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Workers' compensation injury claims among firefighters in Ohio, 2001–2017

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ABSTRACT

Background: Firefighters are at high risk for nonfatal and fatal occupational injuries. While some past research has quantified firefighter injuries using various data sources, Ohio workers' compensation injury claims data largely have not been used. *Methods:* Public and private firefighter claims, including volunteer and career firefighters, from Ohio's workers' compensation data for 2001–2017 were identified based on occupational classification codes and manual review of the occupation title and injury description. The task during injury (firefighting, patient care, training, other/unknown, etc.) was manually coded based on the injury description. Injury claim counts and proportions were described across claim type (medical-only or lost-time), worker demographics, task during injury, injury events, and principal diagnoses. *Results:* 33,069 firefighter claims were identified and included. Most claims were medical-only (66.28%, <8 days away from work) and involved males (93.81%) aged 25-54 years (86.54%). While the task during injury could not be categorized for many narratives (45.96%), the largest percentage that could be categorized occurred during firefighting (20.48%) and patient care (17.60%). The most common injury events were overexertion involving outside sources (31.33%) and struck by objects or equipment (12.68%). The most frequent principal diagnoses were back, lower extremity, and upper extremity sprains (16.02%, 14.46%, and 11.98%, respectively). *Conclusions:* This study provides a preliminary basis for the development of focused firefighter injury prevention programming and training. Obtaining denominator data, enabling rate calculation, would strengthen the risk characterization. Based on the current data, prevention efforts focusing on the most frequent injury events and diagnoses may be warranted.

1. Introduction

Firefighters are responsible for responding to and ensuring public health and safety during many types of emergency scenarios including structural and wildland fires, motor-vehicle incidents, medical emergencies, and hazardous materials incidents. They often carry out work tasks in dynamic and sometimes highly dangerous environments. As a result, many firefighters are at risk for nonfatal and fatal occupational injuries. Environmental factors such as reduced visibility, wet surfaces, and cumbersome personal protective equipment (PPE) may lead to increased risk for slips, trips, and falls (Kong, Suyama, & Hostler, 2013; Park et al., 2015; Sobeih, Davis, Succop, Jetter, & Bhattacharya, 2006). Additionally, activities associated with moving and lifting while in awkward positions during emergency response (e.g. quickly lifting a hose over the shoulder, moving heavy or injured patients down stairs, etc.) may lead to increased risk for musculoskeletal injuries during work (Gentzler & Stader, 2010). It is important to characterize and understand these injuries to inform efforts to develop and target effective preventative strategies that maintain the safety and health of firefighters.

While some past research efforts have focused on describing firefighter injuries, the work is still limited in scope and must be expanded to realize its full impact. The National Fire Protection Association (NFPA) publishes an annual report of national estimates for firefighter injuries among public fire departments within the United States and reported that 64,875 injuries occurred in 2020. While used widely by fire departments around the country, these data are limited in application due to the exclusion of state, federal, and private fire departments, which represent

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approximately 4% of United States fire departments (United States Fire Administration, 2022). One study used data from the National Electronic Injury Surveillance System occupational supplement (NEISS-Work) to quantify nonfatal injuries among firefighters from 2003-2014 (Marsh, Gwilliam, Konda, Tiesman, & Fahy, 2018). Although informative, this analysis relied on emergency department (ED) data and therefore excluded injuries that were not severe enough to warrant emergency care and injuries that were cared for via other medical interventions (self-care, non-emergency medical facilities, etc.). Analyses by Poplin, Harris, Pollack, Peate, and Burgess (2012), Frost, Beach, Crosby, and McGill (2016), and Jahnke, Poston, Haddock, and Jitnarin (2013) have provided helpful insight on injuries among the fire services, however, their broad application is limited by their study populations, which included workers outside of firefighters, only Canadian firefighters, or a select few United States fire departments, respectively.

Another suitable data source for understanding industry-specific occupational injuries is workers' compensation injury claims. These data provide rich information on workers' demographics, industry, injury type, and injury diagnosis, along with other key incident characteristics. While one previous study by Walton et al. provided valuable insight by examining workers' compensation claims among firefighters in the state of Illinois, these research efforts need to be further explored using data from other states (Alexander, Wurzelbacher, Zeiler, & Naber, 2021).

The state of Ohio is among only four states in the United States (North Dakota, Ohio, Washington, and Wyoming) that has an exclusively state-run workers' compensation system. That is, most private and public employees must be insured by the Ohio Bureau of Workers' Compensation (OHBWC), except sole proprietorships, partnerships, and large employers (generally with > 500 employees) that may self-insure if they are financially able. About two-thirds of all workers in Ohio are covered by the OHBWC. The OHBWC data have been used to investigate various worker populations including ambulance services (Reichard, Al-Tarawneh, & Konda, 2018), skilled nursing (Bush, Reichard, Wurzelbacher, Tseng, & Lampl, 2020), and landscaping (Alexander et al., 2021). One analysis of OHBWC data has focused on firefighters specifically but was limited to examining only musculoskeletal disorders (Hanson et al., 2021). However, no analysis of OHBWC data to date has focused on broadly describing injury claims among firefighters. The current study aims to build on the current understanding of nonfatal injuries among firefighters by providing a descriptive analysis of workers' compensation injury claims in the state of Ohio.

2. Methods

Through a formal agreement, the National Institute for Occupational Safety and Health (NIOSH) and OHBWC collaborated to use workers' compensation data for research and surveillance efforts of occupational injuries within Ohio. The data shared through this agreement were de-identified and included information about claim type, workers' occupations, workers' demographics, injury diagnoses, and a free-text injury narrative.

2.1. Claim identification and study population

This analysis of OHBWC data included both private and public employer workers' compensation claims for firefighters from 2001 to 2017. Public and private claims were included because fire departments can be both public (e.g., territory, township, locality-based) or private (e.g. fire protection services for private companies or insured communities) in nature. From these data, initial identification of firefighter claims was completed based on two inclusion criteria. First, claims with OHBWC-specific occupation codes of 5111 (Supervisors: Firefighting and Fire Prevention Occupations), 5120 (Firefighting and Fire Prevention Occupations, Firefighters, Firemen), or 5122 (Fire Inspection and Fire Prevention Occupations) were identified. Additionally, claims that did not have one of the three occupation codes but had a claimant occupation title including either the text "fire" or "ff" (not case-sensitive) were also identified. This initial claim identification step resulted in n = 34,810 claims.

Following initial claim identification, the occupation title and injury narrative of the 34,810 claims were manually reviewed by two researchers with subject matter expertise to verify that the claimants were indeed firefighters. Cross-review of the manually identified claims by the two researchers was done and adjudication was completed via discussion of individual claims when necessary. Cases mutually agreed upon as not being firefighter related were excluded (n = 1,741). As such, n = 33,069 firefighter claims were included in the final analyses. While these claims included both volunteer and career firefighters, there was no reliable way to delineate between these two groups.

2.2. Data coding and variable definitions

This analysis presents information about claimant demographics as well as three descriptive variables of the injury: the "task" that the claimant was performing when the injury occurred, the leading injury event (e.g., struck by objects or equipment, overexertion involving outside sources, falls on the same level, etc.), and the leading Return-to-work (RTW) diagnosis (e.g., back sprain, lower extremity sprain, burn, etc.).

For this analysis, previously coded variables in the OHBWC were used. RTW diagnoses were coded using a previously used OHBWC machine-learning prediction algorithm (Alexander et al., 2021; Bertke et al., 2016; Bush et al., 2020; Reichard et al., 2018), based on the International Classification of Diseases, 9th or 10th revision (ICD-9/10-CM) diagnoses codes, which are reported by the claimant's medical provider on the billing form sent to the OHBWC. Claims diagnoses transitioned from ICD-9-CM to ICD-10-CM system in 2015. For 2015–2017 claims, OHBWC mapped the ICD-10-CM codes to ICD-9-CM and then selected a RTW code based on the ICD-9-CM codes (Meyers et al., 2018). All claims were then categorized into 57 pre-defined diagnosis categories as designed by OHBWC and NIOSH using methods previously described elsewhere (Alexander et al., 2021; Bertke et al., 2016). For claims that had multiple diagnoses, the prediction algorithm used the code that would restrict the workers return to work the most significantly (Bertke et al., 2016).

The leading injury event for each claim was defined using the Occupational Injury and Illness Classification System (OIICS) version 2.01 (Bureau of Labor Statics (BLS)). Based on the narrative injury text and the RTW diagnosis of the injury claim, each claim was assigned a two-digit OIICS event or exposure code using a machine learning auto-coder developed by NIOSH. This method and its accuracy has been described previously by Bertke et al. (2016) Predicted categorizations were manually reviewed for accuracy if the accuracy score of the predictions fell in the bottom quartile or if the claim cost was high (95th percentile) (Bertke et al., 2016). For selected analyses stratified by injury event, the researchers summarized claims across categorizations of selected two-digit (over-exertion involving outside sources (OIICS = 71) and struck by object or equipment (OIICS = 62)) and one-digit (slips, trips, and falls (OIICS = 4)) classifications to assist in practical translation of results.

One additional categorical variable labeled "task" was added to all claims specifically for this study. This additional variable was coded based on the injury narrative text and identified the "task"

that the claimant was performing when the injury occurred. The task variable included eight broad categories: (1) firefighting; (2) patient care; (3) responding to a motor-vehicle incident (MVI) including patient care; (4) training tasks; (5) physical fitness/exercise; (6) worker involved in an MVI; (7) long-term or repeated chronic exposure to firefighting hazards (musculoskeletal pain, hearing loss, cancer, etc.); and (8) other/unclear/multiple. Claims with injury narratives describing multiple contributing tasks or with unclear or ambiguous information were categorized as other/unclear/multiple. For n = 2,000 cases, this variable was coded manually by two trained researchers with subject matter expertise and cross-adjudicated. While statistical methods were not applied to assess intra- or inter-operator repeatability, all discrepancies in coding were discussed individually and then mutually agreed upon by the research team. Using these 2,000 manually coded cases, a naïve bayes machine learning algorithm was trained to code the injury narratives. This algorithm was used to automatically code the task variable for the remaining claims. Task codes assigned with $\geq$ 95% prediction confidence (n = 6,650 claims) were not reviewed following the auto-coding. The auto-coded task variables for the remaining 24,419 claims (73.8%) were manually reviewed by two researchers, recoded as necessary (approximately 15% of reviewed claims), and adjudicated as described above.

Both medical-only and lost-time injury claims were included in this analysis as both stratified and combined results throughout. Lost-time claims are defined as claims that required the worker to spend eight or more days away from work, while medical-only claims required seven or fewer days away or medical treatment only. As such, lost-time claims were generally considered to be of greater severity than medical-only, although that assumption may not always be valid.

2.3. Analytical approach

Descriptive analyses were used to calculate the frequency of claims by year, claimant demographic characteristics, task during injury, injury events, and RTW diagnoses. Additional stratification of frequencies was completed by the yearly weather season, where each season was defined by using the meteorological definition of the Northern Hemisphere (winter includes December, January, and February; spring includes March, April, and May; summer includes June, July, and August; and fall includes September, October, and November).

The OHBWC data represented a census of injury claims (except for firefighters employed by self-insured organizations). Therefore, statistical analyses was performed to aid in determining the extent to which differences among the levels of various measures were notable. Specifically, Poisson regression was performed on claim counts for measures including age group, task, year, quarter, claim type (medical-only or lost-time), injury event, and RTW diagnosis to examine differences in claim counts across the presented categories. Two models were fit, one examining injury event and the other examining RTW diagnosis, and both models included the other factors.

All analyses were conducted using SAS® Version 9.4. Because of the lack of valid worker counts, especially for volunteer firefighters, the results were expressed as occurrence of claims per year.

3. Results

A total of 33,069 claims were identified as firefighter claims; 11,152 (33.72%) were identified as lost-time and 21,917 (66.28%) were medical-only (Table 1). The number of medical-only claims was significantly higher than lost-time claims ($p < 0.05$). From 2001 to 2017, there was a statistically significant decline in total claims ($p < 0.05$) (Fig. 1). Most of the total claims involved males (93.81%). The highest proportion of claims occurred among firefighters between 25 and 54 years old (86.54%), with all other age groups having similar proportions.

Among claims where a task could be identified, the highest proportion of injuries occurred during firefighting (20.48%), followed by patient care tasks (17.60%) (Table 1). Leading injury events for all claims included overexertion involving outside sources (excessive physical effort directed at an outside source of injury or illness, 31.33%) and struck by object or equipment (12.68%). In comparing the differences in injury events by claim type, most injury events had higher occurrence of medical-only claims, but one (fires) had a higher proportion of lost-time claims. The four leading injury events (overexertion from outside sources, struck by object or equipment, struck against object or equipment, and falls on same level) saw significant decreases in total claims from 2001 to 2017 ($p < 0.01$) (Fig. 2).

RTW diagnoses with the largest number of claims included back, upper extremity, and lower extremity sprains (16.02%, 14.46%, and 11.98%, respectively). In comparing the differences for various RTW diagnoses by claim type, most RTW diagnoses had higher proportions of medical-only claims ($p < 0.05$), but several had higher proportions of lost-time claims ($p < 0.05$), including disc disorders, dislocations, upper and lower extremity fractures, and neck sprains (Table 1).

Three specific injury events were explored (overexertion involving outside sources, struck by object or equipment, and slips, trips, and falls) in more detail because they were the most prevalent or important for translation (Table 2). For these three injury events, the most claims involved male firefighters aged 25–54 years. Overexertion involving outside sources were most commonly reported during patient care tasks (39.85%) and firefighting (13.84%). For struck by object or equipment events, the most claims were reported for firefighting tasks (20.49%) and patient care (5.80%). Similarly, slips, trips, or falls had the most claims reported for injuries from firefighting (22.62%) and patient care (5.66%). For overexertion involving outside sources, the most common RTW diagnoses were back and upper extremity sprains (38.44% and 25.38%, respectively). For struck by objects or equipment events, the most common RTW diagnoses for claims were open wounds (35.87%) and contusions (22.70%). For slips, trips, or falls, the most common RTW diagnoses were lower extremity sprains (29.55%) and contusions (15.02%).

By month, the two months with the highest proportion of claims were January and February, and the two months with lowest proportion were November and December. By season, the highest proportion of claims occurred in the third quarter of the year (summer) and the lowest in the fourth quarter of the year (fall) (Table 3). The highest proportion of slips, trips, and falls occurred during the winter months (27%) relative to spring, summer, or fall (17%, 15%, and 16%, respectively). The highest occurrence of exposure to harmful substances or environments occurred during the summer months (12%) relative to the winter (8%), spring (9%), or fall (9%).

Table 4 presents the leading injury events among firefighting and patient care tasks stratified by the most common RTW diagnoses. The proportions of injuries attributable to firefighting were highest among events involving overexertion and bodily reactions (injury resulting from a single or prolonged instance of free bodily motion, 26.99%), exposure to harmful substances or environments (22.77%), or slips, trips, and falls (20.89%). Overexertion and bodily reactions during firefighting most commonly resulted in back, lower extremity, or upper extremity sprains (19.47%, 16.47%, and 26.42%, respectively). Exposure to harmful substances or environments during firefighting most commonly led to burns (45.72%) or poisoning and toxic effects (19.26%). The proportion of injuries

Table 1
Demographic, event, and injury characteristics of Ohio firefighter workers' compensation claims, 2001–2017.

	Lost-time[a]		Medical-only[a]		Total	
	N	%	N	%	N	%
Total	11,152	33.72	21,917	66.28	33,069	100.00
Sex						
Male	10,578	94.85	20,444	93.28	31,022	93.81
Female	561	5.03	1372	6.26	1933	5.85
Unknown	13	0.12	101	0.46	114	0.34
Age (years)						
<25	280	2.51	1982	9.04	2262	6.84
25–34	1975	17.71	6538	29.83	8513	25.74
35–44	4328	38.81	7448	33.98	11,776	35.61
45–54	3667	32.88	4663	21.28	8330	25.19
55–64	838	7.51	1109	5.06	1947	5.89
65+	64	0.57	169	0.77	233	0.70
Missing	0	0.00	8	0.04	8	0.02
Task [b]						
Firefighting	1989	17.84	4784	21.83	6773	20.48
Patient care	2285	20.49	3534	16.12	5819	17.60
Training	547	4.90	1331	6.07	1878	5.68
Physical fitness/exercise	550	4.93	688	3.14	1238	3.74
Responding to an MVI [c]	286	2.56	724	3.30	1010	3.05
Worker involved in an MVI [c]	252	2.26	485	2.21	737	2.23
Long-term exposure	214	1.92	203	0.93	417	1.26
Other/unclear/multiple	5029	45.10	10,168	46.39	15,197	45.96
Leading injury events [d]						
Overexertion involving outside sources (71)	4532	40.64	5830	26.60	10,362	31.33
Struck by object or equipment (62)	510	4.57	3683	16.80	4193	12.68
Other exertions or bodily reactions (73)	1307	11.72	1569	7.16	2876	8.70
Falls on same level (42)	987	8.85	1530	6.98	2517	7.61
Struck against object or equipment (63)	336	3.01	1818	8.29	2154	6.51
Slip or trip without fall (41)	842	7.55	1041	4.75	1883	5.69
Falls to lower level (43)	836	7.50	957	4.37	1793	5.42
Exposure to temperature extremes (53)	202	1.81	1311	5.98	1513	4.58
Exposure to other harmful substances (55)	196	1.76	1269	5.79	1465	4.43
Roadway incidents (26)	341	3.06	654	2.98	995	3.01
Leading RTW diagnoses [e,f]						
Back sprains	1889	16.94	3410	15.56	5299	16.02
Lower extremity sprains	1697	15.22	3085	14.08	4782	14.46
Upper extremity sprains	1704	15.28	2259	10.31	3963	11.98
Open wounds	244	2.19	3457	15.77	3701	11.19
Contusion	307	2.75	2386	10.89	2693	8.14
Burn	315	2.82	905	4.13	1220	3.69
Soft tissue/enthesopathy	730	6.55	487	2.22	1217	3.68
Disc Disorders	952	8.54	127	0.58	1079	3.26
Dislocation	879	7.88	184	0.84	1063	3.21
Other/unspecified effects of external cause	23	0.21	927	4.23	950	2.87

Footnotes:
[a] Lost-time injury claims involve 8 or more days of work; Medical-only claims involve 0–7 days away from work.
[b] Task claims were manually coded and defined by using the injury narrative text to identify the "task" that the claimant performed when the injury occurred.
[c] MVI = Motor vehicle incident.
[d] Based on the two-digit OIICS injury event codes classified by parentheses.
[e] Return-to-work (RTW) diagnoses.
[f] Based on ICD-9 and ICD-10 codes.

attributable to patient care tasks was highest among events involving overexertion and bodily reactions (73.19%). Of the overexertion and bodily reaction claims during patient care, most resulted in back sprains (47.83%) or upper extremity sprains (17.49%).

4. Discussion

This study sought to describe the workers' compensation claims among Ohio firefighters from 2001 to 2017. Overall, the number of Ohio firefighter claims decreased over time. Claimants were mostly males between 25 and 54 years old with those aged between 35 and 44 having the highest number of claims. The three leading injury events for all firefighter claims were overexertion involving outside sources, struck by objects or equipment, and other exertions or bodily reactions. The leading RTW diagnoses were back, lower extremity, and upper extremity sprains. While more slips, trips, and falls were reported in winter than the other months, exposure to harmful substances or environments was reported more often during the summer. Finally, overexertion and bodily reactions during firefighting and patient care were more likely to result in back, lower extremity, and upper extremity sprains.

The finding that the number of claims, medical only claims in particular, are decreasing over time is reflective of a decline in injury claims in the data set (Meyers et al., 2018) as well as in other comparable industries such as ambulance service workers (Reichard et al., 2018) and skilled nursing facility workers (Bush et al., 2020). The most obvious decrease in claims among the injury events examined in Fig. 2 was in overexertion involving outside sources; struck by object or equipment and falls on the same level claims decreased less prominently. This aligns generally with previous research among ambulance service workers and is likely due to struck by object or equipment and falls on the same level claims being less predictable and thus preventable (Bush et al., 2020). The current analysis of

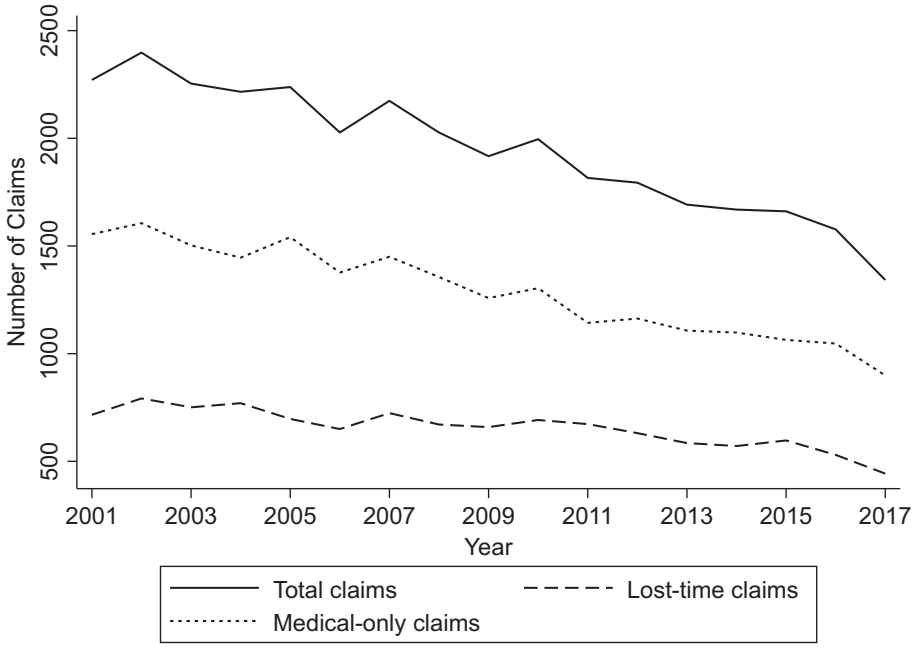

Fig. 1. Ohio firefighter workers' compensation claims by claim type, 2001–2017. Footnote: Lost-time claims involve 8 or more days away from work; medical-only claims involve 0–7 days away from work.

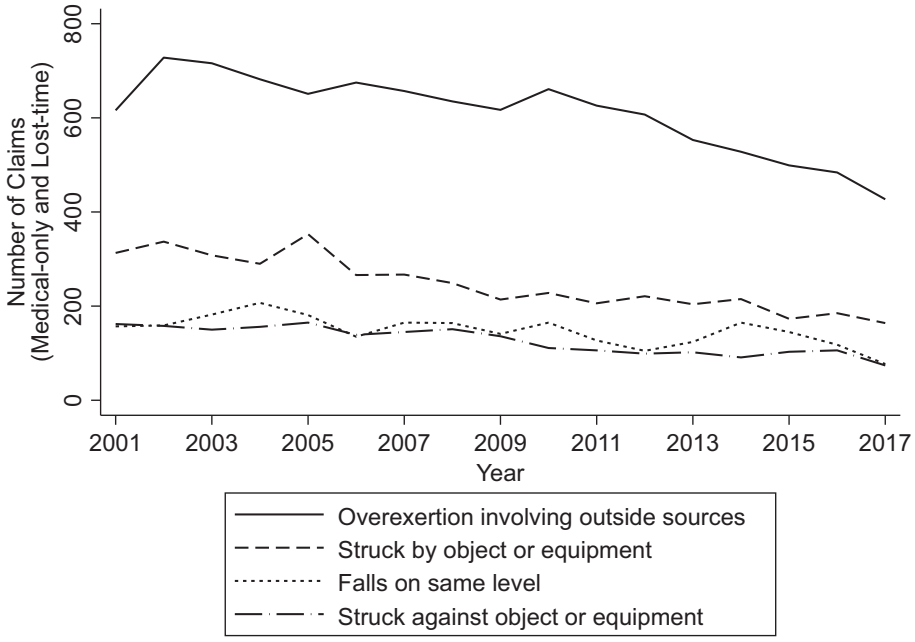

Fig. 2. Ohio firefighter workers' compensation claims by selected injury events, 2001–2017.

firefighter injuries was dominated by male workers (93.81%) with the highest proportion between the ages of 35–44 (35.61%), whereas a more even gender distribution (43.0% male) and younger age (highest proportion in 25–34 years, 41.3%) has been demonstrated for injuries among ambulance service workers (Reichard et al., 2018). While it is difficult to conclusively assess differences when comparing counts rather than rates of injury claims, these observed differences are likely due to differences in the worker population demographics rather than true injury risk across demographic groups in differing industries.

Identifying and understanding risks that firefighters specifically face is complex. A single, comprehensive data source does not exist. Therefore, various national and state data sources have been used to identify risks among firefighters. Although the data for the current study were limited to a single state, similar results have been found in larger, national studies. Each year, the NFPA surveys fire departments and calculates demographics of the firefighter workforce based on the survey responses. Our results indicating that 92.81% of the claims involved males are similar to the NFPA national estimates (92%) (Evarts & Stein, 2020). NFPA also estimates that 71% of firefighters nationally are between the ages of 20 and 49 years, which is comparable to our study finding that 86.54% of firefighter claimants were between 25 and 54 years old (Evarts & Stein, 2020).

Table 2
Characteristics of Ohio firefighter workers' compensation claims by selected injury events, 2001–2017[h].

	Over-exertion involving outside sources[a]		Struck by object or equipment[b]		Slips, trips, & falls[c]	
	N	%	N	%	N	%
Sex						
Male	9809	94.66	3936	93.87	5708	92.17
Female	524	5.06	239	5.70	465	7.51
Unknown	29	0.28	18	0.43	20	0.32
Age (years)						
<25	414	4.00	417	9.95	354	5.72
25–34	2472	23.86	1301	31.05	1303	21.04
35–44	4137	39.92	1412	33.70	2126	34.33
45–54	2768	26.71	859	20.50	1858	30.00
55–64	555	5.36	182	4.34	486	7.85
65+	16	0.15	19	0.45	65	1.05
Missing	0	0.00	0	0.00	1	0.02
Task [d]						
Firefighting	1434	13.84	859	20.49	1408	22.62
Patient care	4129	39.85	243	5.80	354	5.66
Training	606	5.85	304	7.25	276	4.46
Physical fitness/exercise	578	5.58	89	2.12	98	1.73
Responding to an MVI [e]	261	2.52	161	3.84	122	2.00
Worker involved in an MVI [e]	34	0.33	36	0.86	4	0.06
Long-term exposure	12	0.12	2	0.05	3	0.05
Other/unclear/multiple	3308	31.92	2499	59.60	6193	63.43
Leading RTW diagnoses [f,g]						
Disc disorders	746	7.20			154	2.49
Back sprains	3983	38.44			738	11.92
Contusion			952	22.70	930	15.02
Disease of the nervous system and sense organs			101	2.41		
Dislocation					381	6.15
Foreign body, eye			221	5.27		
Lower extremity sprains			122	2.91	1830	29.55
Lower fracture					251	4.05
Neck sprains			100	2.38		
Open wounds			1504	35.87		
Other sprains	460	4.44				
Soft tissue/Enthesopathy	680	6.56			225	3.63
Superficial injury			474	11.30		
Upper extremity sprains	2630	25.38			814	13.14
Upper fracture			150	3.58	174	2.81

Footnotes:
[a] Overexertion due to outside sources (OIICS = 71).
[b] Struck by object or equipment (OIICS = 62).
[c] Slip, trip, falls (OIICS = 4).
[d] Task claims were manually coded and defined by using the injury narrative text to identify the "task" that the claimant performed when the injury occurred.
[e] MVI = Motor vehicle incident.
[f] Return-to-work (RTW) diagnoses.
[g] Based on ICD-9 and ICD-10 codes.
[h] Data in this table include both medical-only and lost-time claims.

Table 3
Ohio firefighter workers' compensation claims injury events by weather season, 2001–2017[b].

	Winter[a]		Spring[a]		Summer[a]		Fall[a]	
	N	%	N	%	N	%	N	%
Total Claims	8317	25.15	8321	25.16	8583	25.96	7848	23.73
Leading injury events								
Overexertion and bodily reaction	3107	37.36	3476	41.77	3525	41.07	3434	43.76
Contact with objects and equipment	1720	20.68	2055	24.70	2080	24.23	1843	23.48
Slips, trips, & falls	2273	27.33	1397	16.79	1305	15.20	1281	16.32
Exposure to harmful substances or environments	630	7.57	787	9.46	1047	12.20	700	8.92
Transportation incidents	299	3.60	250	3.00	237	2.76	257	3.27
Violence and other injuries by persons or animals	124	1.49	167	2.01	209	2.44	179	2.28
Fires and explosions	108	1.30	107	1.29	101	1.18	95	1.21
Non-classifiable	56	0.67	82	0.99	79	0.92	59	0.75

Footnotes:
[a] Seasonality was analyzed by using the meteorological definition of the Northern Hemisphere.
[b] Data in this table include both medical-only and lost-time claims.

A task code similar to the code assigned to cases in the current study was assigned to the data in the emergency department study. Similar to our results, the study of emergency department-treated injuries found that by far the largest number of injuries occurred during firefighting (Marsh et al., 2018). However, previous literature has indicated that firefighting makes up

Table 4
Ohio firefighter workers' compensation claim injury events by return-to-work diagnosis and task, 2001–2017[a,d].

	Overexertion involving outside sources		Slips, trips, & falls		Contact with objects and equipment		Exposure to harmful substances or environments		Fires and explosions		Transportation incidents		Violence and other injuries by persons or animals		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Firefighting Tasks [b]																
Back sprains	356	19.47	164	11.59	28	2.08	0	–	16	4.47	2	6.67	0	–	570	8.42
Lower extremity sprains	301	16.47	415	29.33	85	6.30	0	–	37	10.34	3	10.00	3	2.22	848	12.52
Upper extremity sprains	483	26.42	207	14.63	35	2.59	0	–	31	8.66	6	20.00	2	1.48	768	11.34
Contusion	7	0.38	228	16.11	243	18.01	0	–	4	1.12	5	16.67	2	1.48	492	7.26
Burn	1	0.05	9	0.64	4	0.30	705	45.72	94	26.26	0	–	0	–	813	12.00
Poisoning and toxic effects	46	2.52	13	0.92	22	1.63	297	19.26	27	7.54	1	3.33	89	65.93	514	7.59
Total (Firefighting) [c]	1828	26.99	1415	20.89	1349	19.92	1542	22.77	358	5.29	30	0.44	135	1.99	6773	
Patient Care Tasks [b]																
Back sprains	2037	47.83	87	24.58	2	0.25	0	–	0	–	3	27.27	10	4.52	2139	36.76
Lower extremity sprains	285	6.69	112	31.64	19	2.35	0	–	0	–	0	–	12	5.43	429	7.37
Upper extremity sprains	745	17.49	25	7.06	7	0.86	0	–	0	–	5	45.45	24	10.86	806	13.85
Open wounds	2	0.05	5	1.41	567	70.00	7	4.49	0	–	0	–	63	28.51	649	11.15
Soft tissue/Enthesopathy	200	4.70	15	4.24	6	0.74	0	–	0	–	0	–	2	0.90	224	3.85
Disc disorders	394	9.25	16	4.52	2	0.25	0	–	0	–	0	–	5	2.26	417	7.17
Total (Patient Care) [c]	4259	73.19	354	6.08	810	13.92	156	2.68	0	0.00	11	0.19	221	3.80	5819	

Footnotes:
[a] All percentages are presented as column percentages. Because only select diagnoses are presented, percentages will not add to 100%.
[b] Task/activity claims were manually coded and defined by using the injury narrative text to identify the "task" that the claimant performed when the injury occurred.
[c] Percentages are row percentages and calculated based on total claims.
[d] Data in this table include both medical-only and lost-time claims.

a small proportion (1%-5%) of firefighter activities (Kales, Soteriades, Christophi, & Christiani, 2007). Therefore, the findings that firefighting results in a high proportion of claims in this study and claims and injuries in other studies may be more indicative of the dangers of operating in and around fire grounds compared to other environments. Our results also indicated that firefighting and patient care tasks result in differing distributions of injury events and resulting diagnoses. Specifically, firefighting tasks had a higher proportion of exposures to harmful substances or environments as well as fires and explosions compared to patient care activities. However, patient care tasks had a greater total proportion of overexertion involving outside sources (73.19%) compared to firefighting (26.99%). Injury pathways and injury prevention strategies (administrative controls, PPE, etc.) for the various tasks may differ significantly, making the distinctions of injury characterization across the tasks especially important for future translational efforts. However, it must be also considered that the current study could not categorize a large portion of claims to a certain task based on their injury narrative descriptions (categorizing them within other/unclear/multiple task category) and therefore were likely to be related to tasks other than firefighting specifically (e.g., station work, equipment maintenance).

Several smaller studies have investigated nonfatal firefighter injuries and exposures. One study characterized injuries to firefighters, paramedics, and inspectors in a medium-sized U.S. metropolitan fire department from 2004 to 2009 (Poplin et al., 2012). While that study found that a larger proportion of injuries occurred as a result of physical exercise activities, it also found that sprains and strains were the most prevalent type of injury on all job operations. Similarly, studies by Frost et al. (2016) and Jahnke and colleagues (Jahnke et al., 2013) found that sprains and strains accounted for most firefighter injuries using other Canadian and U. S. sample populations. This increased risk for sprains and strains is in large part because firefighting duties involve strenuous work, dangerous and unpredictable environments, and cumbersome PPE. For this reason, it is crucial to consider possible prevention approaches including fitness, training, and situational awareness.

Our study can be compared to a recent analysis by Brendan et al., which examined musculoskeletal injuries among emergency responder personnel (including firefighters, police, and emergency medical services (EMS) personnel) using OHBWC claims data 2010–2014 (Hanson et al., 2021). Overexertion accounted for most (68.0%) of the musculoskeletal claims among firefighter/EMS personnel in the Brendan analysis (Hanson et al., 2021). While direct comparisons cannot be made because of the sample differences, overexertion involving outside sources in our analysis was also the leading cause of injury (31.33%) with other exertions or bodily reactions being the third most common injury event (8.70%). Overexertion involving outside sources in this context refers to periods of "excessive physical effort directed at an outside source of injury or illness" (e.g., lifting, pushing, carrying, etc.) while other exertions or bodily reactions refers to "injury resulting from a single or prolonged instance of free bodily motion" (e.g. bending, twisting, crawling, etc.) (Statistics, 2012). Not surprisingly given the nature of these types of injury events, the Brendan paper describes back injuries as the most common injury reported from overexertion (Hanson et al., 2021). This finding is similar to our results indicating that the highest proportion of claims with an injury event of overexertion involving outside sources noted back sprain as the RTW diagnosis (38.3%).

Our results can also be compared to a study by Reichard et al. of OHBWC claims among private ambulance service employees from 2001 to 2011 (Reichard et al., 2018). Similarly to our overall firefighter claims, claims for ambulance service employees have steadily been decreasing over time and most commonly resulted in diagnoses of back and upper extremity sprains. The most common injury event for patient care tasks among firefighters in the current study as well as for ambulance service employees was overexertion involving outside sources (73.19% and 45.7%, respectively) (Reichard et al., 2018). In both populations, these types of injuries most commonly resulted in back, upper extremity, or lower extremity sprains and were likely the result of lifting, pushing, or carrying patients or equipment (Reichard et al., 2018). These similar findings for injuries during patient care indicate the necessity for countermeasures to this type of injury such as power cots or other mechanically assisted lifting devices. This type of intervention is being employed for firefighters currently within the OHBWC Safety Intervention Grants program and is discussed further below.

Our analysis also provided a novel examination of seasonality among firefighter claims. First, our results suggest that slips, trips, and falls among firefighters are more likely in the winter months. While the current study did not determine the exact cause of this pattern and no previous research has examined the question specifically in firefighters, it can be postulated that these falls may occur more frequently due to ground ice causing increased slip, trip, and fall hazards (Rosengren, Hsiao-Wecksler, & Horn, 2014) or potentially due to disproportionate amounts of emergency or fire response calls in the winter months. Several previous studies have found similar increases in fall risk during winter months among the general population (Smith & Nelson, 1998) and various other worker populations including newspaper delivery workers (Gao, Holmér, & Abeysekera, 2008), construction (Gao et al., 2008), and healthcare (Drebit, Shajari, Alamgir, Yu, & Keen, 2010). Additionally, exposure to harmful substances or environments in our analysis was reported more often during the summer months. This result may indicate that increased environmental temperatures in the summer months contribute to higher hyperthermic load and result in more heat strain injuries. Additionally, increased environmental temperatures may cause firefighters to remove their PPE prematurely, increasing injury risk. However, some other previous literature has suggested that cardiovascular disease deaths (related to heat strain injuries) peak in the winter months for firefighters due to lack of heat acclimation (Mbanu et al., 2007). The seasonality described here may also contribute to geographic variation in firefighter injuries; however, that concept was not explored here. Because the exact cause of the injuries was not determined in the current workers' compensation claims analysis, this understanding of seasonality should be explored further in future research.

The results presented in this analysis should be considered in future translation and injury prevention efforts. It is most important to recognize injury types and causes that are both highly prevalent as well as effectively preventable. The OHBWC not only addresses firefighter injuries and illnesses by processing the submitted claims and paying medical and indemnity costs, but it is also committed to the prevention of firefighter injuries and illnesses. In addition to providing safety and health consultative services, OHBWC offers Safety Intervention Grants and Firefighter Exposure to Environmental Elements Grants (FEEEG) to aid fire departments in purchasing equipment that enhances the safety of the firefighters, both from physical injuries and from exposure to toxic substances. Examples of the equipment purchased by fire departments with these grants include power cots and loading systems, power hose reels, diesel exhaust systems, extrication tools, gloves and barrier hoods, chest compression systems, and washer extractors for firefighting gear. Several of these grant initiatives align directly with prevention of common injury events recognized in this analysis such as overexertion involving outside sources during patient care (power cots and loading systems) and exposure to temperature extremes or other harmful substances (gloves and barrier hoods). Future research should focus on examining the effectiveness of these grant programs on changing related injury

prevalence among the grantee agencies. This has been done previously in other industries in general (Wurzelbacher et al., 2014) as well as specifically in construction (Lowe et al., 2020), but this has not been done among specific worker groups such as firefighters.

Several limitations should be noted. First, differentiation between volunteer and career firefighters was not attempted in this study. It may be that injury prevalence is different across these groups; therefore, future research should work to examine injuries among these worker populations separately if possible. While coding the claims to a task during injury provided a useful categorization for translation of these results, many narratives either indicated other tasks or were ambiguous. Thus, the largest proportion of claims (45.96%) were categorized as "other/unclear/multiple," highlighting the potential need for clearer narratives.

Secondly, this analysis of workers' compensation claims was limited to injuries only severe enough to justify workers' compensation reporting. Therefore, this analysis likely missed smaller or less significant injuries among firefighters that were not deemed severe enough to report and/or treat.

A general limitation in using workers' compensation data for trend analyses is underreporting, which differs by industry, especially for illnesses (Azaroff, Levenstein, & Wegman, 2002; Fan, Bonauto, Foley, & Silverstein, 2006), However, more recently many states have developed presumptive coverages for firefighters and other first responders in workers' compensation for certain cancers and specific cardiovascular, respiratory, and mental conditions (Quigley et al., 2021; Racicot & Spidell, 2018).

The study was limited in external validity by the exclusion of self-insured employers within Ohio. Because these employers are not covered under the state-based workers' compensation system, injuries in their workers would not be captured by the workers compensations claims data.

Lastly, this analysis did not include injury rates due to the lack of viable population statistics defining the size of the worker population (career and volunteer) within Ohio to use as denominator data. This limited the study's ability to make comparisons of estimated injury risk across specific groups or sub-sets of the data.

5. Conclusions

This study described OHBWC claims among firefighters from 2001 to 2017. While the number of claims among firefighters generally decreased over that time, overexertion involving outside sources, struck by objects or equipment, and slips, trips, and falls remain among the most common injury events reported. It does appear that patient care and firefighting tasks may result in different distributions of both injury events as well as resulting diagnoses. Future injury prevention strategies as well as research efforts should consider these injury events specifically. Intervention programs, awareness, and trainings to encourage engineering controls, administrative controls, and PPE may consider focused efforts to contribute to the future prevention of the injuries highlighted in this analysis. However, future research should also explore intervention effectiveness prior to large-scale or focused intervention efforts.

Authors' contributions

Conception of the work and methods development: TQ, SM, SW, SN; Data management and processing: TQ, SM, SW, SN; Data Analysis: SM, KO, SN; Author initial manuscript: TQ, KO, SM; Lead coauthor and peer-review process: TQ. All authors participated in the development and editing of the manuscript or in providing critical revisions to important intellectual content; and all authors agree to be accountable for all aspects of the work.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Submission declaration

This paper is not being considered for publication by any other journal.

Disclaimer

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