PRESS RELEASE

Beyond the fireground: injuries in the fire service

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ABSTRACT

Background Although firefighting and emergency medical services are high-risk professions, few studies have identified the aetiology of injury in the fire service beyond the fireground.

Methods Data were collected for work-related injuries in a medium-sized metropolitan fire department. In a descriptive study, the factors explored included the nature of injury, agent, mechanism, body location, environment, abbreviated injury scale (AIS), functional capacity index (FCI) and lost time status.

Results From 2004 to 2009, the annual injury incidence rate averaged 17.7 per 100 employees. One-third of all injuries (32.9%) resulted from physical exercise activities, while patient transport, training drills and fireground operations resulted in 16.9%, 11.1% and 10.2% of injuries, respectively. For all job operations, sprains and strains were the most prevalent type of injury (40.2–85.2%), followed by contusions and lacerations (7.7–26.1%). The third most common injury was related to the conventional hazards of the individual job operation. Most injuries (n=862, 95.6%) were minor in severity, while 4.3% of injuries were classified as having some impedance of normal function (FCI 3). Moderate injuries (AIS 2) were infrequent, but comprised a greater proportion of fireground injuries (8.7%) than the other activities (1.0–4.1%); however, lost time injuries were more frequent for patient transport (46.1%) than other operations (22.0–29.1%).

Conclusions Physical exercise, patient transport and training activities were responsible for a greater percentage of injuries than fireground operations. Focused efforts to improve the characterisation of risks during these more diverse set of work processes should help guide the development of salient strategies for injury prevention.

Globally, the burden of occupational injury is significant and largely preventable.[1 2] In the USA, 4340 fatal work-related injuries were reported in 2009.[3] The incidence rate of non-fatal injuries among private industry workers was 3.4 per 100 workers, while public sector workers showed a significantly higher rate of 5.8 per 100 workers.[4] Using year 2000 data, it was estimated that the economic burden of medical treatment and lost productivity due to injury totalled more than US $406 billion, with most of the costs attributed to lost productivity.[5]

Combined, firefighting and emergency medical services have been shown to have one of the highest occupational incident rates for injury and fatalities.[6–8] Among the 1.1 million career and volunteer firefighters in the USA in 2009, 78 150 injuries were reported, a rate of 6.8 injuries per 100 firefighters.[9 10] Since the late 1970s, the number of structural fires has decreased steadily,[11] most notably due to the advent of improved fire suppression and protection systems. However, firefighters have taken on additional responsibilities and are considered first responders for all emergencies (eg, fire, hazardous materials, medical responses, natural disasters and terrorist acts). In one jurisdiction, the City of Tucson, 84.4% of the 79 380 fire department emergency dispatches recorded in 2009 were medical emergencies (Tucson Fire Department, personal communication, 2011). This high proportion of calls due to medical emergencies is consistent with many fire departments now in which medical responses constitute the predominant type of response activity. With these additional roles and responsibilities comes a host of dynamic occupational hazards and risk-laden environments that must be identified and managed.

Studies that have investigated injuries within the fire service have generally focused on aspects of fireground operations.[7 12–15] The International Association of Fire Fighters recently summarised contributory factors to injuries, emphasising how the limited scope of research has been directed only to the variety of physical tasks and hazardous exposures on the fireground.[16] In order to obtain a better understanding of the circumstances in which injury events occur, the present study seeks to build on this earlier work and explore injuries not only on the fireground, but also during other fire service activities.

METHODS

This analysis reflects the first phase of a 4-year project to introduce a participatory-based, risk management system within the fire service in an effort to identify and develop relevant control strategies for preventing injuries.

Setting and population

This descriptive study was designed to explore injuries occurring in the Tucson Fire Department (TFD), a medium-sized metropolitan fire department in the southwest USA. Fire service personnel include firefighters, paramedics, engineers, inspectors, battalion chiefs, etc., referred to in this report as emergency service employees (ESE). The TFD consists of approximately 650 career ESE, operating 21 fire stations and responding to nearly 538 000 residents. In 2009, 84.4% of dispatches involved either basic or advanced life support, while 9.4% encompassed fire-related suppression activities. The remaining 6% focused on basic rescue, hazardous materials and technical rescue (eg, swift water, trench, confined spaces). TFD ESE averaged 41 years of age, 5% were women, and

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race/ethnicity was reported as 76.4% non-Hispanic white, followed by Hispanic (19.6%), with all other groups each comprising less than 3% of the total.

For all emergency responses, the priorities of TFD include life safety, stabilising the incident and property conservation. As a simplified description of roles during a one-alarm fire, a fire engine consists of two firefighters, one engineer and a captain. The captain oversees, assesses and directs all activities of his or her crew. The engineer operates all functions of the fire apparatus (eg, pressure gauges, etc.) and equipment needed for suppression and rescue activities, while the firefighters' primary role is to engage in any search and rescue efforts while actively suppressing the fire. All members of this population are certified as basic-level emergency medical technicians. Paramedics in this department are all trained firefighters who have additional specialty training and certifications to administer advanced life support in the field and during transport to a definitive care facility. As a situation becomes larger or more complex, additional personnel and resources are allocated and responsibilities may change.

Data sources and analyses

Data were abstracted from TFD injury reports, which contained information about the employee (eg, age, rank), the injury, and contributory factors to the injury event. Summarised annual surveillance databases were received for work-related injuries and illnesses that occurred from 2004 to 2009. End-of-year counts of ESE (by rank) and workforce demographics (eg, age, race/ethnicity) and dispatch data were obtained from the human resources department of TFD in order to generate incidence rates.

Inclusion criteria for the present study consisted of all enrolled ESE. While cardiac events (eg, stroke, heart attack, etc.) are the most frequent cause of line of duty deaths in the fire service,[17] these events (along with heat exhaustion, stress and other medical issues) were excluded because these conditions are neither musculoskeletal nor integumentary, which are the foci of our analysis.

For TFD, a reportable injury is defined in accordance with Occupational Safety and Health Administration (OSHA) regulations (29 CFR, 1904.7) (ie, medical treatment, restricted work time, or lost work time), in addition to any injury that occurred to specific body regions: eye, neck, back, knee, ankle and shoulder. The surveillance database includes internally documented injuries (ie, those deemed non-OSHA reportable, but recorded in the TFD system), which had no immediate loss of job function or capabilities, but are documented in the event the injury later progresses to a point requiring a report and or treatment (eg, due to cumulative or repeated trauma).

Classification of injuries

The general characteristics of injury events evaluated and classified in this study included: (1) nature of injury, describing the physical characteristics of the injury; (2) part of the body directly affected; (3) energy source (or agent) that directly inflicted the injury or illness; (4) mechanism of injury, which describes the manner in which the injury was inflicted by the source; and (5) secondary sources that contributed to the event or exposure. Injuries were assessed for anatomical severity using the 2008 version of the abbreviated injury scale (AIS).[18] Included in the most recent AIS coding structure is a prediction score for functional impairment (ie, the functional capacity index; FCI), which ranks the anticipated level of functional ability 1 year after the injury event. AIS and FCI were evaluated to add a standardised measure of severity and expand on the more common occupational use of indicating lost time. When available, a review of the narrative section was used to classify better the risk factors (ie, actions, agents and environmental characteristics) involved in the injury event.

Statistical analyses were focused on the descriptive and distributional characteristics of injury events and their outcome, as well as estimates for the annual population incident rate of injuries. Analyses were conducted using Stata software, V.11.1 (StataCorp, College Station, TX, USA). Human subjects' approval and monitoring was provided by the University of Arizona Institutional Review Board.

RESULTS

As shown in table 1, 902 injuries were reported among ESE between the years 2004 and 2009, with annual incidence rates ranging between 13.6 and 21.5 injuries per 200 000 h (equivalent to 100 full-time employees). The mean age of those injured was 37.9 years (range 20−64 years), compared with 41 years among the entire workforce. Sixty-four per cent of injuries were among those in their 30s and 40s.

The 902 reported injuries were sustained among 409 individuals. Therefore, 45.3% of injuries were repeated injuries, ranging between two and nine injuries to the same person over a 6-year time period. The median time between repeat injuries was 345 days (approximately 11 months) and ranged between 2 and 2067 days (approximately 5.7 years). The current analysis did not determine the extent to which the sustained repeated injuries were to the same body location.

The majority of ESE in this study worked five 24-h shifts over the course of a 9-day tour, followed by six consecutive days off. The day of tour for an injury occurrence was available for 87.3% of the injuries (n=282) that occurred during the most recent 2 years of these data. Most injuries (23.2%) were reported on the third day of tour, while the fifth day of the tour amassed 19.5% of injuries. The first, second and fourth days of tour accounted for 15.5%, 15.8% and 13.3% of the reported injuries, respectively.

The beginning of shifts (from 07:00 to 13:00 hours) showed a considerably higher occurrence of injuries (56.0%) compared with other periods of the shift (figure 1), and appears to be related to the tendency to conduct physical exercise and

Table 1 Annual injury frequency (N=902) and incidence rate, 2004−9

Year	Injury frequency	No employed	24-h Employees	8-h Employees	Total hours worked*	Incidence rate (per 200 000 h)
2004	129	530	477	53	1 441 600	17.9
2005	128	577	490	87	1 546 000	16.6
2006	148	625	518	107	1 664 400	17.8
2007	174	659	566	93	1 770 800	19.6
2008	199	694	580	114	1 852 000	21.5
2009	124	667	613	54	1 824 400	13.6

*Based on an average of 2800 and 2000 h worked by 24 and 8-h employees, respectively.

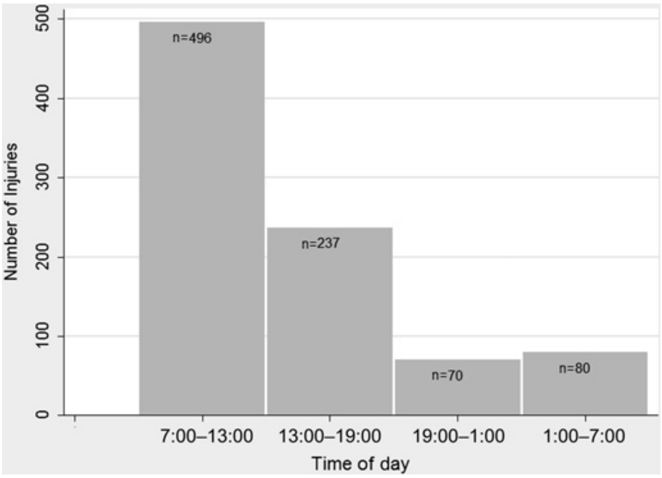

Figure 1 Distribution of reported injuries by time of occurrence (N=883), 2004–9.

training drills at the beginning of shifts, as 74% of exercise injuries and 51% of training-related injuries occurred during this time of day.

Sprains and strains accounted for 67.1% of injuries, primarily to the lower and upper extremities and back (table 2). Contusions and lacerations were also prevalent, accounting for 18.6% of all injuries. Approximately 52% of injuries were among firefighters and paramedics (53.2% of the 2009 population), while 44% encompassed recruits, engineers and captains (39.1% of the 2009 population). Firefighters had the most number of injuries, regardless of the nature. The distribution of injuries was reflective of the proportion of job ranks and primary job responsibilities, as the majority of ESE are firefighters. Captains, engineers and paramedics contributed an equal proportion of the workforce; however, the variability of job activities was greatest among firefighters and paramedics.

Of the 902 injuries, 95.6% were classified as minor (AIS 1), while 3.2% were scored as moderate (AIS 2), consisting of fracture, dislocation, inhalation and electrical injuries, and none were scored as serious or greater (AIS 3–6). Eleven injuries (1.2%) lacked sufficient detail for scoring. The FCI indicated that most injuries (82.0%) were classified as having 'most but not all normal function' (FCI 5), while 4.3% had some impedance of normal function (FCI 3). Thirty per cent of injuries were reported as requiring lost time from work, most often the result of a sprain or strain. Among the lost time injuries, the median number of days lost was 6.0 with a range from 1 to 199.

One-third of all injuries (32.9%) were the result of physical exercise activities (excluding training drills), while 16.9%, 11.1% and 10.2% occurred during patient transport, training and fireground operation processes (table 2). Table 3 further details the

Table 2 Distribution of injury type by descriptive variables, 2004–9

	Injury Type, N (%)						
	Burn (n=26)	Contusion, laceration (n=168)	Fracture, dislocation (n=30)	Puncture (n=24)	Sprain, strain (n=605)	Other* (n=49)	Total (N=902)
Body region							
Lower extremity	5 (19.2)	36 (21.4)	12 (40.0)	6 (25.0)	270 (44.6)	5 (10.2)	334 (37.3)
Upper extremity	14 (53.8)	72 (42.9)	9 (30.0)	13 (54.2)	97 (16.0)	4 (8.2)	209 (23.2)
Back/spine†	0 (0)	3 (1.8)	0 (0)	0 (0)	195 (32.2)	0 (0)	198 (22.0)
Head/face/neck	6 (23.1)	40 (23.8)	8 (26.7)	4 (16.7)	11 (1.8)	32 (65.3)	101 (11.2)
Torso	0 (0)	14 (8.3)	1 (3.3)	1 (4.1)	16 (2.6)	4 (8.2)	36 (4.0)
Other‡	1 (3.9)	3 (1.8)	0 (0)	0 (0)	13 (2.2)	4 (8.2)	21 (2.3)
Missing	0 (0)	0 (0)	0 (0)	0 (0)	3 (0.5)	0 (0)	3 (0.3)
Lost time							
No	21 (80.8)	132 (78.6)	17 (56.7)	22 (91.7)	395 (65.3)	44 (89.8)	631 (70.0)
Yes	5 (19.2)	36 (21.4)	13 (43.3)	2 (8.3)	210 (34.7)	5 (10.2)	271 (30.0)
AIS							
Minor	26 (100)	168 (100)	9 (30.0)	23 (95.8)	605 (100)	31 (63.3)	862 (95.6)
Moderate	0 (0)	0 (0)	21 (70)	0 (0)	0 (0)	8 (16.3)	29 (3.2)
Missing	0 (0)	0 (0)	0 (0)	1 (4.17)	0 (0)	0 (0)	11 (1.2)
Rank							
Firefighter	16 (61.5)	65 (38.7)	15 (50.0)	7 (29.1)	155 (25.6)	19 (38.8)	277 (30.7)
Paramedic	3 (11.5)	35 (20.8)	4 (13.3)	6 (25.0)	134 (22.2)	8 (16.3)	190 (21.1)
Captain	0 (0)	21 (12.5)	3 (10.0)	4 (16.7)	101 (16.7)	13 (26.5)	142 (15.7)
Recruit	5 (19.2)	11 (6.5)	5 (16.7)	1 (4.2)	109 (18.0)	3 (6.1)	134 (14.9)
Engineer	2 (7.7)	26 (15.5)	2 (6.7)	6 (25.0)	80 (13.2)	5 (10.2)	121 (13.4)
Inspector	0 (0)	5 (3.0)	1 (3.3)	0 (0)	17 (2.8)	0 (0)	23 (2.6)
Chief§	0 (0)	5 (3.0)	0 (0)	0 (0)	9 (1.5)	1 (2.0)	15 (1.7)
Job operation							
Patient transport	0 (0)	26 (15.5)	1 (3.3)	5 (20.8)	116 (19.2)	4 (8.2)	152 (16.9)
Fireground	14 (53.9)	24 (14.3)	2 (6.7)	5 (20.8)	37 (6.1)	10 (20.4)	92 (10.2)
Physical exercise	0 (0)	23 (13.7)	14 (14.7)	1 (4.2)	253 (41.8)	6 (12.2)	297 (32.9)
Training and drilling	7 (26.9)	20 (11.9)	2 (6.7)	1 (4.2)	68 (11.2)	2 (4.1)	100 (11.1)
Other¶	5 (19.2)	75 (44.6)	11 (36.7)	12 (50.0)	131 (21.7)	27 (55.1)	261 (28.9)

*Includes electrical, eye, inhalation and non-descriptive 'medical' injuries.
†Assumed to be primarily lower back or lumbar region.
‡External and multiple injuries, as classified by the abbreviated injury scale (AIS).
§Combination of battalion, deputy, assistant and fire chiefs.
¶May include technical rescues, motor vehicle crash, cleaning, maintenance, travel to/from work, etc.

Table 3 Distribution of injury type and mechanism by job operation, 2004–9

	Physical exercise n=297	Patient transport n=152	Training drills n=100	Fireground operations n=92	Other* n=255	Total N=902
Injury type						
Sprain/strain	253 (85.2)	116 (76.3)	68 (68.0)	37 (40.2)	131 (50.2)	605 (67.1)
Contusion/laceration	23 (7.7)	26 (17.1)	20 (20.0)	24 (26.1)	75 (28.7)	168 (18.6)
Fracture/dislocation	14 (4.7)	1 (0.7)	2 (2.0)	2 (2.2)	11 (4.2)	30 (3.3)
Burn	0 (0)	0 (0)	7 (7.0)	14 (15.2)	5 (1.9)	26 (2.9)
Medical†	5 (1.7)	2 (1.3)	0 (0)	0 (0)	17 (6.5)	24 (2.7)
Puncture	1 (0.3)	5 (3.3)	1 (1.0)	5 (5.4)	12 (4.6)	24 (2.7)
Eye, not further specified	1 (0.3)	0 (0)	2 (2.0)	4 (4.4)	10 (3.8)	17 (1.9)
Inhalation	0 (0)	2 (1.3)	0 (0)	4 (4.4)	0 (0)	6 (0.7)
Electrical injury	0 (0)	0 (0)	0 (0)	2 (2.2)	0 (0)	2 (0.2)
Mechanism of injury						
Acute overexertion	243 (81.8)	103 (67.8)	40 (40.0)	24 (26.1)	69 (26.4)	479 (53.1)
Cutting, piercing	7 (2.4)	20 (13.2)	5 (5.0)	16 (17.3)	40 (15.3)	88 (9.8)
Struck by/caught between	18 (6.1)	10 (6.6)	10 (10.0)	6 (6.5)	31 (11.9)	75 (8.3)
Fall	8 (2.7)	4 (2.6)	5 (5.0)	12 (13.0)	14 (5.4)	43 (4.8)
Thermal effect	0 (0)	0 (0)	6 (6.0)	14 (15.2)	3 (1.2)	23 (2.6)
Transportation-relate	0 (0)	1 (0.7)	2 (2.0)	0 (0)	17 (6.5)	20 (2.2)
Foreign body in orifice	1 (0.3)	1 (0.7)	1 (1.0)	6 (6.5)	9 (3.6)	18 (2.0)
Electrical, radiation or other	0 (0)	0 (0)	0 (0)	2 (2.2)	11 (4.2)	13 (1.4)
Chemical effect	0 (0)	2 (1.3)	1 (1.0)	3 (3.3)	3 (1.2)	9 (1.0)
Mechanism of injury, unspecified	20 (6.7)	8 (5.3)	29 (29.0)	5 (5.4)	42 (16.1)	104 (11.5)
Missing	0 (0)	3 (2.0)	1 (1.0)	4 (4.4)	22 (8.4)	30 (3.3)

*May include technical rescues, motor vehicle crash, cleaning, maintenance, travel to/from work, etc.
†Lacks detail and coded as a non-descriptive 'medical' injury.

distribution of injuries by job operation. Sprains and strains accounted for 67.1% of all injuries, primarily to the extremities and back, but only 40.2% of injuries during fireground operations. Contusions and lacerations were also prevalent, accounting for 18.6% of all injuries, but comprised only 7.7% of physical exercise-related injuries. The third most common injury type parallelled the expected hazards to the individual operation: burns during fireground operations (15.2%) and training drills (7.0%); punctures during patient transport (3.3%); and fractures and dislocations (4.7%) during physical exercise. Moderate injuries (AIS 2) comprised a greater proportion of fireground injuries (8.7%, n=8) than the other activities (range 1.0–4.1%), while lost time injuries were proportionally higher (46.1%, n=70) in patient transport injuries than other job operations (range 22.0–29.1%). The mechanism by which an injury occurred was most often acute overexertion (53.1%), followed by cutting or piercing (9.8%), and being struck by or caught between an object (8.3%). Thermal mechanisms were identified with only 2.6% of all injuries.

DISCUSSION

Most emergency response activities require awkward positioning and significant exertion, increasing the likelihood of injury as well as the need for above-average functional movement. Moore-Merrell *et al*[16] suggested that on-duty injuries were likely to be the result of multiple contributory factors acting in concert with each other; however, no known studies of the fire service have provided a comprehensive description of the hazards and risks of operational responsibilities. While most studies related to the fire service have focused attention on the hazards and injuries during fireground operations, findings from the current study indicate that the largest percentage of injuries result from participation in some form of mandatory physical exercise during one's shift. These injuries occurred at twice the frequency of the next highest job task (ie, patient transport).

The purpose of physical exercise is to prepare one for their job and to condition a person to perform those job tasks with the utmost amount of efficiency, so that injuries are prevented. Therefore, it is somewhat of a paradox that physical exercise, which aims to prevent injuries (and other adverse health outcomes), is actually the most frequent cause of injury. The role that physical exercise plays in the occurrence and severity of injury has not been well documented in the emergency services. Exploring the root causes of these events and the manner in which physical exercise is performed, monitored and evaluated should be of greater emphasis within the fire service. The types of exercise practised by TFD include a wide range of activities (eg, jogging, basketball, circuit training, olympic lifting, metabolic conditioning, interval training, etc.), and vary in exercise programming structure and management. As supported by Barklage,[19] fire departments should institute, promote and maintain a comprehensive fitness and performance programmes to ensure opportunities for maintaining the proper level of fitness necessary to complete the myriad of physical job tasks performed by ESE, and thereby decreasing the potential for acute and cumulative injuries. There are also obvious benefits to comprehensive fitness programmes, most notably the potential prevention of cardiovascular disease, which as mentioned earlier is the leading cause of line-of-duty deaths in the fire service. The National Fire Protection Association standard 1583 (standard on health-related fitness programmes for fire department members) provides relevant policies governing this aspect of work.

In addition to physical exercise, injuries were frequent during patient transport, training drills and fireground operations. Nearly 85% of emergency dispatches are in response to some type of medical issue(s), representing the most frequently performed activity by fire service personnel in TFD; whereas the most frequently trained activity understandably focuses on fireground operations, as this environment typically involved the most variability and the greatest number of hazards that pose a threat to life. Patient transport research has predominantly focused on the risk and consequences of ambulance crashes, in addition to assaults, gurney design and the ergonomic lifting and transfer of patients.[20–27] Fireground research is often performed in training and drilling settings and has focused on individual issues such as heat stress, lung injury, noise, chemical and thermal hazards, slips/trips/falls and overexertion during tactical and overhaul operations.[7 28–32] A comparison with previous research findings is not possible, as the job operations described in the current study are broadly defined and lack the level of specificity with regard to the hazards and job tasks/activities (eg, noise, patient lifting, bench press), that is often presented in other research. How operations are defined is important and will dictate the activities and job tasks undertaken, and therefore the potential hazards. For example, patient transport may be defined as simply the physical lifting and lateral transfer of a patient, or encompass the entire process from call dispatch to release of the patient at a definitive care facility. The extent of detail will depend on the individual department.

From 2004 to 2009, the annual incidence rate of injury in TFD ranged between 13.5 and 21.5 injuries per 100 employees, compared with the 2009 estimated national incidence rate of 6.8 injuries per 100 firefighters.[9 10] It is conceivable that the increased injury rate seen in TFD is a reflection of their reporting and tendency to document all OSHA and non-OSHA reportable injuries. Injuries are reported in the TFD for purposes of documentation, accountability and tracking of potential injury progression. While this practice makes logical sense given the nature of working 24-h shifts and encountering multiple hazards during that time, it does, however, lead to an increase in the proportion of minor injuries reported. This may also explain why a well-accepted method for scoring injury severity, the AIS, did not provide much added detail on the nature of injuries in this population of ESE, because an overwhelming majority of injuries were minor in severity. In attempting to describe injury severity better in this population, identifying an appropriate metric proved challenging. The use of a trauma-based scale (ie, AIS) to measure all injuries in this setting did not represent the types of injuries well. When developing the minor injury severity scale for child injuries, Peterson *et al*[33] noted the lack of an available scale or widely accepted method to measure the severity of minor injuries. An evaluation of functional capacity loss was considered to be a useful alternative measure for this population. The classification scheme from the FCI appears to match the general characteristics of injuries in this population well. However, given the median time loss was 6 days, FCI may not accurately measure the short-term (or acute) loss of function described in this injury study as FCI reflects the likely extent of functional limitation or reduced capacity 1 year post-injury.[34 35]

Thirty per cent of all injuries were noted to have resulted in lost time. Patient transport operations produced the greatest proportion of lost time injuries, consisting mostly of back sprains/strains (60.0%). In most occupational settings, a lost time injury is designated when the individual misses the following shift of work from when the injury occurred. Against conventional thinking, approximately half (55.2%) of the moderate injuries—comprised primarily of fractures and dislocations—were classified as having no lost time. Upon further examination, an injury was classified as lost time only in situations when the employee was not performing any department-related duties (including regular job tasks or light duty assignments), and was compensated (eg, workers' compensation). Therefore, the lost time designation could be considered more of an indicator of cost than as a measure of severity; however, this observation requires further study.

Results from evaluating AIS, FCI and lost time indicate that a more relevant measure of severity is needed for this occupational population of ESE. While the vast majority of injuries can be considered minor using a trauma-based scale, the acute loss of function can be significant. When evaluated over the span of a career, these injuries have the potential to accumulate and result in some loss of function towards the end of one's career. This is supported by the 45% of repeated injuries identified in this study's 6-year time period. In theory, a combination of an ordinal scaling system based on acute functional loss, matched to a true accounting of time loss from normal job activities, could provide an improved indication of severity to the individual, and thus the department.

This analysis was limited by a lack of detail provided by the injury database. Improvements to the description of injury events can be made by including standardised metrics for specific activity performed at the time of injury, the individual's condition before injury, equipment used, known causes, objects and equipment, or other factors (eg, environmental conditions). In order to improve any assessment of severity or functional loss, improved surveillance systems are needed that incorporate standardised metrics for injury and illness. As described by Reason,[36] one of the primary steps in establishing a strong safety culture in an organisation is to improve on its reporting culture, which would enhance the ability to detail circumstances at the time of injury. The National Fire Incident Reporting System presents an excellent resource and template for departments to adopt standardised reporting structure and details.[37]

The at-risk exposure time is another area of study requiring further exploration. Time spent on-shift performing the job tasks described in this study has not been assessed. Evaluating the time spent performing these activities (ie, exposure time), and the environments in which they occur, would improve hazard profiles and generate a more accurate estimate of injury risk. By improving the reporting system and estimates of exposure time, the identification and characterisation of risks would occur more efficiently so that the development and application of relevant resources (ie, controls) can be implemented to mitigate potential hazard effects in the future.

This study has demonstrated that the events associated with injury among ESE occur well beyond that of the fireground. Due

What is already known on the subject

- Firefighting and emergency medical services are high-risk professions.
- Previous research has largely been focused on the physical tasks and exposures on the fireground.

What this study adds

- The magnitude and range of hazards faced during a typical work shift extend well beyond the fireground.
- Physical exercise and patient transport activities are two of the most frequent injury-related job tasks.
- Identification and characterisation of hazard profiles for the most frequent injury-related job tasks can help target prevention efforts.

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to the number and variation of emergency situations ESE are responsible for responding to, focused efforts should be made to identify and address the injury risks encountered during physical exercise, patient transport and training activities, in addition to the existing focus on fireground hazards. Furthermore, there is a clear need to evaluate the structure and management of physical exercise in the fire service. While most studies indicate the need for improved fitness (eg, cardiovascular health and functional mobility) in order to carry out response activities, efforts should also be concentrated on providing these men and women with improved resources and structure to maintain fitness levels and training-based skills without exposing themselves to injury in those processes.

Ongoing efforts of this research are focused on characterising the risks of injury throughout the processes of patient transport, fireground operations and physical exercise. The identification and implementation of prevention control strategies are being led by a partnership between the TFD workforce and project researchers. Intervention effectiveness will be assessed by process evaluation techniques and a comparison of overall injury rates and rates specific to each operation.

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