

Nonfatal Injuries to Firefighters Treated in U.S. Emergency Departments, 2003–2014



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Introduction: Several studies of nonfatal firefighter injuries have been conducted but are limited by the inclusion criteria used and coverage. The aim of this study was to enhance current knowledge by providing national estimates of nonfatal injuries to firefighters treated in U.S. emergency departments.

Methods: Nonfatal injuries from 2003 through 2014 were extracted from the National Electronic Injury Surveillance System occupational supplement (NEISS-Work). NEISS-Work captures nonfatal occupational injuries, illnesses, and exposures treated in a sample of U.S. emergency departments. Nonfatal injury rates were calculated based on NEISS-Work counts (numerator) and counts from the National Fire Protection Association (denominator). Data were analyzed from 2016 through 2017.

Results: Between 2003 and 2014, an estimated 351,800 firefighters were treated in emergency departments for nonfatal injuries. The overall rate was 260 injuries per 10,000 firefighters. Career firefighters had an annual rate of 699 injuries per 10,000 firefighters; volunteers had a rate of 39 injuries per 10,000 firefighters. Leading injury events were fires and explosions (36%) and overexertion and bodily reactions (20%). A majority (38%) of injuries occurred during firefighting activities, 7% occurred during training, and 7% occurred during patient care. Sprains and strains accounted for the largest proportion of injuries in all three of these activities: 28% firefighting activities, 32% training, and 36% patient care.

Conclusions: The results demonstrate that nonfatal injuries for firefighters remained high throughout the study period. The predominance of sprains and strains in all firefighting activities suggests the need for additional research and prevention needs in areas of improved fitness, safer body postures and movements, and situational awareness.

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INTRODUCTION

Firefighters (FFs) perform crucial tasks to ensure public safety and health. With a workforce of more than one million,¹ FFs are responsible for critical public safety activities, such as fighting structure and wildland fires, responding to vehicle and hazardous material incidents, and assisting during medical calls. These tasks can lead to injury and death.

Several studies have investigated nonfatal FF injuries and exposures but were limited by inclusion and coverage. One study characterized injuries to FFs, paramedics, and inspectors in one medium-sized U.S. metropolitan fire department (FD) from 2004 to 2009.² Studies by

Frost et al.³ and Jahnke and colleagues⁴ were limited to a large Canadian metropolitan FD and 11 FDs in the central U.S., respectively. Two other studies included federal wildland FFs⁵ and workers' compensation records

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from suburban FFs from 77 Illinois municipalities.⁶ Although the findings of these and similar studies provide insight into FF injuries, these findings are not necessarily generalizable beyond the populations of interest.

The National Fire Protection Association (NFPA) produces annual national FF injury estimates from its survey of public FDs.⁷ The survey collects data on injuries sustained during all types of assignments and is recognized as an important tool for the fire service. However, there are also certain limitations of the survey. The survey excludes state, federal, and private FDs and the same departments do not consistently participate from year to year. In addition, there are no details on injury severity, and it is unknown if FDs define injuries consistently.

Because existing data are limited by inclusion criteria, comprehensive research is needed to better understand the epidemiologic characteristics of FFs at a national level to help inform and direct prevention strategies. To address the gaps of previous research and existing estimates, the current study uses national data with a standardized case definition to describe nonfatal occupational injuries among FFs that were treated in emergency departments (EDs). This study enhances knowledge of FF injuries by producing national estimates without restrictions, such as establishment ownership or worker status (career versus volunteer).

METHODS

Study Sample

Nonfatal occupational injuries, illnesses, and exposures to FFs from 2003 through 2014 were extracted from the occupational supplement to the National Electronic Injury Surveillance System (NEISS-Work), an ED-based surveillance system. Because only a small proportion (<5%) of FF illnesses and exposures were identified in NEISS-Work, the term “injury” will be used to refer to injuries, illnesses, and exposures.

The National Institute for Occupational Safety and Health (NIOSH) collects NEISS-Work in collaboration with the Consumer Product Safety Commission. NEISS-Work is collected from a stratified probability sample of $\cong 67$ U.S. hospital EDs. Case identification occurs via medical chart review. An injury is considered work-related if it occurred to civilian, non-institutionalized workers working for pay or compensation, working on a farm, or volunteering for an organized group.^{8,9} To calculate national estimates, each NEISS-Work case is assigned a statistical weight based on the inverse probability of the hospital being selected.^{8,9} Individual case weights are summed to produce estimates.^{8,9} The NEISS-Work data are maintained by NIOSH as restricted-access data. Review was not required by NIOSH's IRB because the analysis was conducted using existing surveillance data and did not include any personal identifiers.

NEISS-Work event/exposure information was coded based on the Bureau of Labor Statistics Occupational Injury and Illness

Classification System (OIICS). Data prior to 2011 were coded based on version 1.01.¹⁰ Data from 2011 to 2014 were coded based on OIICS, version 2.01.¹¹ Version 2.01 was a major revision to version 1.01 and was considered a break in series.¹⁰

Labor force estimates for FFs were obtained from the NFPA National Fire Experience Survey.¹² Survey data are collected two ways: through a sample of FDs stratified into nine categories based on the size of the community protected by the FD for populations of $\geq 2,500$ and from a random sample of FDs protecting communities with $< 2,500$.¹² National estimates are calculated by weighting results according to the proportion of the total U.S. population accounted for by communities in each of the ten strata. Estimates are available by year, age group, and worker status.

Measures

This analysis included FFs treated in EDs for injuries related to on-duty functions. Common on-duty functions included fighting fire, salvage and overhaul, responding to/returning from an incident, training, equipment and building maintenance, public education, and fundraising. FFs are often cross-trained as emergency medical services workers, so FFs providing patient care are also included. Various occupations were excluded such as administrator, emergency medical services worker with no indication of concurrent FF employment, clerk, communications operator, dispatcher, mechanic, fire investigator, forest service ranger, lifeguard, maintenance worker, cook, and ambulance driver. Although the criteria used for this study were more restrictive than criteria used by other systems,¹³ it insured that correct cases were included with a high degree of confidence.

Because NEISS-Work does not include standardized industry and occupation codes, a stepwise process was used to identify cases. The inclusion/exclusion criteria noted above was used to develop a list of keywords to search business type, employer type, and occupation type from 2003 through 2014. The 12,400 unweighted cases initially identified were categorized as clearly a FF, not a FF, possibly a FF, or missing information. If all three variables listed above were clearly FF-related, cases were automatically included without further review ($n=5,100$, 41%). For the remaining cases ($n=7,300$, 59%), narrative text was manually reviewed to determine FF status. If the worker was participating in any on-duty functions noted above, the case was retained in the study sample. Three of the study's authors reviewed all questionable cases; consensus was required to include cases in the study. Of the 7,300 cases, there were 1,900 included after manual review. As a final step, the 7,000 cases included were assigned a work activity code that reflected the task being performed when the injury occurred: activities directly related to fighting fires, training, patient care, physical activity excluding formal training, and all other activities. Training included formal training such as FD drills, FD training, fire training academy, or fire school. Physical activity included nonformal activities. One author initially assigned these codes and a second author reviewed the codes. All questionable code assignments were further reviewed by other authors to reach consensus.

Statistical Analysis

Data were analyzed in 2016–2017. Estimates, variances, and 95% CIs were calculated using PROC SURVEYMEANS in SAS, version 9.3. All variables were analyzed for 2003 to 2014 except two, event

and worker status. Because of the OIICS break in series, analyses by event were limited to 2011 through 2014 data. Worker status (career, volunteer) was only available from NEISS-Work for 2009 forward. Career workers include both public and private workers. Average annual rates were calculated as the estimated nonfatal injuries from NEISS-Work divided by the estimated FFs from NFPA and expressed as the number of injuries per 10,000 FFs. For comparison purposes, an annual average rate was calculated for all other workers. This rate was calculated as the estimated nonfatal injuries for all workers, except FFs, from NEISS-Work divided by the estimated number of all other workers (except FFs) from the Current Population Survey, a national household survey conducted monthly on \cong 60,000 non-institutionalized residents.¹⁴ An annual average rate was calculated for all other workers excluding FFs aged \geq 16 years and expressed as the number of nonfatal work injuries per 10,000 workers. Because the Current Population Survey is not designed to comprehensively capture volunteers, the Current Population Survey was not used to calculate rates for FFs.

RESULTS

From 2003 through 2014, an estimated 351,800 FF injuries were treated in EDs (Table 1). The highest annual estimate (32,900 injuries, 95% CI=16,100, 49,700) occurred in 2003 while the lowest (22,800 injuries, 95% CI=14,400, 37,200) occurred in 2013 (Figure 1A). Male FFs sustained most of the injuries (95%; Table 1). FFs aged 30–39 years sustained the largest percentage of injuries (35%). By contrast, workers aged 20–29 years sustained the largest percentage of injuries for all other U.S. workers (29%, 95% CI=27%, 31%), whereas workers aged 30–39 years accounted for the second largest percentage (24%, 95% CI=23%, 25%) of injuries among all other U.S. workers. Among the 175,800 FF injuries (95% CI=113,900, 237,700) from 2009 through 2014, 82% (144,200 FF injuries, 95% CI=83,700, 204,700) occurred to career FFs and 10% (18,400 volunteer FF injuries, 95% CI=9,400, 27,400) occurred to volunteers (data not shown). The remaining 8% (13,200 injuries, 95% CI=93,000, 17,100) had other or unknown worker statuses.

The annual average rate of injuries per 10,000 FFs was 260 (95% CI=168, 352; Table 1). The FF rate was 1.2 times higher than the nonfatal ED-treated injury rate of 214 injuries per 10,000 workers (95% CI=172, 256) for all other U.S. workers (except FFs). The highest rate (300 injuries per 10,000 workers, 95% CI=150, 450) was in 2003; the lowest rate (200 injuries per 10,000 workers, 95% CI=128, 272) was in 2013 (Figure 1B). FFs aged 20 to 29 years had the highest rate of 332 injuries per 10,000 FFs whereas FFs \geq 60 years had the lowest rate (86). Career FFs had an annual rate of 699 injuries per 10,000 FFs (95% CI=411, 987), whereas volunteers had a rate of 39 injuries per 10,000 (95% CI=20, 58).

From 2003 through 2014, 38% of FF injuries occurred during firefighting activities, whereas 7% occurred during training and 7% occurred during patient care (Table 1). Forty-seven percent could not be assigned distinct activity codes because of limited information contained in the record. From 2009 through 2014, career FFs had similar percentages by worker activity (data not shown). However, more than half (55%, 10,200 injuries, 95% CI=4,600, 15,800) of the injuries to volunteer FFs occurred during firefighting activities.

Of the FF injuries from 2003 through 2014, a total of 97% (340,200 injuries, 95% CI=216,000, 464,400) were treated and released (data not shown). The most common injuries were sprains and strains (34%) and contusions and abrasions (14%; Table 1). Body parts most commonly affected were lower extremities (21%) and the trunk (19%; Table 1).

From 2003 through 2014, the most common injuries during firefighting activities were sprains and strains (28%, 37,200 injuries,^a 95% CI=13,800, 60,600) and contusions and abrasions (13%, 17,300 injuries,^b 95% CI=6,100, 28,500; data not shown). Training and patient care activities both most often resulted in sprains and strains. Sprains and strains accounted for 32% (7,300 injuries, 95% CI=3,700, 11,000) of training activities and 36% (8,600 injuries,^c 95% CI=3,100, 14,100) of patient care activities.

From 2011 through 2014, events frequently leading to nonfatal injuries were fires and explosions (36%) and overexertion and bodily reactions (includes injuries caused by excessive physical effort and working in an awkward position; 20%; Table 2). Leading events for career and volunteer FFs were similar. However, fires and explosions accounted for almost half of the injuries among volunteers. Between 2011 and 2014, the number of injuries resulting from fires and explosions for all FFs decreased 48%, whereas the number of injuries resulting from overexertion and bodily reactions increased 43% (Figure 2). For this same period, sprains and strains, the leading diagnosis, were most usually caused by overexertion and bodily reactions (14,400 injuries, 95% CI=9,500, 23,900); fires and explosions (10,300 injuries, CI=1,900, 18,700); and falls, slips, and trips (8,300 injuries, 95% CI=4,300, 12,300; data not shown).

DISCUSSION

Identifying and understanding risks that FFs face is complex as no single, comprehensive data source exists.¹⁵

^aEstimate is statistically unreliable, with a coefficient of variation of 31%.

^bEstimate is statistically unreliable, with a coefficient of variation of 32%.

^cEstimate is statistically unreliable, with a coefficient of variation of 32%.

Table 1. Characteristics of Fire Fighters Treated in Emergency Departments for a Work-Related Injury, 2003–2014 (NEISS-Work)

Characteristic	Weighted estimate (95% CIs)	Weighted percent	Rates per 10,000 fire fighters (95% CIs)
Total ^a	351,800 (225,500, 478,100)	100	260 (168, 252) ^b
Sex			
Male	333,500 (210,000, 457,000)	95	— ^c
Female	18,200 (11,300, 25,100)	5	—
Age, years			
16–19	12,900 (6,600, 19,200)	4	269 (141, 410)
20–29	95,900 (58,300, 133,500)	27	332 (205, 459)
30–39	124,300 (67,100, 181,500)	35	330 (182, 182)
40–49	80,500 (51,100, 109,900)	23	232 (149, 381)
50–59	30,800 (21,300, 40,300)	9	145 (101, 189)
≥ 60	6,900 (3,100, 10,700)	2	86 (40, 132)
Task ^d			
Firefighting	134,900 (71,900, 197,900)	38	—
Training	23,100 (12,000, 34,200)	7	—
Patient care	23,800 (11,800, 35,800)	7	—
Physical activity, excluding training	5,400 (1,700, 9,100) ^e	2	—
Other/unknown activity	164,500 (102,400, 226,600)	47	—
Diagnosis ^d			
Sprain/strain	118,200 (63,800, 172,600)	34	—
Contusions/abrasions	49,200 (26,100, 72,300)	14	—
Laceration	26,300 (17,600, 35,000)	7	—
Fracture/dislocation	16,900 (11,900, 21,900)	5	—
Puncture	6,200 (3,800, 3,800)	2	—
Other ^f	135,000 (90,600, 57,900)	38	—
Body part ^d			
Lower extremities	73,400 (46,800, 100,000)	21	—
Trunk	65,100 (35,800, 94,400)	19	—
Head and face	42,600 (29,600, 55,600)	12	—
Hand and fingers	41,800 (29,300, 54,300)	12	—
Shoulder	32,900 (9,400, 56,400)	9	—
Upper extremities	27,300 (15,800, 38,800)	8	—
Neck	15,100 (5,200, 25,000)	4	—
All other body parts	53,500 (37,300, 69,700)	15	—

^aWeighted estimates and percentages may not add to totals due to rounding.

^bCI for the rate does not include error associated with the denominator and likely underestimates the total rate variance.

^cDenominator data for sex was not available for the entire 12-year period.

^dRates were not calculated for task, diagnosis, and body part.

^eEstimate is statistically unreliable with a coefficient of variation of 34%.

^f“Other” diagnosis includes burns, anoxia, dermatitis, internal injuries, poisonings, foreign body, concussions, electric shock, crushing, and other diagnoses that did not meet minimum reporting requirements.

NEISS-Work, National Electronic Injury Surveillance System—occupational supplement.

Therefore, risks must be identified via analysis of available data, including the ED data used in the current study. This study offers a national perspective of nonfatal FF injuries without establishment ownership or industry restrictions. Based on the findings, it is clear that FF injuries treated in EDs remained high and relatively unchanged throughout the 12-year study period. These findings are similar to the national findings from the NFPA.⁷

Like other research,^{5,7,16–20} this study found that sprains and strains—not burns—were the most common injury among FFs. Sprains and strains accounted for the largest proportion in the three primary activities that FFs undertake: firefighting, training, and patient care. Because firefighting involves strenuous work, dangerous and unpredictable environments, and heavy personal protective equipment,²¹ it follows that FFs are at an

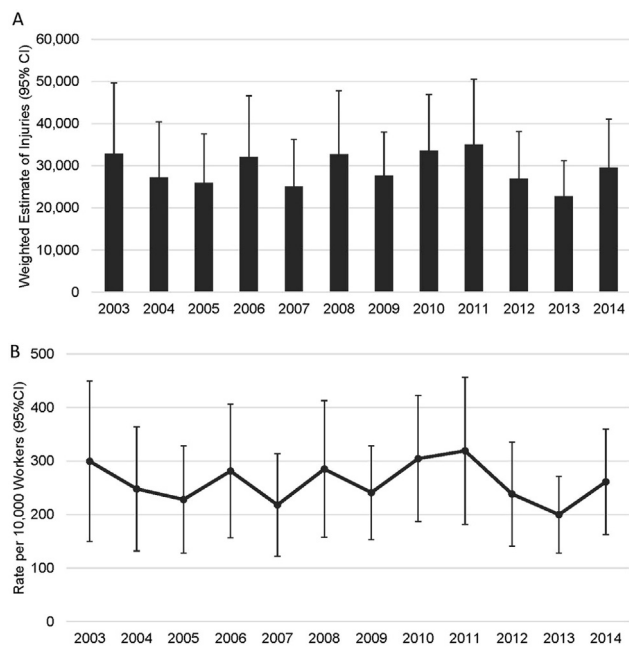


Figure 1. (A) Weighted estimates of nonfatal injuries to fire fighters treated in emergency departments, 2003–2014. (B) Rates of nonfatal injuries per 10,000 fire fighters^a treated in emergency departments, 2003–2014.

^aDenominator data are from the NFPA fire department profile (NFPA 2016b).

NFPA, National Fire Protection Association.

increased risk for sprains and strains. It is crucial to consider possible approaches to preventing sprains and strains from occurring, including fitness, training, and situational awareness.

FFs' overall fitness and health are critical factors in injury occurrence and severity.^{22,23} Poplin and colleagues²² found an association between lower fitness levels and increased injury risk among career FFs. To execute physically demanding jobs properly and safely, FFs should achieve and maintain some degree of physical fitness. This can be encouraged by departments through worksite health promotion.^{24,25} However, Stefano²⁶ describes obstacles to workers participating in wellness programs including lack of information on risk, lack of appropriate training, and lack of motivation. The NFPA 1583 Standard on Health-Related Fitness Programs is a positive, nonpunitive tool that outlines five components that FDs can implement to improve members' health and fitness.^{21,27} The National Volunteer Fire Council, and the International Association of Fire Fighters/International Association of Fire Chiefs also have health and fitness initiatives that can be implemented. Regardless of the program, training FFs on the importance of proper physical fitness can potentially lead to improved FF safety and health^{2,5–7,19,20,28} and ultimately in a reduction in the number of sprains and strains.

Although standard injury prevention recommendations from the Occupational Safety and Health Administration, such as keeping the work environment free of clutter, using caution on slippery or uneven surfaces, and avoiding strenuous activity when tired,²⁹ are feasible in controlled environments, these practices are generally not options for FFs who have little control over their work environment.³⁰ Therefore, regular education and training for FFs on the risks of heavy and awkward lifting, and working on slippery and uneven surfaces^{2,5,6,19,20,28} are imperative. Ensuring that staff are trained on safe lifting techniques, the use of ergonomically appropriate equipment, and the importance of proper physical fitness can potentially lead to improved FF safety and health.^{2,5,6,16–18,28,31}

A discussion on injury prevention for FFs would not be complete without mentioning situational awareness and risk management. Many emergency scenes have competing distractions, making situational awareness a challenge for FFs. Kunadharaju et al.³² noted that risks can in fact “become so commonplace that their significance is diminished to the point that they are accepted as normal.” Situational awareness begins the moment a call comes in and involves company officers, safety officers, incident commanders, and FFs. Risk management is described in NFPA 1500.³³ This standard suggests that the department identify and train someone as a safety officer to ensure that risks are identified and controlled at an emergency scene. Implementing a risk management system that involves risk identification and situational awareness may potentially reduce injuries, including sprains and strains.

Most injuries in this study occurred to career FFs (82%) with a rate of 699 injuries per 10,000 workers (95% CI=411, 987), 18 times higher than the volunteer FF rate (39 injuries per 10,000 workers, 95% CI=20, 58). This finding is similar to previous research.¹⁶ Higher rates for career FFs may be explained by the fact that career FFs are on duty more than volunteer FFs.³⁴ Career FFs respond to more incidents and work longer shifts than volunteers who generally work as needed.^{34,35} Given the differences in levels of emergency response, population-based rates such as those presented here do not adequately account for hours that career and volunteer FFs actually work. Improved data accounting for actual on-duty hours are needed to determine differences in rates between career and volunteer FFs.

Limitations

The most significant limitations of this study are related to case identification using NEISS-Work. First, because NEISS-Work does not include standardized occupation or industry codes, a systematic methodology was

Table 2. Event by Worker Status for Fire Fighters Treated in Emergency Departments, 2011 Through 2014 (NEISS-Work)

Event or exposure ^a	Career		Volunteer		Total	
	Weighted estimate (95% CIs)	Weighted percentage	Weighted estimate (95% CIs)	Weighted percentage ^b	Weighted estimate (95% CIs)	Weighted percentage ^b
Fires and explosions	34,200 ^b (12,900, 34,200)	35	6,600 (3,100, 10,100)	46	41,300 (20,400, 62,200)	36
Overexertion and bodily reactions	20,600 (13,100, 28,100)	23	2,200 (900, 3,500)	16	23,400 (15,800, 31,000)	20
Contact with objects and equipment	14,600 (9,800, 19,400)	14	2,700 ^b (1,000, 4,400)	16	17,800 (12,400, 23,200)	16
Falls, slips, trips	14,800 (10,800, 23,500)	15	— ^c	— ^c	16,900 (8,300, 25,500)	15
Exposures to harmful substances or environments	8,600 (4,600, 12,600)	7	— ^c	— ^c	9,300 (5,000, 13,600)	8
Transportation incidents	2,500 ^b (1,000, 4,000)	3	— ^c	— ^c	2,700 (1,200, 4,200)	2
Violence and other injuries by persons or animals	1,900 ^b (600, 3,200)	2	— ^c	— ^c	2,200 (900, 3,500)	2
Nonclassifiable	— ^c	— ^c	— ^c	— ^c	— ^c	— ^c
Total ^d	98,100 (55,600, 140,600)	100	14,200 (7,300, 21,100)	100	114,500 (72,800, 187,300)	100

^aEvent or exposure coded using the Occupational Injury and Illness Classification System (OIICS), version 2.01 (2012).

^bEstimate is statistically unreliable with a coefficient of variation greater than 30%.

^cEstimate did not meet minimum reporting requirements.

^dWeighted estimates and percentages may not add to totals because of rounding.
NEISS-Work, National Electronic Injury Surveillance System—occupational supplement.

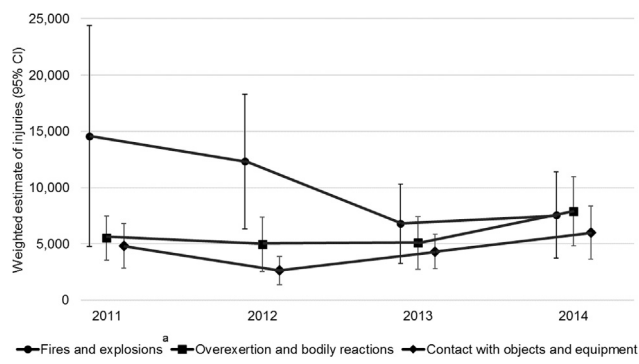


Figure 2. Weighted estimates of nonfatal injuries to fire fighters treated in emergency departments by event, 2011–2014.

^aEstimate for 2011 is statistically unreliable with a coefficient of variation of 34%.

Note: Data points for each year are adjusted slightly to aid visualization.

established to identify cases. This approach erred on specificity over sensitivity, and it is possible that FFs were missed in the case-identification approach. Furthermore, because the data only include ED-treated injuries, the study did not include injuries not needing immediate care, treated in other medical venues, or self-treated. Case capture may be incomplete despite succinct definitions of what constitutes work-relatedness. For example, injuries may not be identified as work-related because of a lack of information provided by the worker at the time of treatment, incomplete medical records, or errors in abstraction. Finally, NEISS-Work does not contain information on potential confounding factors, such as work conditions, lifestyle factors, and physical or mental comorbidities, and does not contain specific details regarding personal protective equipment use.

CONCLUSIONS

This study provides systematically collected and nationally representative nonfatal ED-treated FF injuries. Unlike other studies that have explored FF injuries, the findings from this study are not restricted by establishment ownership or worker status (career versus volunteer). The results demonstrate that FFs incurred ED-treated occupational injuries at a higher rate than the general workforce from 2003 through 2014. The predominance of sprains and strains suggests additional research and prevention needs in the area of improved physical fitness programming, training on safe body postures and movements, and an increased focus on situational awareness.

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