (%)	Sciatica (back) (%)	Epicondylitis (elbow) (%)	Bursitis (knee) (%)
Accommodation and food services	11 407	9.0	12.0	8.3	4.0	3.1	0.2
Administrative and support and waste management and remediation services	12 331	9.8	7.8	6.1	3.9	2.5	0.4
Agriculture, forestry, fishing, and hunting	5984	10.2	7.0	5.6	4.2	2.1	0.6
Arts, entertainment, and recreation	1852	10.2	8.6	4.8	3.3	3.3	0.4
Construction	30 613	10.9	7.2	3.4	4.8	2.8	0.9
Educational services	4544	12.1	10.5	6.6	4.2	3.2	0.2
Finance and insurance	1430	7.6	41.0	19.4	2.9	5.0	0.1
Health care and social assistance	21 789	9.7	9.3	5.6	4.5	2.2	0.2
Information	1403	9.6	17.9	12.1	3.5	4.5	0.4
Management of companies and enterprises	77	13.0	14.3	11.7	2.6	1.3	0.0
Manufacturing	18 648	12.1	13.7	8.3	4.0	3.8	0.3
Mining, quarrying, and oil and gas Extraction	429	15.2	8.4	2.6	4.9	2.3	0.0
Other services (except public administration)	7496	11.7	14.7	8.4	3.9	3.3	0.5
Professional, scientific, and technical services	3452	10.1	19.1	10.2	4.3	3.9	0.3
Public administration	9663	12.6	14.1	6.0	3.2	2.8	0.4
Real estate and rental and leasing	4046	10.9	8.0	3.6	5.1	3.0	0.6
Retail trade	19 077	11.2	9.9	5.3	4.2	2.7	0.4
Transportation and warehousing	9730	6.5	2.9	1.4	2.0	1.2	0.2
Utilities	755	11.9	11.9	5.4	3.0	2.6	0.0
Wholesale trade	11 085	11.0	9.0	4.8	4.1	2.3	0.3
All sectors	175 811	10.9	10.2	5.8	4.2	2.8	0.4

WMSD, work-related musculoskeletal disorder; NAICS, North American Industry Classification System; SF, State Fund.
Row percentages do not add to 100% as not all possible diagnoses related to WMSDs were examined. Only those WMSD diagnoses previously validated were measured.
[a]Injured/ill worker must be medically certified as unable to perform normal work duties beyond a three calendar day waiting period not including the date of injury.

While continuous declines in observed WMSD rates are promising, they must be interpreted with caution. Decreased incidence of WMSDs may be indicative of improving workplace safety as we better understand these disorders over time and how to reduce exposures. This decline could also be partially attributed to fewer workers eligible for workers' compensation in industries with high exposure to WMSD risk. Alternatively, a seeming decrease in workers developing WMSDs over time may also be related to increased under-reporting and WMSD surveillance limitations.[19–24] It is important to consider this under-reporting with the trends presented here, especially if the degree of under-reporting is changing over time. Studies of union carpenters within Washington State have suggested a shifting of health care utilization, with increasingly more workers being treated for WMSDs using private health care insurance and fewer using workers' compensation.[25–28] A few potential reasons for workers shift to private health insurance that have been suggested include simplicity in the process compared to workers' compensation, increased pressure not to file claims due to safety incentive programs, and a fear of jeopardizing long-term employment with a history of filing claims.[25]

We also observed decreasing WMSD trends by specific body part, diagnosis, and industry (Figs. 2 and 3, and Table 3). While all of the specific WMSD rates reported were significantly decreasing over time, the rate of decrease varied. Morse et al. found rates of under-reporting to be uniform by industry in the Connecticut workers' compensation system, with no indication that under-reporting of WMSDs is related to type of WMSD or industry.[20] Therefore, the WMSD trend variation reported from the Washington State workers' compensation system is likely reflecting some differences of exposure and incidence within groups and is not completely explained by under-reporting. For example, the WMSDs affecting the back, neck, and hand/wrist decreased at a faster rate than other evaluated body areas. This variation in trends by affected body area may be reflected in the trends

TABLE 7 Washington State workers' compensation compensable[a] WMSD claims by NAICS industry sector and type of event, 1999-2013

NAICS 2-digit industry sector	Total (*n*)	Overexertion: lifting (%)	Overexertion: pulling (%)	Overexertion: holding, carrying, turning, wielding objects (%)	Overexertion: other, unspecified (%)	Bodily reaction (%)	Repetitive motion (%)	Bending, climbing, crawling, reaching, twisting (%)	Other (%)
Accommodation and food services	11 786	33.3	6.0	7.8	27.6	12.1	7.2	5.0	1.0
Administrative and support and waste management and remediation services	14 877	30.3	9.3	6.4	30.8	10.9	5.7	4.4	2.2
Agriculture, forestry, fishing, and hunting	6524	23.9	10.9	6.4	30.5	16.0	5.1	5.5	1.6
Arts, entertainment, and recreation	1856	23.8	3.7	5.7	28.4	23.5	6.6	6.6	1.7
Construction	29 522	28.7	6.7	8.4	31.1	13.7	4.9	4.6	1.8
Educational services	12 874	24.1	8.1	6.1	34.0	14.4	6.0	4.9	2.4
Finance and insurance	2093	17.6	4.4	3.8	39.8	10.7	8.7	3.2	11.8
Health care and social assistance	39 223	24.9	8.9	6.1	41.8	7.3	5.0	3.7	2.3
Information	2837	19.0	6.5	5.8	33.9	15.3	6.7	6.0	6.8
Management of companies and enterprises	83	18.1	2.4	7.2	33.7	7.2	14.5	8.4	8.4
Manufacturing	37 893	22.3	9.7	4.2	33.7	14.3	8.6	4.9	2.2
Mining, quarrying, and oil and gas extraction	557	23.0	8.8	3.8	36.4	17.2	3.6	4.5	2.7
Other services (except public administration)	7536	23.5	7.2	5.0	34.3	14.5	8.8	4.8	2.1
Professional, scientific, and technical services	3301	25.7	6.6	6.5	32.0	11.0	7.9	4.4	6.0
Public administration	22 066	18.4	8.1	5.0	33.7	19.2	5.4	5.7	4.5
Real estate and rental and leasing	3839	27.4	8.6	8.2	33.2	11.5	4.7	4.2	2.2
Retail trade	37 098	34.5	8.3	5.3	28.9	10.3	6.7	4.7	1.4
Transportation and warehousing	18 173	25.8	14.1	5.7	32.0	13.1	3.3	4.2	1.7
Utilities	1752	16.0	10.4	4.1	33.0	19.1	6.8	6.2	4.3
Wholesale trade	13 573	36.4	9.8	4.6	28.0	11.0	4.9	3.9	1.4
All sectors	267 463	26.8	8.8	5.8	33.0	12.6	6.0	4.6	2.3

WMSD, work-related musculoskeletal disorder; NAICS, North American Industry Classification System.

[a]Injured/ill worker must be medically certified as unable to perform normal work duties beyond a three calendar day waiting period not including the date of injury.

by industry categories. For example, WMSDs decreased at a significantly faster rate among the Finance and Insurance industry, which has more WMSDs related to the hand/wrist than any other body area. Conversely, WMSDs decreased at significantly slower rates among the Public Administration and Arts, Entertainment, and Recreation industries, which are industries with the highest proportions of WMSDs related to the knee and shoulder. Though the results presented here can't be used to definitively determine the source of the variation in trends, there may be a faster decline among specific types of WMSDs in part because there has been more of a research focus on risk assessment and control methods for WMSDs affecting the back and hand/wrist.

Even in recognition of a declining trend of WMSDs in Washington State from 1999 to 2013, WMSDs continue to place a large physical, social and economic burden on the workers and industries of Washington State. WMSD-related claims account for over 40% of compensable claims and compensable claim costs each year and lead to more work-time lost than non-MSD compensable claims. The majority of WMSD claimants documented here were male, and the greatest proportion of claimants were in the 35-44 years of age group. Similar demographic patterns have been reported among other states, and nationally.[16,29] We also report the BMI of workers in Washington and found more workers than expected with knee-related WMSDs and carpal tunnel syndrome with higher BMIs, associated with being overweight or obese. This finding is supported by other WMSD research that indicates BMI is an individual-level risk factor for WMSDs.[8,30]

4.2 | High risk industries

Job exposures, such as nature of tasks performed and work conditions, are of primary importance for prevention of WMSDs. Work exposures in this study were described by comparing WMSD incidence by industry sectors and industry groups. It is important to consider industries both with high WMSD incidence counts and rates for prioritization purposes.[11,14] In this study, we used a metric that takes both WMSD count and rate per exposure into account to rank industries—the Prevention Index (PI). The top five industry sectors ranked by PI we identified were as follows: Construction; Transportation and Warehousing; Health Care and Social Assistance; Manufacturing; and Public Administration. These industries have been previously identified in Washington and nationally as high-risk industries for WMSDs and these rankings have not changed substantially in recent years.[1,10,11,15]

We also ranked industry groups (four-digit NAICS code) by PI for a more detailed look at the industry distribution of WMSDs. Similar to the ranking for the more general industry sector categories, the top PI ranking industry groups were related to Construction (Foundation, Structure, and Building Exterior Contractors), Transportation and Warehousing (Scheduled Air Transportation, Couriers and Express Delivery, and General Freight Trucking) and Health Care and Social Assistance (Nursing Care Facilities). Previous studies using earlier Washington data report these industry groups to be the top-ranking by PI, indicating a need for continued focus on safety of workers in these industries.[14] Ranking the more detailed industry groups revealed that the high WMSD incidence among the Health Care and Social Assistance sector is largely driven by health care. The three highest ranking industry groups in the Health Care and Social Assistance sector were Nursing Care Facilities, General Medical and Surgical Hospitals, and Community Care Facilities for the elderly. With the aging of the population, industries involved in care for the elderly are among the fastest growing.[31] Therefore, it will continue to be of particular importance to reduce and control WMSD risk among these workers.

4.3 | WMSD types by industry

The types of WMSDs sustained, such as body part affected, specific WMSD diagnosis, and event leading to the WMSD were also examined by industry sector. Back-related WMSDs were the greatest proportion of WMSD claims for most industries. The most common event leading to the WMSD reported among all industries was overexertion, resulting from excessive physical force directed at an outside source (eg, while lifting, pulling, pushing, turning, wielding, holding, carrying, or throwing). The highest proportions of claims due to WMSDs affecting the back were observed among those in Wholesale Trade; Health Care and Social Assistance; and Construction. Exposure to tasks involving heavy lifting may be increased among workers in these industries putting them at an especially high risk for back-related WMSDs. In contrast, higher proportions of WMSDs affecting the hand and wrist were observed among the Finance and Insurance; Information; and Professional, Scientific, and Technical Services industries.

Specific tasks performed by workers vary by industry and these different exposures may help explain why there are differences in the distribution of WMSD claims by affected body part, diagnosis, or event. Recently, a five-year WMSD exposure study funded by the National Institute for Occupational Safety and Health (NIOSH) was completed by the Safety and Health Assessment and Research for Prevention (SHARP) program in Washington State in which the physical and organizational factors that contribute to WMSDs were examined in specific industry sectors. The five-year exposure study focused on workers in three of the top five, high-risk industries identified in this publication—Manufacturing, Construction, and Health care— as well as Agriculture, Services, and Wholesale and Retail.

Researchers involved in this five-year exposure study found WMSD exposures vary across industries, supporting the results presented here. Manufacturing work was characterized by some of the following exposures: prolonged standing, manual material handling activities, and high levels of hand activity.[32] This may in part explain why the highest proportion of WMSD claims among those in Manufacturing are related to the back and hand/wrist. Work in Construction had some similar exposures as Manufacturing, but also kneeling and squatting exposures.[33] Results presented here also support this finding, since a higher proportion of WMSD claims were knee-related among those in Construction. Finally, the comparatively large proportion of WMSD claims related to the back and resulting from overexertion in Health Care and Social Assistance was reflected

in the five-year exposure study results. They found health care workers were faced with unique physical demands that increased WMSD risk including lifting and pulling patients.[34]

Awareness of work-hazards and exposure assessment are an important first step in controlling and preventing WMSDs. Many of the assessment tools commonly used now were developed in a specific industry, often manufacturing, and then used in a variety of other industries. The surveillance results described here, as well as the results of the five-year exposure study indicate tailored assessments to reflect differences in job tasks by industry are needed. For example, an exposure assessment should evaluate squatting and kneeling postures for workers in the Construction industry as we report relatively high proportions of knee-related WMSDs, but are less important when evaluating workers in Health Care and Social Assistance. Additionally, lifting assessments developed to estimate the risk of injury from manual material handling activities, such as lifting rigid and stable objects, may only be used to assess lifting patients under certain conditions.[35] SHARP researchers involved in the 5-year exposure study have therefore, recently developed specific physical job evaluation checklists for the Agriculture; Construction; Health Care; Manufacturing; Services; and Wholesale, Retail industries to address this need.[36]

4.4 | Strengths and limitations

These results are subject to several limitations. Most importantly, using workers' compensation claims data for WMSD surveillance underestimates the true incidence and does not include capture WMSDs among workers exempt from workers' compensation in Washington State nor WMSDs that do not result in a claim. Evidence of this is provided above. Under-reporting may result from cost-shifting away from workers' compensation as described earlier. There is also a bias in the compensation system in which acute injuries are more readily accepted than conditions that develop over time.[37,38] Both State Fund and self-insured claims are reported to the Washington workers' compensation system used for this analysis, but limited data were available for self-insured claims. Self-insured employers in Washington employ approximately one-third of the workforce, including those industries known to be high-risk for WMSDs such as Aerospace and Health Care.

The results presented here are limited by the administrative data source used to capture incidence. Outcome misclassification is potentially another limitation with this analysis. Misclassification was examined for the WMSD definition used here using record review and reported previously.[11] In 2005, a coding change from ANSI z16.2 to OIICS occurred and may have led to small disruptions in the trend. Rate trends during this time should be interpreted with caution; however, significant decreases in WMSD claims are still present when excluding data before 2005. Additionally, only the biomechanical events that led to the condition are captured in this system and therefore described here. Other exposures, such as culture and psychosocial factors may be important in the development of WMSDs, are not described due to lack of data.

Rates presented here were calculated using hours at work reported by employers. Hours by industry are available and therefore, allowed for rates to be calculated by industry. Data are not available from this source by occupation, which is also important to consider as some high risk occupations exist within low risk industries.

4.5 | Generalizability

We present the epidemiology of WMSDs using the Washington State workers' compensation system, one of the most comprehensive state-based administrative data systems capturing work-related conditions in the U.S. Workers' compensation coverage and allowances and distribution of industries differ from state to state, and therefore, incidence counts and hours of work exposure by industry are likely to be different across states. Additionally, specific monetary costs or days of time loss compensated by this system cannot be directly imputed to other states. However, the trends and patterns described here have relevance beyond Washington State. As discussed above, the decreasing WMSD trend described in this paper has also been documented nationally. These data also allowed us to calculate incidence rates per exposure. Industries identified here by highest WMSD rates are expected to have higher rates in other states as well. Relative rankings of most common and costly types of WMSDs, body part affected, and exposures leading to WMSDs are also thought to be relevant outside of Washington State.

5 | CONCLUSION

The importance of tracking WMSD patterns and trends is evident as the burden persists. WMSDs continue to cause pain and disability among workers leading to costly medical evaluations and treatments and lost work time. High risk industries are identified here and differences of WMSD type presented by industry to guide research and prevention activities.

Future research should focus on the relationship between decreasing claim rates and exposures in the workplace over time to better understand the trend reported here. Shoulder-related WMSDs should be of particular interest for study as they have a high incidence and high cost compared to the other affected body areas in this study. High risk industries continue to be those characterized by heavy manual handling and repetitive work—Construction; Transportation and Warehousing; Health Care; Manufacturing; and Public Administration. Characterization of WMSD claims by body part and exposure/event for each industry here indicates the need for exposure assessment tools and exposure reduction approaches that are tailored for the specialized work within each industry.

AUTHORS' CONTRIBUTIONS

JM is the primary author of this work and was lead in each aspect of the study, including: conceptualization of surveillance plan, data collection, coding, analyses, interpretation of results, literature review, drafting the manuscript, and organizing the internal review and editing

process. The primary author is solely responsible for final approval of the version to be published. The second author, DA, offered technical expertise, including: conceptualizing the data extraction plan, guidance on variable definitions, interpretation of results, critical review for accuracy of content and interpretation. Both authors are accountable for any part of the submitted work.

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ETHICS APPROVAL AND INFORMED CONSENT

This work was performed at the Washington Department of Labor and Industries. The Washington State Institution Review Board (WSIRB) determined this research to be exempt. Informed consent was not required as this research did not involve human subjects as determined by the WSIRB.

DISCLOSURE (AUTHORS)

The authors reports no conflicts of interest.

DISCLOSURE BY AJIM EDITOR OF RECORD

Rodney Ehrlich declares that he has no competing or conflicts of interest in the review and publication decision regarding this article.

DISCLAIMER

None.

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SUPPORTING INFORMATION

Additional Supporting Information may be found online in the supporting information tab for this article.

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