# Occupational Injuries Among Emergency Responders

**Audrey A. Reichard, MPH, OTR* and Larry L. Jackson, PhD**

**Background** *Emergency responders frequently incur injuries while providing medical, fire, and law enforcement services. National surveillance systems provide fragmented perspectives on responder injuries because they omit specific classes of workers (e.g., government or volunteers); they report only selected injuries; and employment information is incomplete.*

**Methods** *We characterized injuries among emergency medical services (EMS), firefighting, and police occupations by using data from the National Electronic Injury Surveillance System—Occupational Supplement (NEISS-Work) for injuries treated in U.S. hospital emergency departments in 2000–2001.*

**Results** *Sprains and strains were the leading injury (33–41%) among EMS, firefighter, and police occupations. Police officers and career firefighters had the highest injury rates (8.5 and 7.4 injuries per 100 full-time equivalent workers, respectively).*

**Conclusions** *The physical demands of emergency response are a leading cause of injuries that may benefit from similar interventions across the occupations. To assess risk, improved exposure data need to be acquired, particularly for volunteers.* Am. J. Ind. Med. 53:1–11, 2010. *Published 2009 Wiley-Liss, Inc.*†

***KEY WORDS: emergency responder; emergency medical services; paramedic; law enforcement; police; sheriff; firefighter; occupational injuries; nonfatal***

## INTRODUCTION

Emergency responders, including emergency medical services (EMS) personnel, firefighters, and law enforcement officers, risk their health and safety to assist in medical emergencies; motor vehicle incidents; building and wildland fires; hazardous material spills; crimes and public disturbances; search and rescue; and natural and human-caused disasters. They are exposed to a variety of occupational hazards including motor vehicle crashes en route to a scene, assaults, extreme demands on their musculoskeletal systems, hazardous environments and temperature extremes, contact with hazardous and infectious materials, lengthy and erratic work hours, and stress. Although these hazards are broadly understood, each response incident may vary greatly in types of exposures and complexity such that the hazards may not be readily identifiable or the comparative risk reasonably characterized. Responding to these incidents regularly results in fatal and nonfatal injuries to emergency responders.

In 2007, 5,488 paid and volunteer workers died from an injury at work based on the Bureau of Labor Statistics (BLS) National Census of Fatal Occupational Injuries (CFOI) [BLS, 2008a]. Thirteen of the deaths occurred among emergency medical technicians (EMTs) and paramedics; 62 among fire fighting and prevention workers; and 156 among police officers, detectives, and first-line supervisors (excluding correctional officers). The BLS does not separately report deaths for volunteers. However, for the same year, the National Fire Protection Association (NFPA)

Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Morgantown, West Virginia

The findings and conclusions in this report are those of the author and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

*Correspondence to: A.A. Reichard, Division of Safety Research, National Institute for Occupational Safety and Health, 1095 Willowdale Road, MS 1808, Morgantown, WV 26505. E-mail: akr5@cdc.gov

Accepted 7 September 2009
DOI 10.1002/ajim.20772. Published online in Wiley InterScience (www.interscience.wiley.com)

**TABLE I.** Number and Rate of Nonfatal Occupational Injuries and Illnesses by Fire and Police Protection Industries With Local Government Employers for Selected States, 2007 [BLS, 2008c]

| | Fire protection[a] | | | | Police protection[a] | | | |
|---|---|---|---|---|---|---|---|---|
| | Number of cases | | Rate[b] | | Number of cases | | Rate | |
| State | Total[c] | DAFW[d] | Total | DAFW | Total | DAFW | Total | DAFW |
| Arizona | 900 | 400 | 10.9 | 4.4 | 1,300 | 200 | 10.7 | 1.6 |
| Connecticut | 1,700 | 700 | 24.1 | 10.6 | 1,900 | 800 | 22.0 | 9.6 |
| Maine | 200 | 100 | 10.4 | 3.7 | 300 | 100 | 11.5 | 2.8 |
| New Jersey | 1,800 | 900 | 14.0 | 7.1 | 3,700 | 1,900 | 12.5 | 6.5 |
| New York | 8,700 | 8,000 | 66.0 | 60.8 | 8,200 | 4,600 | 17.7 | 10.0 |
| Oklahoma | 600 | 300 | 13.6 | 7.2 | 1,100 | 300 | 11.5 | 3.3 |
| Virginia | 1,300 | 600 | 11.3 | 5.3 | 1,500 | 500 | 7.9 | 2.4 |

[a]North American Industry Classification System 2002 Edition [OMB, 2002].
[b]Rate: incidents per 100 full-time workers (one full-time worker = 2,000 hr worked).
[c]Total recordable cases.
[d]Cases with one or more days-away-from-work.

reported that 30 of 57 injury-related municipal firefighter deaths occurred among volunteer firefighters [Fahy et al., 2008].

National surveillance systems offer very limited data on nonfatal injury and illness estimates and rates among emergency responder occupations or the affiliated industry classifications for justice, public order, and safety activities. Although the BLS reports work-related nonfatal injuries and illnesses among private industry employers through the Survey of Occupational Injuries and Illnesses (SOII), SOII currently omits responders on a national basis that work for public agencies or as volunteers. Selected states do report injuries among state and local government workers. Furthermore, the BLS only reports nonfatal cases by occupation for cases involving days-away-from-work (DAFW); excluding a large number of injuries and illnesses that are presumably less severe. In 2007, for private industry workers only, the BLS reported 4,560 injuries and illnesses involving DAFW among EMTs, paramedics, ambulance drivers, and attendants, 90 cases among firefighters, and 150 cases among police officers [BLS, 2008b]. The results were significantly higher for EMS personnel than firefighters or police because a large number of EMS personnel are employed by hospitals or other private companies, but almost all firefighters and police officers work for federal, state, or local government agencies and their injuries and illnesses are not captured by the BLS survey on a national basis.[1]

Through the SOII, selected states report nonfatal injuries and illnesses by industry for state and local government workers, including fire and police protection [BLS, 2008c]. These industries serve as a proxy for two of the three emergency responder groups by occupation which is currently not available otherwise. Seven states, representing 17% of the U.S. population [US Census Bureau, 2008], released the number of total recordable cases, number of cases involving DAFW, and the associated rates for fire and/or police protection within local governments for 2007 (Table I). Among the reporting states, the state-based total recordable cases, DAFW cases, and associated injury rates for the fire and police protection industries varied widely. Usually, the fire protection industry injury rates were only slightly larger than the police protection industry rates within each state. Four of these states also reported rates for state government employed police protection with rates for total recordable cases that ranged from 3.9 to 8.6 injuries per 100 FTE. Among these states, the local police injury rates were two to three times larger than the state government police rates.

The NFPA annually conducts a national fire department survey of injuries that includes career and volunteer firefighters. The NFPA reported that there were approximately 80,100 injuries in 2007 [Karter and Molis, 2008] among the estimated 1.15 million U.S. firefighters [Karter and Stein, 2008] resulting in an injury rate of 7.0 injuries per 100 firefighters.

On a local scale several groups have examined nonfatal work-related injuries among EMS personnel in urban EMS systems [Hogya and Ellis, 1990; Gershon et al., 1995; Maguire et al., 2005]. In a recent study, Maguire et al. [2005] estimated an injury and illness rate of 34.6 per 100 full time, paid EMS personnel in two urban agencies. From a national perspective, the National Registry of Emergency Medical Technicians (NREMT) conducts a voluntary survey of NREMT-certified EMS personnel, excluding all EMS

[1] Beginning with data for 2008, the BLS is expected to report national estimates for state and local government employees.

personnel from states with no NREMT certification requirement. For 1999–2005, there were an estimated 8.1 nonfatal injuries and illnesses resulting in lost workdays per 100 EMS personnel annually [Studnek et al., 2007]. In an effort to provide more comprehensive, national estimates the National Highway Traffic Safety Administration (NHTSA) is evaluating development of a national EMS injury surveillance system [USDOT, 2007].

In general, the overall size of the emergency responder labor force is difficult to characterize. Based on the BLS Current Population Survey (CPS), there were an estimated 179,000 paid EMTs, paramedic, ambulance drivers, and attendants; 344,000 paid firefighters and first-line supervisors; and 925,000 paid police and sheriff's patrol officers, detectives, first-line supervisors, and transit and railroad police in 2007 [BLS, 2008d]. The CPS estimates exclude volunteers. The BLS Occupational Employment Survey (OES) provided similar estimates: 222,700 paid EMS; 341,900 paid firefighters, and 826,200 law officers [BLS, 2008e]. To attain the total number of paid and volunteer EMS personnel, Maguire and Walz [2004] relied on EMS certification numbers. Certified emergency medical technicians (EMTs; basic, intermediate, and paramedic) numbered 721,000 individuals in 2002 with an additional 128,000 persons certified as first responders. Certification alone does not necessarily reflect active work, certification requirements vary from state to state, and EMS workers can hold certification in more than one state. The NHTSA reported on the many difficulties in enumerating the EMS workforce including issues with the cross-trained firefighter/EMS workers [USDOT, 2008]. The NHTSA crudely estimated the number of volunteer EMS in 2003 to be 244,000–273,000. NFPA firefighter workforce estimates include volunteers, but not the number of firefighters providing EMS services, although 59% of fire departments provide these services [Karter and Stein, 2008]. In 2007, there were approximately 30,200 U.S. fire departments staffed by 1,148,800 firefighters (28% career and 72% volunteer firefighters) [Karter and Stein, 2008].

Definitional issues, identification of workers performing emergency response, and data collection issues make capturing emergency responder injury experiences difficult and hinder comparisons between occupational groups. To address the limited availability of nonfatal injury information for EMS personnel, firefighters, and police (herein grouped as emergency responders) and the lack of comparable data, we analyzed occupational injuries and illnesses among these workers that were treated in U.S. hospital emergency departments in 2000–2001. This analysis provides an injury baseline largely preceding the events of September 11, 2001 and subsequent events that may have influenced the emergency responder workforce such as increased funding for training and infrastructure development [Canada, 2003].

## METHODS

The National Institute for Occupational Safety and Health (NIOSH) uses an occupational supplement to the National Electronic Injury Surveillance System (NEISS-Work)[2] to collect data on all work-related injuries and illnesses treated in an emergency department (ED) [Marsh et al., 2006]. Given that 90–95% of NEISS-Work cases can likely be classified as an injury rather than an illness [Jackson, 2001], further reference to cases in this article will simply be referred to as injuries.

The 2000 and 2001 NEISS-Work data analyzed for this study were collected from a geographically stratified probability sample of 67 U.S. hospitals having a 24-hr ED. Each case is weighted based on the inverse probability of the selected hospital being included in the sample. National injury estimates were calculated by summing the individual case weights. Estimates were calculated for worker age and sex, diagnosis, body part affected, and injury source and event by EMS, fire, and law enforcement occupations. The injury source and the event or exposure were coded by using the Occupational Injury and Illness Classification System (OIICS) [BLS, 1992]. Injuries arising from the events or subsequent rescue efforts related to September 11, 2001 were not included.

Cases were defined as work-related if they occurred to a civilian (non-military), non-institutionalized worker who was working for compensation or as part of an organized volunteer group, regardless of the number of hours worked. Work time is inclusive of break time (when on the employer's premises) and required job transportation (e.g., en route to the scene of an emergency). As fitness requirements exist for some EMS, firefighter, and law enforcement personnel, injuries occurring to these groups during recreational activities on the premises or in a training program were considered to be work related.

We used NEISS-Work occupation and employer information (employer name and business type) to identify potential emergency responder cases by keyword searches. We reviewed and coded occupations as EMS, firefighter, or law enforcement based on the Standard Occupational Classification (SOC) Manual [OMB, 2000]. EMS workers included EMTs and paramedics (SOC 29-2041) and ambulance drivers and attendants (SOC 53-3011). Workers identified in the NEISS-Work record as EMS workers were classified as such regardless of the type of employer. Workers identified as firefighter or fire/EMS were coded as EMS if the employer description was listed as EMS or ambulance. Cases

[2] The NEISS is administered by the Consumer Product Safety Commission (CPSC). CPSC collects data from hospital EDs on patients who seek care for product-related injuries that occur outside of work. In addition, CPSC facilitates the NIOSH collection of all ED-treated occupational-related injuries and illness through a hospital subsample without restriction to consumer product involvement. The NEISS and NEISS-Work cases are mutually exclusive.

with an occupation of fire/EMS were coded as firefighters if the employer information indicated fire/EMS, fire only, or unknown. Firefighters included firefighters (SOC 33-2011) and fire supervisors (SOC 33-1021). Fire inspectors were excluded. Law enforcement workers included police and sheriff's patrol officers (SOC 33-3051), transit and railroad police (SOC 33-3052), and police supervisors (SOC 33-1012). Law enforcement occupations not usually involved in emergency response were excluded (e.g., detectives, bailiffs, and correctional officers).

If the injured worker's occupation was not provided or could not be readily determined, employer information was examined for employment within the North American Industrial Classification System (NAICS) defined industries of emergency medical transportation services (NAICS 621910), fire protection (NAICS 922160), or law enforcement (NAICS 922120) [OMB, 2002]. The narrative description of the injury also was used to assess whether the case should be included. In addition to occupation coding, firefighters were classified into the specific employment types of career (i.e., paid), volunteer, or unknown based on information contained within the narrative comment fields and information provided by the NFPA categorizing the named fire department for each firefighter case as all career, mostly career, all volunteer, or mostly volunteer.

We primarily estimated emergency responder injury rates by using denominator information from two BLS population surveys: published tabular worker counts from the OES, an establishment survey [BLS, 2001, 2002a], and counts and full-time equivalent (FTE) workers (1 FTE = 2,000 hr per year) for workers age $\geq$15 years from CPS microdata, a household survey [BLS, 2008f]. For 2000–2001, the OES provides labor force estimates for SOC 2000 occupation groupings [OMB, 2000] listed above. The CPS occupation groupings are based on the 1990 Bureau of Census classifications [US Census Bureau, 1992]. A unique occupation classification for EMS workers does not exist in the latter occupation scheme and both surveys only include paid workers.

The CPS microdata allows more complex labor force estimations for number of workers and number of hours worked in multiple jobs. CPS reports the occupation and specific hours worked for primary jobs, occupation for secondary job, hours worked for all jobs but the primary job, and total hours worked for all jobs. Thus, we used these data to estimate the responder labor force when the workers served as responders in their primary job and/or a secondary job. The BLS injury and illness reporting generally only includes workers based on their primary job. We computed counts of law enforcement and firefighters as the number of workers who had a primary job or secondary job occupation indicated as law- or fire-related (an individual with two responder jobs is counted once for each job). We computed FTE estimates by including hours worked for primary jobs and/or secondary jobs when the associated occupation was law- or fire-related and the worker reported no more than two jobs worked. If a worker reported a responder occupation for their primary and secondary job and reported more than two jobs, only primary job hours were included in the FTE estimate because the total of the imputed hours in other jobs were not necessarily law- or fire-related.

The CPS law enforcement occupation groupings include detectives, bailiffs, game wardens, park enforcement, and a few other minor occupations that are not generally considered as emergency responders. To correct for the inclusion of these workers in the CPS count and FTE estimates, we reduced the CPS labor force estimates by 14.4% (i.e., the proportion of the non-responder occupations based on OES estimates for 2000–2001 [BLS, 2001, 2002a]).

To attain labor force estimates that included volunteers, we estimated the paid and volunteer EMS labor force based on the number of certified EMT personnel in 2002 [Maguire and Walz, 2004]. We also estimated the EMS labor force by combining the average of the 2000 and 2001 paid EMS personnel estimates from the OES (184,800) and the average of the estimates of volunteer EMS workers derived by NHTSA for 2003 (258,600) [USDOT, 2008]. We used career and volunteer firefighter estimates from NFPA surveys [Karter and Stein, 2008].

Variances for NEISS-Work estimates were calculated based on classical variances of a stratified sample with an approximation for $n$ for each stratum adjusted for monthly hospital reporting. Annually, the hospitals in the NEISS-Work sample tend to remain the same. Thus, the yearly samples were treated as dependent in variance calculations. Variance calculations for the CPS employment data were computed as specified in Employment and Earnings [BLS, 2002b]. The variances from the NEISS-Work data and the CPS data were pooled to compute 95% confidence intervals (95% CI) for rates. Other confidence intervals were based solely on the NEISS-Work data variance.

## RESULTS

In 2000 and 2001, an annual average of 3,984,300 (95% CI = $\pm$1,142,300) work-related injuries were treated in hospital EDs at a rate of 3.0 ($\pm$0.6) per 100 FTE among all workers. Of these injuries, 123,900 ($\pm$42,700) occurred to emergency responders ($\sim$3% of the total). Among responder injuries, EMS personnel had 18% (21,900) of the injuries; firefighters had 30% (37,300); and law enforcement officers had 52% (64,800) (Table II). Among the 37,300 firefighter injuries, 71% of the injuries occurred to career firefighters and 21% occurred to volunteer firefighters. The career/volunteer status was unknown for the balance of the injured firefighters.

We estimated injury rates among all EMS and all firefighters (i.e., paid and volunteer) that tended to be about half the injury rate among career firefighters and law

**TABLE II.** Labor Estimates and Average Annual Number and Rate of Emergency Responder Injuries Treated in an Emergency Department by Occupation, 2000–2001

| | Annual average workforce | | | | |
|---|---|---|---|---|---|
| **Responder group** | **Data source** | **Units** | **Labor estimate** | **Number of injuries[a] (±95% CI)** | **Rate per 100 FTE or workers (±95% CI)** |
| EMS | | | | | |
| All EMS | Cert. EMTs | Count[b] | 721,400 | 21,900 (±9,000) | 3.0 (±0.9) |
| All EMS | OES/NHTSA | Count[c] | 443,400 | 21,900 (±9,000) | 4.9 (±1.4) |
| Fire | | | | | |
| Career firefighters | CPS | FTE[d] | 355,800 | 26,500 (±18,100) | 7.4 (±3.6) |
| Career firefighters | CPS | Count[e] | 286,700 | 26,500 (±18,100) | 9.2 (±4.5) |
| Career firefighters | OES | Count[f] | 323,700 | 26,500 (±18,100) | 8.2 (±4.0)[g] |
| Career firefighters | NFPA | Count[i] | 290,200 | 26,500 (±18,100) | 9.1 (±4.4)[g] |
| Volunteer firefighters | NFPA | Count[i] | 781,000 | 10,500 (±6,100) | 1.3 (±0.6)[g] |
| All firefighters | NFPA | Count[i] | 1,071,200 | 37,300 (±18,400)[h] | 3.5 (±1.2)[g] |
| Law Enforcement | | | | | |
| Police/sheriff/transit | CPS | FTE[j] | 763,900 | 64,800 (±25,700) | 8.5 (±2.4) |
| Police/sheriff/transit | CPS | Count[k] | 739,000 | 64,800 (±25,700) | 8.8 (±2.5) |
| Police/sheriff/transit | OES | Count[l] | 705,500 | 64,800 (±25,700) | 9.2 (±2.6)[g] |

[a]Total annual average number of ED-treated injuries to responders = 123,900 (±42,700).
[b]Based on number of certified emergency medical technicians in 2002 (excludes certified first responders) [Maguire and Walz, 2004].
[c]Based on number of paid EMS personnel from the OES [BLS, 2001, 2002a] and average number of volunteers estimated by NHTSA [USDOT, 2008].
[d]Based on full-time equivalent firefighters (1 FTE = 2,000 hr) for hours worked in primary and secondary jobs from the CPS.
[e]Based on number of firefighters with a fire-related primary or secondary job from the CPS.
[f]Based on number of firefighters and firefighter supervisors from the OES (excludes fire inspectors and investigators).
[g]Confidence interval for the rate does not include error associated with the labor force estimate and likely underestimates the total rate variance.
[h]Based on NFPA estimates of the number of firefighters [Karter and Stein, 2008].
[i]Total includes injuries to firefighters with unknown career or volunteer status.
[j]Based on full-time equivalent officers (1 FTE = 2,000 hr) for hours worked in primary and/or secondary jobs from the CPS (excludes detectives, bailiffs, wardens, parking and correctional officers).
[k]Based on number of officers with a law-enforcement-related primary job and workers with a non-law-related primary job, but a law-related secondary job from the CPS (excludes detectives, bailiffs, wardens, parking and correctional officers).
[l]Based on number of police and sheriff's patrol officers, transit and railroad police and police supervisors from the OES (excludes detectives, bailiffs, wardens, and parking).

enforcement regardless of whether the latter rate denominators were hours- or count-based (Table II). The EMS injury rate based solely on the number of certified EMTs which includes paid and volunteer EMS was about 40% lower than the EMS rate based on the combination of paid EMS workers from OES and volunteers from the crude NHTSA estimate. Separate rates for paid EMS versus volunteers could not be determined. Using the NFPA labor counts for volunteer firefighters, volunteers had a much lower ED-treated apparent injury rate than career firefighters. Because there are more than 2.5 times as many volunteer firefighters and a relatively small number of injuries compared to career firefighters, the overall firefighter rate (3.5 per 100 firefighters) was much lower than the career firefighter injury rate. The EMS rate similarity to the overall firefighter rate may be, in part, a reflection of the large volunteer contingent within these occupations. Among career firefighter rates, the CPS hours-based rate (7.4 per 100 FTE) was lower than the count-based rate (9.2 per 100 FTE) because the CPS FTE estimate was 24% higher than the count-based labor estimate. The CPS and NFPA career firefighter counts were similar but slightly lower than the OES labor count. Career firefighter rates were slightly lower than law enforcement rates when comparing rates based on the same labor force data source. Unlike rates for firefighters, the law enforcement hours- and count-based rates were the same because the FTE estimate was only 3% higher than the count of workers.

ED-treated emergency responders included teenagers through workers in their mid-80s, with the majority of injuries occurring to responders aged 25–44 years (Table III). Among EMS personnel, workers <25 years old sustained a quarter of the EMS injuries. Injuries to firefighters and law enforcement officers <25 years old were 13% and 5%, respectively. Injured women represented 32% of EMS personnel; 5% of firefighters; and 13% of law enforcement officers. Among all emergency responders, sprains and strains and contusions and abrasions were the leading diagnoses. Nearly 99% of all injuries were treated in the ED and released, indicative of the mild to moderate severity of these injuries. However, initial treatment and release from the ED does not preclude extensive additional medical treatment including surgery or prolonged rehabilitation therapy.

**TABLE III.** Average Annual Number of Emergency Responder Injuries Treated in an Emergency Department by Occupation, Age, Sex, Diagnosis, and Body Part, 2000–2001

| | EMS (n = 21,900) | | | Fire (n = 37,300) | | | Law enforcement (n = 64,800) | | |
|---|---|---|---|---|---|---|---|---|---|
| **Characteristic** | **Number** | **(±95% CI)** | **%** | **Number** | **(±95% CI)** | **%** | **Number** | **(±95% CI)** | **%** |
| Age group (years) | | | | | | | | | |
| <25 | 5,400 | (±2,600) | 25 | 4,800 | (±3,900) | 13 | 3,000 | (±1,200) | 5 |
| 25–34 | 9,400 | (±4,500) | 43 | 13,400 | (±6,400) | 36 | 34,200 | (±14,100) | 53 |
| 35–44 | 5,000 | (±2,400) | 23 | 12,500 | (±7,200) | 34 | 18,100 | (±7,800) | 28 |
| >44 | 2,200 | (±1,200) | 10 | 6,600 | (±4,400) | 18 | 9,500 | (±4,600) | 15 |
| Sex | | | | | | | | | |
| Female | 7,000 | (±3,200) | 32 | 1,700 | (±1,200) | 5 | 8,600 | (±3,500) | 13 |
| Male | 14,900 | (±6,400) | 68 | 35,500 | (±17,700) | 95 | 56,100 | (±23,000) | 87 |
| Diagnosis | | | | | | | | | |
| Sprain/strain | 9,000 | (±3,900) | 41 | 12,100 | (±6,800) | 33 | 21,900 | (±9,300) | 34 |
| Contusions/abrasions | 2,800 | (±1,600) | 13 | 4,800 | (±2,700) | 13 | 17,300 | (±7,500) | 27 |
| Laceration | 1,200 | (±900) | 6 | 4,100 | (±2,000) | 11 | 4,800 | (±2,300) | 8 |
| Fracture/dislocation | —[a] | | — | 1,700 | (±1,000) | 4 | 2,800 | (±1,600) | 4 |
| Puncture | 1,700 | (±1,200) | 8 | — | | — | 2,700 | (±1,300) | 4 |
| Burns | — | | — | 2,100 | (±1,900) | 6 | — | | — |
| Anoxia | — | | — | 1,700 | (±1,000) | 5 | 1,100 | (±1,300) | 2 |
| Dermatitis/conjunctivitis | — | | — | 1,600 | (±4,500) | 4 | — | | — |
| Other[b] | 6,300 | (±3,400) | 29 | 8,500 | (±6,200) | 23 | 12,900 | (±7,300) | 20 |
| Body part | | | | | | | | | |
| Arm | 3,400 | (±1,700) | 16 | 6,500 | (±4,600) | 18 | 11,100 | (±4,200) | 17 |
| Hand | 3,400 | (±2,000) | 16 | 5,000 | (±2,900) | 13 | 12,200 | (±4,700) | 19 |
| Leg & foot | 3,800 | (±1,900) | 17 | 8,900 | (±4,400) | 24 | 16,600 | (±7,100) | 26 |
| Neck & back | 6,400 | (±3,200) | 29 | 6,800 | (±4,500) | 18 | 11,100 | (±5,500) | 17 |
| Head | — | | — | — | | — | 2,400 | (±1,200) | 4 |
| Face | 1,400 | (±600) | 6 | 4,100 | (±2,200) | 11 | 5,200 | (±2,300) | 8 |
| All parts of body | — | | — | 4,700 | (±3,800) | 13 | 4,600 | (±3,600) | 7 |
| Other/not stated | — | | — | — | | — | 1,600 | (±1,400) | 2 |

[a]Does not meet minimum reporting requirements.
[b]Inclusive of unspecified musculoskeletal pain and exposures to blood, body fluids, biological pathogens, and hazardous chemicals.

## EMS

The most common injuries among EMS personnel were sprains and strains (41%) and contusions and abrasions (13%) (Table III). Sprains and strains often occurred to the lower trunk (49%) and frequently resulted from a task involving bodily motion[3] (81%). A few of the sprains and strains (8%) resulted from transportation incidents involving motorized road vehicles. Overall, the injuries resulted from events or exposures attributed to bodily motions (39%); exposure to harmful substances (21%), including needles, syringes, and blood and body fluids; and contact with objects and equipment[4] (16%) (Table IV). The primary source of EMS injuries was the broad category of "persons, plants, animals, and minerals" which largely resulted from injuries involving other people (31%) and bodily motion of the injured workers themselves (10%).

## Firefighters

Commonly treated injuries to firefighters were sprains and strains (33%) and contusions and abrasions (13%) (Table III). Sprains and strains primarily affected the lower trunk (23%), ankle (20%), and knee (18%) and were usually caused by

[3] Herein bodily motion refers to "bodily reaction and exertion" which includes injuries occurring from "free bodily motion, from excessive physical effort, or from repetition of a bodily motion." It is generally non-impact and includes slips and trips without a fall [BLS 1992].

[4] Contact with objects and equipment denotes injuries resultant of "contact between the injured person and the source of the injury." It includes struck against an object, struck by an object, caught in an object, and rubbed against an object. Falls, assaults, transportation incidents, and fires and explosions are excluded from the category [BLS 1992].

**TABLE IV.** Average Annual Number of Emergency Responder Injuries Treated in an Emergency Department by Occupation, Event or Exposure and Source of Injury, 2000–2001

| | EMS (n = 21,900) | | | Fire (n = 37,300) | | | Law enforcement (n = 64,800) | | |
|---|---|---|---|---|---|---|---|---|---|
| **Characteristic** | **Number** | **(±95% CI)** | **%** | **Number** | **(±95% CI)** | **%** | **Number** | **(±95% CI)** | **%** |
| Event or exposure | | | | | | | | | |
| Contact with objects/equipment | 3,400 | (±1,900) | 16 | 6,500 | (±3,100) | 17 | 10,000 | (±4,700) | 15 |
| Falls | 1,700 | (±1,300) | 8 | 4,200 | (±2,400) | 11 | 7,400 | (±3,600) | 11 |
| Bodily motions | 8,600 | (±4,000) | 39 | 7,500 | (±5,100) | 20 | 12,500 | (±6,400) | 19 |
| Harmful exposure | 4,500 | (±2,700) | 21 | 2,800 | (±2,400) | 8 | 4,700 | (±2,900) | 7 |
| Transportation incidents | 2,100 | (±1,400) | 10 | 1,800 | (±1,300) | 5 | 9,100 | (±4,300) | 14 |
| Fires and explosions | —[a] | | — | 12,000 | (±9,500) | 32 | — | | — |
| Assaults and violent acts | 1,100 | (±800) | 5 | — | | — | 16,800 | (±5,600) | 26 |
| Non-classifiable | — | | — | — | | — | 3,100 | (±2,400) | 5 |
| Source of injury | | | | | | | | | |
| Persons, plants, animals, and minerals | 10,800 | (±5,000) | 49 | 10,400 | (±8,300) | 28 | 29,000 | (±11,300) | 45 |
| Structures and surfaces | 1,800 | (±1,300) | 8 | 7,100 | (±4,500) | 19 | 10,100 | (±4,700) | 16 |
| Tools, instruments, and equipment | 3,200 | (±1,700) | 15 | 2,000 | (±1,000) | 5 | 2,500 | (±1,300) | 4 |
| Vehicles | 3,000 | (±1,600) | 14 | 3,100 | (±1,800) | 8 | 10,800 | (±5,200) | 17 |
| All other sources | 3,000 | (±1,600) | 14 | 14,600 | (±7,000) | 39 | 12,400 | (±6,000) | 19 |

[a]Does not meet minimum reporting requirements.

bodily motion (51%) and falls[5] (16%) with only 6% of the sprains and strains caused by transportation incidents. Events frequently leading to nonfatal firefighter injuries were fires and explosions (32%) and bodily motions (20%) (Table IV). More than a quarter of the injuries were attributed to persons, plants, animals, and minerals; and 47% of those were specifically attributed to the body motion of the injured worker.

Among firefighters, career firefighters had proportionately fewer lacerations (8%) than volunteer firefighters (17%), but a slightly higher proportion of sprains and strains (34% vs. 28%, respectively). Injury events for career and volunteer firefighters were primarily fire and explosion related (30% and 38%, respectively), followed by non-fire-related bodily motion events that accounted for 24% of injuries to career firefighters as compared to 11% of injuries to volunteer firefighters. Contact with objects and equipment contributed to 16% of injuries to career firefighters and 22% to volunteer firefighters. In general the distribution of injury types and events were not notably different between firefighter groups. However, the career and volunteer injury rates based on counts of firefighters differed by a factor of seven (9.1 vs.1.3 injuries per 100 firefighters; Table II).

## Law Enforcement

Law enforcement officers were frequently diagnosed with sprains and strains (34%) and contusions and abrasions (27%) (Table III). Sprain and strain injuries most often affected the lower trunk (19%), knee (16%), ankle (14%), and neck (13%). Forty-seven percent of the sprains and strains were attributable to bodily motions and 18% to transportation incidents mostly involving motorized road vehicles. Law enforcement officers had proportionately two to three times as many sprains and strains from transportation incidents as EMS or firefighters. The primary events for all injuries to law enforcement officers were assaults and violent acts (26%) and bodily motions (19%) (Table IV). Another person was involved in 86% of the assaults and violent acts and 17% of the bodily motion related injuries. The primary source of 70% of bodily motion related injuries (i.e., largely sprains and strains) was the body condition, motion, or position of the injured worker.

[5] Excludes slips, trips, and loss of balance without a fall [BLS 1992].

# DISCUSSION

## Injury Characteristics

We found sprains and strains followed by contusions/abrasions and lacerations to uniformly be the leading injury diagnoses among all three responder occupations. Prior studies also identified the leading injury diagnoses as musculoskeletal injuries such as sprains and strains among EMS [Hogya and Ellis, 1990; Gershon et al., 1995; Maguire et al., 2005; BLS, 2008b]; among firefighters [Walton et al., 2003; Karter, 2007; Karter and Molis, 2008; USFA, 2008]; and among law enforcement officers [Sullivan and Shimizu, 1988; Clarke and Zak, 1999]. Magnetti et al. [1999] found sprains and strains to be the second leading diagnoses (24%)

among volunteer firefighter workers' compensation claims with lacerations/contusions (29%) as the leading diagnosis. In our work, the combined diagnoses of lacerations and contusions/abrasions were a lower proportion of the diagnoses than sprains/strains for EMS and fire occupations whereas for law enforcement the two diagnosis groups were essentially equal. Only firefighters were generally treated in the ED for burns and anoxia.

Among all three responder occupation groups we found that the upper extremities were the most frequently injured body parts followed by the lower extremities for fire and law enforcement and neck and back for EMS. USFA [2008] and Magnetti et al. [1999] reported a similar order of injury frequency by part of body affected for firefighters. Among EMS workers, a number of studies have indicated back injuries as a leading issue [Gershon et al., 1995; Walton et al., 2003; Maguire et al., 2005; BLS, 2008b]. Among privately employed EMS personnel, SOII data have identified that 61% of injuries resulting in DAFW were due to a sprain or strain and 34% affected the back [BLS, 2008b]. Gershon et al. [1995] identified ''handling of stretchers'' as a primary cause of back injuries. Back injuries have also been identified as common among firefighters [USFA, 2008] and law enforcement officers [Clarke and Zak, 1999].

The leading event or exposure for EMS workers was bodily motion, largely overexertion. Similarly, the SOII data indicated that 49% of the DAFW injuries for EMS personnel involved overexertion [BLS, 2008b]. For firefighters the leading event or exposure was fires and explosions, correlating with NFPA reports that 48% (38,400) of the injuries occurred on the fireground with a rate of 24.6 per 1,000 fires [Karter and Molis, 2008]. The leading event or exposure for law enforcement officers was assaults and violent acts. This reflects voluntarily reported data from the Uniform Crime Reporting System that show that 59,200 officers were assaulted in 2007 with approximately 15,500 officers incurring a reportable injury [FBI, 2008].

Ambiguities in the OIICS coding precedence rules for events or exposures obscure to some extent the detailed injury mechanisms by requiring that ''assault and violent acts,'' ''transportation incidents,'' and ''fires and explosions'' take precedence over other events and exposures [BLS, 1992]. For example, automatically classifying fireground injuries to the fires and explosions event division, as we did, makes directly comparing injuries by event or exposure somewhat misleading across the responder groups. The source of the injury in combination with diagnosis frequently provided a better understanding of the incident such as when overexertion by the injured worker led to sprains or strains.

## Injury Rates

The EMS ED-treated injury rate of 3.0 per 100 certified EMTs included injuries among career and volunteer workers as well as ambulance drivers and attendants. The alternative rate estimate of 4.9 per 100 EMS workers was based on quite reasonable labor estimates for paid EMS, but very crude extrapolations for volunteers. Nevertheless, the latter rate may be a better reflection of the true EMS injury rate because it tends to minimize certification issues. Both EMS rates were relatively similar to the overall worker injury rate for the same time period; but seven to ten times lower than the EMS worker rate estimated by Maguire et al. [2005] for two urban EMS providers (34.6 per 100 full-time paid personnel). The rates were more similar to the BLS rate for cases involving DAFW (4.1 per 100 FTE) among paid EMS. However, our EMS rate applies only to ED-treated injuries. The 1988 National Health Interview Survey, Occupational Health Supplement indicated that occupational injuries seen in the ED represented approximately 34% of work-related injuries [CDC, 1998]. If ED-treated injuries still represent about one-third of all medically treated occupational injuries, extrapolating to an overall injury rate for EMS workers results in rates of 8.9–14.5 injuries per 100 workers depending upon which EMS labor force estimate is used. Even these extrapolated rates are considerably less than the urban rate estimated by Maguire et al. [2005]. Although the urban rate derived from two EMS providers may not be broadly representative, the similarity to the disparity noted in career and volunteer firefighter rates that we observed led to a combined career and volunteer firefighter injury rate that was much smaller than the career firefighter, largely urban, injury rate. Our EMS injury rates lend some credence to the rate dilution effect of including volunteers on a number-of worker-basis in rate calculations and support the need for measures of the number of hours worked as an index of exposure for all members of these mixed workforces. If most of the ED-treated injuries among EMS workers occurred to paid personnel, the EMS injury rate would be similar to career firefighter and law enforcement rates. For example, if all of the ED-treated injuries occurred to paid EMS workers, the maximum EMS injury rate would be nearly 12 injuries per 100 workers based on an OES labor force estimate of 184,800 paid EMS workers [BLS, 2001, 2002a]. The true rate may be lower but is not readily determined without a better labor force estimate than the number of certified EMTs or extrapolations to estimate volunteers and a method to identify injured EMS workers as career or volunteer.

In examining the relative risk of career and volunteer firefighters, career firefighters obviously had a significantly greater risk of incurring an injury requiring ED treatment than volunteers based on the number of workers. However, hazard exposure may vary greatly between these groups not only in terms of call volume and fireground exposures, but in other types of emergency response, training, and maintenance activities. Magnetti et al. [1999] also noted differences between volunteer and career fire departments in organizational finances, physical fitness criteria, and job

turnover. Ninety-five percent of volunteer firefighters serve communities with fewer than 25,000 people, whereas 74% of career firefighters serve communities with larger populations [Karter and Stein, 2008]. The rate of fireground injuries per 100 firefighters increased steadily with community size from a low of 1 for communities with a protected population of less than 2,500 people to about 9 for communities with greater than 250,000 people [Karter and Molis, 2008]. Within the smallest communities, largely protected by volunteer firefighters, the injury rate was approximately 1.6 per 100 fires compared to greater than 3 injuries per 100 fires for the largest communities [Karter and Molis, 2008]. Obtaining estimates of the hours worked by volunteer firefighters may help elucidate whether volunteer firefighters have significantly lower injury rates. However, characterizing the complex hazard exposure differences between working in largely urban versus rural settings is also needed.

Law enforcement officers had more than one and one half times as many ED-treated injuries as firefighters and three times as many as EMS workers, although the law enforcement labor force was about one-third smaller than the firefighter labor force and likely larger than the EMS labor force. Overall, the law enforcement injury rate was nearly two to three times greater than among EMS workers and all firefighters, but similar to the injury rates for career firefighters. These rates apply only to ED-treated injuries. Extrapolating these rates to all injuries, assuming that ED-treated injuries represent approximately 34% of work-related injuries as described above, the hours-based injury rates for law enforcement officers and career firefighters would be 25.0 and 21.8 injuries per 100 FTE, respectively. Although the extrapolated rate for firefighters is very similar to the average rate (20.5 per 100 FTE) reported by the selected states for the fire protection industry (Table I), the extrapolated rate for law enforcement officers is more than twice as high as the median police protection industry rate (11.5 per 100 FTE) for the seven reporting states. This may be a reflection of a larger number of less hazardous occupations (e.g., clerical and bailiff staff) working in the police protection industry compared to the fire protection industry. It also suggests that industry-based assessments of risk for these responder groups may not be as representative as occupation-based risk assessments.

## Strengths and Limitations

Comparing ED-treated nonfatal injuries among the three emergency responder occupations has several distinct advantages despite the disparate response duties of these occupations. This study provides a standardized comparison of nationally representative data. The national estimates of nonfatal occupational injuries among the responders are not restricted to just private industry workers, proxies based on local government fire or police protection industry groups, career versus volunteer status, or injury outcome or lost-work-time. In using industry classification as a proxy for responder injuries, the injury numbers and rates would likely include injuries to occupations not generally considered as emergency responders. Two of the responder groups have large numbers of volunteer workers that are commonly not characterized in other data sources. Although limited to medical treatment in an ED, NEISS-Work provides a uniform basis for comparing responder injuries.

Because NEISS-Work data only include ED-treated injuries, under-representation may result for injuries that are less serious, injuries that do not need immediate medical care, or injuries that may have been self-treated or treated but not recorded in ED charts, especially among EMS personnel. The lack of need for urgent medical care is especially relevant for emergency responder occupations given that sprains and strains are the most common diagnosis and are commonly treated in non-emergency medical venues. Compared to other occupations, an additional bias may result owing to emergency responders being treated in the ED more commonly than other medical venues because of their frequent presence in the ED secondary to the nature of their jobs. Capture of all cases may be incomplete despite succinct definitions of what constitutes a work-related injury. For example, all injuries may not consistently 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 abstracting the medical record. Detailed breakdowns of injury characteristics are also restricted by the limited number of cases captured in the relatively small NEISS-Work hospital sample and the relatively large variances.

Because of a paucity of occupation information in the medical record, we likely misclassified some fire department employees when attempting to ascertain if they were fire or EMS workers. Also, our comparison of injuries among career and volunteer firefighters may have been influenced by the use of NFPA fire department employment classifications as a proxy in determining volunteer versus career status or misclassification by hospital record abstractors of injuries to volunteers as non-work-related. Whereas we combined NEISS-Work employment data with information from the NFPA to classify firefighters as career or volunteer, there is no equivalent source of information for EMS personnel to identify their career versus volunteer status.

The characteristics, the exact time or year of collection, and the general availability of labor force data for rate estimations were also limiting. The EMS personnel injury rates were based on certification numbers and crude estimates for the number of EMS volunteers and are not comparable to the labor force data used for career firefighters and law enforcement. The EMS certification numbers may have over-counting due to inclusion of inactive, but certified workers and potential double-counting because of

individuals with multiple levels of certification or certification in more than one state. Conversely, they do not include non-certified workers which could potentially result in an undercount in states not requiring certification. Many firefighters may be certified, but may rarely provide medical services. Hours-based labor estimates for volunteer firefighters were also not available. Our observed injury rate differences between career and volunteer firefighters highlight the need for better hazard exposure data for firefighters, in particular, but suggest that similar data for EMS workers is critical as well. Differences in occupational classification schemes restrict comparisons of occupational groups over time and limit rate comparisons using different labor force estimates. For example, our OES-based proportional correction of CPS labor force data to estimate law enforcement officers primarily involved in response activities may be biased because of inherent differences in the BLS establishment and household labor surveys.

## CONCLUSIONS AND RECOMMENDATIONS

Our analyses provide nationally representative nonfatal injury baseline data for emergency responders that may be used to assess injury trends. Career firefighters and law enforcement officers have ED-treated injury rates two to three times greater than the U.S. labor force. EMS personnel and volunteer firefighters had apparent injury rates more comparable to the general worker experience. However, the true risk among the responder occupations is difficult to assess because comparable exposure and labor force information, including volunteer and secondary job data, is not available across the responder occupations. Nevertheless our results provide a baseline for future assessments of nonfatal injuries among emergency responders.

Although the emergency response duties and the detailed injury circumstances are commonly different for each responder occupation, there are many incidents to which all three groups respond and there are many common hazards. The prevalence of sprain and strain injuries suggests that training on safer body postures and movements, more ergonomically appropriate equipment [Conrad et al., 2008], improved physical fitness [Nabeel et al., 2007], and policy interventions [Walton et al., 2003] should be focus areas for research and prevention activities that may benefit all three responder groups. Reducing traffic safety hazards while responding and attending to emergencies clearly would benefit all three groups. Similarly, assault and violence prevention activities would universally aid these responders [Dorfman and Walker, 2007].

In general, among all emergency responders, there is a need for new and enhanced research and prevention efforts to improve worker health and safety for day-to-day efforts and for joint responses. Improvements in emergency responder health and safety may lead to broader health and safety benefits among the communities they serve.

## ACKNOWLEDGMENTS

We thank Tom Schroeder and other members of the CPSC Division of Hazards and Data Systems for their management of NEISS and collaboration with NIOSH in the collection of work-related injuries and illnesses, as well as the coders at each NEISS hospital for their diligent medical record abstraction. We thank Rita Fahy of the NFPA for her contribution in identifying volunteer versus career firefighters and manuscript review; Brian Maguire of University of Maryland, Baltimore County, Mike Martell, Kate Newman and Janice Windau, Bureau of Labor Statistics, and Suzanne Marsh, NIOSH, for manuscript review; and Susan Derk, Pam Bosley, and John Myers of NIOSH for their efforts in the collection, coding, editing, and analysis of NEISS-Work injury data.

## REFERENCES

BLS. 1992. Occupational injury and illness classification manual. Washington, DC: U.S. Department of Labor.

BLS: Occupational Employment Statistics: 2000 National Occupational Employment and Wage Estimates [Internet]. 2001. Washington (DC): USDOL Bureau of Labor Statistics [cited 2008 Dec 30]. Available from: http://www.bls.gov/oes/2000/oes_nat.htm.

BLS: Occupational Employment Statistics: 2001 National Occupational Employment and Wage Estimates [Internet]. 2002a. Washington (DC): USDOL Bureau of Labor Statistics [cited 2008 Dec 30]. Available from: http://www.bls.gov/oes/2001/oes_nat.htm.

BLS. 2002b. Washington (DC): USDOL Bureau of Labor Statistics. Employ Earnings 49(1):241–249.

BLS: TABLE A-5. Fatal occupational injuries by occupation and event or exposure, All United States, 2007 [Internet]. 2008a. Washington (DC): USDOL Bureau of Labor Statistics [cited 2008 Dec 29]. Available from: http://www.bls.gov/iif/oshwc/cfoi/cftb0227.pdf.

BLS: Case and Demographic Characteristics for Work-related Injuries and Illnesses Involving Days Away From Work: Tables R9-12, R41, R43, & R100 [Internet]. 2008b. Washington (DC): USDOL Bureau of Labor Statistics [cited 2008 Dec 29]. Available from: http://www.bls.gov/iif/oshcdnew.htm.

BLS: State Occupational Injuries, Illnesses, and Fatalities [Internet]. 2008c. Washington (DC): USDOL Bureau of Labor Statistics [cited 2008 Dec 29]. Available from: http://www.bls.gov/iif/oshstate.htm.

BLS. 2008d. Washington (DC): USDOL Bureau of Labor Statistics. Employ Earnings 55(1):214. 218 [cited 2008 Dec 29]. Available from: http://stats.bls.gov/opub/ee/empearn200801.pdf.

BLS. 2008e. Occupational employment and wages, 2007. Washington (DC): U.S. Department of Labor, Bureau of Labor Statistics. USDL 08-0620. Available from: http://www.bls.gov/news.release/pdf/ocwage.pdf.

BLS: Current Population Survey [Internet]. 2008f. Washington (DC): USDOL Bureau of Labor Statistics. Basic Monthly CPS [microdata files extracted 2008 May 07]. Available from: http://www.bls.census.gov/cps_ftp.html#cpsbasic.

Canada B. 2003. First Responder Initiative: Policy Issues and Options. Washington (DC): Congressional Research Services, Library of Congress. Report for Congress CRS RL31475; 18 p.

CDC. 1998. Surveillance of nonfatal occupational injuries treated in hospital emergency departments—United States, 1996. Morb Mortal Wkly Rep 47:302–306.

Clarke C, Zak MJ. 1999. Fatalities to law enforcement officers and firefighters, 1992-97. Compens Work Cond 4(2):3–7.

Conrad KM, Reichelt PA, Lavender SA, Gacki-Smith J, Hattle S. 2008. Designing ergonomic interventions for EMS workers: Concept generation of patient-handling devices. Appl Ergon 39(6):792–802.

Dorfman WI, Walker LE. 2007. First Responder's Guide to Abnormal Psychology: Applications for Police, Firefighters and Rescue Personnel. New York (NY): Springer. 233 p.

Fahy RF, LeBlanc PR, Molis JL. 2008. Firefighter fatalities in the United States—2007. Quincy (MA): National Fire Protection Association, Fire Analysis and Research. Available from: http://www.nfpa.org.

FBI. Law enforcement officers killed and assaulted, 2007 [Internet]. 2008. Clarksburg (WV): U.S. Department of Justice, Federal Bureau of Investigation [cited 2008 Dec 29]. Available from: http://www.fbi.gov/ucr/killed/2007/.

Gershon RRM, Vlahov D, Kelen G, Conrad B, Murphy L. 1995. Review of accidents/injuries among emergency medical services workers in Baltimore, Maryland. Prehospital Disaster Med 10:14–18.

Hogya PT, Ellis L. 1990. Evaluation of the injury profile of personnel in a busy urban EMS system. Am J Emerg Med 8(4):308–311.

Jackson LL. 2001. Nonfatal occupational injuries and illnesses treated in hospital emergency departments in the United States. Inj Prev 7(Suppl 1):i21–i26.

Karter MJ, Jr. 2007. Patterns of firefighter fireground injuries. Quincy, MA: National Fire Protection Association, Fire Analysis and Research. Available from: http://www.nfpa.org.

Karter MJ, Jr., Molis JL. 2008. U.S. firefighter injuries—2007. Quincy (MA): National Fire Protection Association, Fire Analysis and Research. Available from: http://www.nfpa.org.

Karter MJ, Jr., Stein GP. 2008. U.S. Fire Department Profile through 2007. Quincy (MA): National Fire Protection Association, Fire Analysis and Research. Available from: http://www.nfpa.org.

Magnetti SM, Wyant WD, Greenwood J, Roder NJ, Linton JC, Ducatman AM. 1999. Injuries to volunteer firefighters in West Virginia. J Occup Environ Med 41:104–110.

Maguire BJ, Hunting KL, Guidotti TL, Smith GS. 2005. Occupational injuries among emergency medical services personnel. Prehosp Emerg Care 9:405–411.

Maguire BJ, Walz BJ. 2004. Current emergency medical services workforce issues in the United States. J Emerg Manage 2:17–26.

Marsh SM, Derk SJ, Jackson LL. 2006. Nonfatal occupational injuries and illnesses among workers treated in hospital emergency departments—United States,2003. Morb Mortal Wkly Rep 55:449–452.

Nabeel I, Baker BA, McGrail MP, Jr., Flottemesch TJ. 2007. Correlation between physical activity, fitness, and musculoskeletal injuries in police officers. Minn Med 90(9):40–43.

OMB., Office of the President, Office of Management and Budget. 2000. Standard Occupational Classification Manual. Lanham (MD): Bernan Associates.

OMB. Office of Management and Budget. 2002. North American Industry Classification System. Lanham (MD): Bernan Associates.

Studnek JR, Ferketich A, Crawford JM. 2007. On the job illness and injury resulting in lost work time among a national cohort of emergency medical services professionals. Am J Ind Med 50:921–931.

Sullivan CSB, Shimizu KT. 1988. Epidemiological studies of work-related injuries among law enforcement personnel. J Soc Occup Med 38:33–40.

US Census Bureau: American FactFinder [Internet]. 2008. Washington (DC): US Census Bureau; United States–States; and Puerto Rico. GCT-T1-R. 2007 Population Estimates [cited 2008 Dec 29]. Available from: http://factfinder.census.gov/servlet/GCTTable?_bm=y&-geo_id=01000US&-_box_head_nbr=GCT-T1-R&-ds_name=PEP_2007_EST&-format=US-9S.

US Census Bureau. 1992. 1990 Census of Population and Housing, Alphabetical Index of Industries and Occupations. Washington (DC): U.S. Department of Commerce; 1990 CPH-R-3.

USDOT. U.S. Department of Transportation, National Highway Traffic Safety Administration. 2007. Feasibility for an EMS workforce safety and health surveillance system. Washington DC: U.S. Department of Transportation. Report DOT HS 810 756; [cited 2007 May 14]. Available from: http://www.nhtsa.dot.gov/staticfiles/DOT/NHTSA/Traffic%20Injury%20Control/Articles/Associated%20Files/EMSWorkforceFeasibility3.pdf.

USDOT. U.S. Department of Transportation, National Highway Traffic Safety Administration. 2008. EMS workforce for the 21st century: A national assessment. Washington DC: U.S. Department of Transportation. Report DOT HS 810 943; [cited 2008 Aug 8]. Available from: http://www.nhtsa.gov/staticfiles/DOT/NHTSA/Traffic%20Injury%20Control/Articles/Associated%20Files/EMSWorkforceReport_June2008.pdf.

USFA. US Fire Administration. 2008. Fire-related firefighter injuries in 2004. Emmitsburg (MD): US Fire Administration. Available from: http://www.usfa.dhs.gov/downloads/pdf/publications/2004_ff_injuries.pdf.

Walton SM, Conrad KM, Furner SE, Samo DG. 2003. Cause, type, and workers' compensation costs of injury to firefighters. Am J Ind Med 43:454–458.