**Chapter 21
Occupational injury prevention and management**

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**Introduction**

The delivery of prehospital emergency care by EMS personnel, including EMS physicians, is physically and mentally demanding. In contrast to many other occupations, the need or demand for prehospital care is not scheduled, and the amount of physical or mental work required for each patient is unpredictable. EMS workers must possess both physical strength and aerobic capacity to safely access and extricate patients. An EMS worker must lift and move patients onto stretchers, hospital beds, and other equipment, which requires core strength and flexibility [1]. Many EMS workers are at risk of injury due to poor physical health and conditioning. Other common EMS activities, such as driving/operating ambulances, pose significant safety risks to both patient and EMS worker [2,3]. A large proportion of fatal injuries while on the job are the result of driving ambulances or other EMS vehicles (e.g. “fly cars,” helicopters). Preventing fatal and non-fatal injuries in the EMS setting requires a multifaceted approach [2].

**Occupational fatalities**

There are few studies of EMS worker occupational fatalities. A recent study of the Bureau of Labor Statistics (BLS – this acronym will be used in this chapter for this agency, and not for Basic Life Support) Census of Fatal Occupational Injuries (CFOI), years 2003–2007, identified 65 fatalities and showed that the rate of fatalities for compensated EMS workers exceeds the rate of the general working public (6.3 per 100,000 full-time equivalents (FTE) versus 4.0 per 100,000, respectively) [4]. A recently published study using the same dataset for the same time period (2003–2007) identified six fewer fatalities (n = 59) [5]. An earlier study by Maguire et al. involved a collation of events from multiple databases: the BLS CFOI, Fatality Analysis Reporting System (FARS), and National EMS Memorial Service database [6]. Findings suggest that the rate of occupational fatalities among EMS workers may be more than 2.5 times greater than rates experienced by the general working public [6].

Most documented EMS occupational fatalities have been linked to motor vehicle or aircraft crashes. A retrospective review of the FARS data from 1987 to 1997 determined that more than half (53%) of ambulance crashes involved an ambulance crossing an intersection. The review identified 339 ambulance crashes, 405 fatalities, and 838 injuries [7]. A majority of fatalities resulting from an ambulance crash involved the ambulance driving in emergency mode, also known as “lights and sirens” [7]. In Maguire and Smith’s study of BLS data, 86% (n = 51) of documented fatalities were linked to transportation [5]. Findings from the same BLS dataset by Reichard and colleagues linked 76% of fatalities to crashes involving motor vehicles and aircraft [4].

**Occupational injuries**

There are few studies exploring non-fatal injuries among EMS workers. A study by Reichard and colleagues identified an estimated 99,400 non-fatal injuries between 2003 and 2007 that were severe enough to be evaluated and treated in emergency departments [4]. Based on standardized coding in the Occupational Injury and Illness Classification Manual (OIICS), 33% were linked to “bodily exertion and exertion,” 21% to “exposure to harmful substances or environments,” and 18% to “contact with objects and equipment” [4]. The most common non-fatal injury diagnoses were sprain/strain (38%), contusion/abrasion (17%), and laceration/puncture (14%). The neck and back were the most commonly cited body parts affected by non-fatal injury (31%), suggesting that lifting and moving patients and/or equipment are common causes of injury.

Research by Suyama and colleagues examined worker compensation reports for three public safety bureaus (police, fire, and EMS) in a large urban area [8]. The study determined that the absolute frequency of reported injuries was higher for police and fire compared to EMS. When adjusted for the size of the workforce, however, the rate of injuries that led to lost work time was highest among EMS workers [8].

Emergency medical services workers face repeated exposure to bodily fluids, including blood, elevating their risk of infection and illness from human immunodeficiency virus (HIV), hepatitis B virus (HBV), and hepatitis C virus (HCV). Findings from a 2002 survey sample of 2,664 paramedics determined that the rate of any exposure to blood in past 12 months was 6 per 10,000 calls and 3.7 per 10,000 patients [9]. Most exposures appear to involve intact skin and were attributed to the higher frequency of uncontrolled bleeding in the prehospital setting versus in-hospital [10].

There is a high probability that a violent patient will injure EMS workers [11–15]. Corbett and colleagues determined that >60% of EMS workers in a southern California urban system were assaulted while on the job [12]. A separate study by Mock and colleagues determined that EMS workers are exposed to at least one violent patient or event every 19 calls/patients [14]. A more recent study by Grange and Corbett determined that while violent patients accounted for <9% of patient encounters, more than half (53%) involved violence (verbal or physical) against EMS workers [15]. While it is widely known that EMS workers are often exposed to violence and violent patients, few EMS workers report receiving enough training to respond appropriately and safely [11,12].

One limitation of previous research is underreporting of injuries through the required or standard channels within organizations. As many as 32% of injuries go unreported to employers due to a complex set of factors, including but not limited to stigma associated with being injured, worker-perceived low injury severity, and other unknown factors [16]. Anonymous reporting via survey research may reveal that the proportion of EMS workers injured while on duty is greater than that counted based on injuries reported to the emergency department, employer injury logs, or worker’s compensation databases. Recent research by the University of Pittsburgh’s EMS Agency Research Network (EMSARN) shows that a large proportion of EMS workers are injured during shiftwork. [Figure 21.1](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/Vol2/c21.xhtml#c21-fig-0001) shows self-reported injury data from 2,367 EMS workers in the US and Canada taking part in EMSARN research studies in 2011 and 2012. When asked to reflect on the previous 2 months, nearly half of EMS workers (45.8%) self-report injuries occurring during shifts. Injuries while lifting or moving patients were the most common injury type reported.



[**Figure 21.1**](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/Vol2/c21.xhtml#R_c21-fig-0001) EMS worker self-reported injury.

Source: Data from the 2011 and 2012 cohorts of the EMS Agency Research Networks ([EMSARN.org](http://emsarn.org/)) and responses version 2 of the EMS Safety Inventory (EMS2-SI).

Ambulance crashes are not an uncommon occurrence, with somewhere between 4% and 9% of all EMS providers having been involved in ambulance crashes [17,18]. Drivers involved in ambulance crashes are at increased risk for additional ambulance crashes in the future [19]. Half of drivers involved in crashes have been involved in multiple crashes [20]. Risk of an accident is also increased for younger/inexperienced drivers and those reporting sleep problems [18]. Ambulance crashes represented the greatest source of tort claims against EMS agencies in one analysis of a national insurance company, comprising 37% of all claims [21]. Crashes are also the leading cause of fatal injury [6].

There are few published studies that focus specifically on injuries incurred during EMS transport. Available data suggest that ambulance crashes occur in both emergency and non-emergency modes of transport [20]. Becker et al. examined ten years of data from two national databases: the FARS registry and the General Estimates System (GES) [22]. The analysis from this national dataset included a comparison of EMS, fire, and police crashes [22]. EMS crashes represented the highest proportion of crashes where emergency vehicle operators were killed or injured [22]. Becker et al. also noted that restrained occupants were significantly less likely to be killed or seriously injured in ambulance crashes when compared to unrestrained occupants [22]. This is consistent with findings from Kahn et al. [7]. Authors noted that improperly restrained occupants were 2.5 times as likely as unrestrained occupants to sustain serious or fatal injuries, and that serious or fatal injuries were nearly three times more likely to occur in the rear compartment compared to the front. Few EMS workers report wearing seat belts while providing care in the rear compartment of the ambulance, and providers report the need to be unrestrained in order to perform patient care tasks [23,24]. Seat belt behavior may be modifiable with EMS agency policy intervention [25].

One method of mitigating the risk associated with ambulance response and transport is the use of “drivecams” or onboard event recorders. These recorders are activated when the vehicle exceeds preset G-force limits. One large EMS agency conducted a prospective study, outfitting its fleet of 54 vehicles with onboard event recorders and observing the changes in driving behavior over time [26]. They noted that the proportion of activations per mile and activations per response steadily decreased over time [26]. The installation of these devices may influence providers to adopt more conservative driving behaviors.

Brice and associates published a comprehensive report on the proceedings of a conference of ambulance safety experts [2]. The authors implemented a Haddon matrix to conceptualize the problem of safety during ambulance transport and propose actionable solutions. A central tenet of several proposed solutions is the fostering of a culture of safety within the EMS agency.

Emergency medical services worker injuries have been linked to poorer perceptions of workplace safety culture [27]. Workplace safety culture refers to the aggregated beliefs that EMS workers create through their work and exposure to the safety conditions, policies, and practices within their EMS agency [28]. Common domains of EMS workplace safety culture include safety climate, teamwork climate, perceptions of management, working conditions, stress recognition, and job satisfaction [28]. There are few studies of EMS workplace safety culture [27–30]. Recent research by EMSARN linked a higher number of EMS workers reporting recent injuries to lower (poorer) scores on five of six domains of safety culture [27]. This association suggests that worker injuries are more common in EMS agencies where EMS workers perceive safety conditions as poor or “less positive.”

**Injury prevention**

A large proportion of non-fatal EMS injuries are musculoskeletal and associated with lifting and moving patients or equipment. Carrying equipment and patients over long distances is part of the daily occupational tasks of the prehospital provider. In spite of ergonomic improvements in patient movement devices, physical force must be applied to move patients in the course of prehospital care. Musculoskeletal injuries, including back injuries, hinder the job performance of EMS providers. To prevent back injury, it is essential for the prehospital provider to have adequate strength and flexibility. The core muscles of the hip and torso contain an individual’s center of gravity and initiate movement. The muscles that attach to the core provide proximal stability for efficient upper and lower extremity movements. Activation of trunk musculature precedes any upper or lower limb movements and compensatory changes in trunk muscle recruitment have been demonstrated in people with low back pain [1].

Adequate hip flexibility is also another important key for prevention of low back injuries. Tightness of the hip musculature can lead to reciprocal inhibition of the core musculature. For example, a tight iliopsoas (an important muscle for sagittal plane hip function) can lead to reciprocal inhibition of the gluteus maximus, transversus abdominis, internal abdominal oblique, and multifidus muscles. All of these muscles play important roles in spinal stabilization in the sagittal and transverse planes.

Improving the biomechanics of patient movement has received considerable attention in recent years. One research group used an ecological model of musculoskeletal injuries in the fire service to identify targets for ergonomic interventions for moving and lifting [31]. Focus groups were conducted with 25 firefighter/paramedics from 13 suburban fire departments. The participants identified lateral transfers, bed-to-stairchair transfers, and stair descent transport as areas needing improved technology. A separate study by the same group reported that a simple strap placed around the feet of the patient being transported down stairs while strapped to a long spine board reduced the strain on the EMS providers carrying the patient [32]. Although more expensive, descending control devices, which alter a movement from a carrying-type configuration to a push-pull configuration, also reduce muscular activation and could reduce injury. Interventions for reducing muscle activation and strain during lateral transfers have been less successful [32].

Ambulance stretchers have evolved over time from models requiring the providers to lift the stretcher from the ground to the ambulance deck to those requiring the provider to lift only the wheel carriage to fully powered stretchers that demand virtually no lifting. While there is a growing literature documenting a reduction in injuries after implementing mechanical patient movement devices in the hospital, little is known about the role of these devices for EMS workers. One study conducted in a large urban EMS system examined the rate of injuries before and after placing electrically powered patient stretchers on every ambulance in the system [33]. The incidence rates for overall injury before and after the intervention were 61.1 and 28.8 per 100 FTE with a corresponding risk reduction of 0.47 (95% confidence interval (CI) 0.41–0.55) [33]. The subcategory of stretcher-related injuries had the lowest risk reduction (0.30; 95% CI 0.17–0.52) when comparing pre- and postintervention time periods [33].

## Comparing studies

Few studies have been performed using directly comparable datasets, denominators, numerators, and methodologies. For this reason, there remains a great deal of uncertainty about the true magnitude of fatal and non-fatal injury rates and risks for EMS workers. Much of this uncertainty can be attributed to variation in the methods and data used to quantify fatal and/or non-fatal injuries, and it is worth highlighting for the benefit of medical directors charged with monitoring these data in their own systems. There are multiple appropriate methods by which to estimate rates. Subtle differences in the method used to calculate the rate can lead to substantial differences in the final estimate. One example could be differences in the selection of the denominator for an incidence density calculation. It is critical to report this information in full, and be mindful of the decision made by authors when evaluating and comparing relevant literature. The true rate of fatal and non-fatal injuries among EMS workers is undetermined due in part to the lack of a uniform database of EMS workers. Differences in data collection threaten confidence in the ability to aggregate data and accuracy in statistics.

In the broadest sense, an injury rate is calculated in the following fashion. The numerator is the number of events in a population for a given time period. The denominator is the number of people in the population at risk during the time period. The denominator of employed and volunteer EMS workers is poorly documented, as is often true with large and dynamic populations. Estimates of EMS workers in the US range from between 800,000 and 1 million [34–37].

In this chapter, we cite two studies that examine fatal and non-fatal injuries among EMS workers. Investigators in one study defined their population for determining non-fatal injuries as “EMTs employed in the private sector with injuries resulting in at least one day of lost work time,” and for fatal injuries as “private sector and government-employed EMTs” [5]. Investigators of the separate study included compensated and volunteer EMTs, ambulance drivers and attendants, while excluding military workers [4]. Investigators also included injuries among firefighters if it was documented that the firefighter was performing EMS duties at the time of the injury (e.g. patient transport/rescue) [4]. Differences in denominators and identification of numerators result in differences between seemingly similar studies involving similar worker populations. Differences in rates may then be misinterpreted as one workplace, agency, region, or other defined area having a much higher or lower rate of injuries or fatalities.

Emergency medical services systems should have mechanisms in place to capture all injuries to workers within the system. Using the cumulative incidence rate (number of injuries per period of time divided by the number of workers at beginning of time period), the system can calculate the risk of individual EMS worker sustaining an injury over a given period of time and determine if that rate meets internal and external benchmarks. A uniform, centralized national reporting system has been proposed and would be very useful in refining the estimates of the risk of occupational injury in EMS [2].

## References

1. 1 Crill MT, Hostler D. Back strength and flexibility of EMS providers in practicing prehospital providers. *J Occup Rehabil* 2005;15(2):105–11.
2. 2 Brice JH, Studnek JR, Bigham BL, et al. EMS provider and patient safety during response and transport. proceedings of an ambulance safety conference. *Prehosp Emerg Care* 2012;16(1):3–19.
3. 3 Slattery DE, Silver A. The hazards of providing care in emergency vehicles. An opportunity for reform. *Prehosp Emerg Care* 2009;13(3):388–97.
4. 4 Reichard AA, Marsh SM, Moore PH. Fatal and nonfatal injuries among emergency medical technicians and paramedics. *Prehosp Emerg Care* 2011;15(4):511–17.
5. 5 Maguire BJ, Smith S. Injuries and fatalities among emergency medical technicians and paramedics in the United States. *Prehosp Disaster Med* 2013;28(4):376–82.
6. 6 Maguire BJ, Hunting KL, Smith GS, Levick NR. Occupational fatalities in emergency medical services. *A hidden crisis. Ann Emerg Med* 2002;40(6):625–32.
7. 7 Kahn CA, Pirrallo RG, Kuhn EM. Characteristics of fatal ambulance crashes in the United States: an 11-year retrospective analysis. *Prehosp Emerg Care* 2001;5(3):261–9.
8. 8 Suyama J, Rittenberger JC, Patterson PD, Hostler D. Comparison of public safety provider injury rates. *Prehosp Emerg Care* 2009;13(4):451–5.
9. 9 Leiss JK, Ratcliffe JM, Lyden JT, et al. Blood exposure among paramedics: incidence rates from the national study to prevent blood exposure in paramedics. *Ann Epdemiol* 2006;16(9):720–5.
10. 10 Boal WL, Leiss JK, Ratcliffe JM, et al. The national study to prevent blood exposure in paramedics: rates of exposure to blood. *Int Arch Occup Environ Health* 2010;83(2):191–9.
11. 11 Tinitnalli JE, McCoy M. Violent patients and the prehospital provider. *Ann Emerg Med* 1993;22(8):1276–9.
12. 12 Corbett SW, Grange JT, Thomas TL. Exposure of prehospital care providers to violence. *Prehosp Emerg Care* 1998;2(2):127–31.
13. 13 Pozzi C. Exposure of prehospital providers to violence and abuse. *J Emerg Nurs* 1998;24(4):320–33.
14. 14 Mock EF, Wrenn KD, Wright SW, Eustis TC, Slovis CM. Prospective field study of violence in emergency medical services calls. *Ann Emerg Med* 1998;32(1):33–6.
15. 15 Grange JT, Corbett SW. Violence against emergency medical services personnel. *Prehosp Emerg Care* 2002;6(2):186–90.
16. 16 Cutter J, Jordan S. Uptake of guidelines to avoid and report exposure to blood and body fluids. *J Adv Nurs* 2004;46(4):441–52.
17. 17 Schwartz RJ, Benson L, Jacobs LM. The prevalence of occupational injuries in EMTs in New England. *Prehosp Disaster Med* 1993;8(1):45–50.
18. 18 Studnek JR, Fernandez AR. Characteristics of emergency medical technicians involved in ambulance crashes. *Prehosp Disaster Med* 2008;23(5):432–7.
19. 19 Biggers WAJ, Zachariah BS, Pepe PE. Emergency medical vehicle collisions in an urban system. *Prehosp Disaster Med* 1996;11(3):195–201.
20. 20 Custalow CB, Gravitz CS. Emergency medical vehicle collisions and potential for preventive intervention. *Prehosp Emerg Care* 2004;8(2):175–84.
21. 21 Wang HE, Fairbanks RJ, Shah MN, Abo BN, Yealy DM. Tort claims and adverse events in emergency medical services. *Ann Emerg Med* 2008;52(3):256–62.
22. 22 Becker LR, Zaloshnja E, Levick NR, Li G, Miller TR. Relative risk of injury and death in ambulances and other emergency vehicles. *Accid Anal Prev* 2003;35(6):941–8.
23. 23 Larmon B, LeGassick TF, Schriger DL. Differential front and back seat safety belt use by prehospital care providers. *Am J Emerg Med* 1993;11(6):595–9.
24. 24 Cook RT, Meador SA, Buckingham BD, Groff LV. Opportunity for seatbelt usage by ALS providers. *Prehosp Disaster Med* 1991;6:469–71.
25. 25 Studnek JR, Ferketich A. Organizational policy and other factors associated with emergency medical technician seat belt use. *J Safety Res* 2007;38(1):1–8.
26. 26 Myers LA, Russi CS, Will MD, Hankins DG. Effect of an onboard event recorder and a formal review process on ambulance driving behavior. *Emerg Med J* 2012;29(2):133–5.
27. 27 Weaver MD, Wang HE, Fairbanks RJ, Patterson PD. The association between EMS workplace safety culture and safety outcomes. *Prehosp Emerg Care* 2012;16(1):43–52.
28. 28 Patterson PD, Huang DT, Fairbanks RJ, Wang HE. The emergency medical services safety attitudes questionnaire. *Am J Med Qual* 2010;25(2):109–15.
29. 29 Patterson PD, Huang DT, Fairbanks RJ, Simeone SJ, Weaver MD, Wang HE. Variation in emergency medical services workplace safety culture. *Prehosp Emerg Care* 2010;14(4):448–60.
30. 30 Eliseo LJ, Murray KA, White LF, Dyer S, Mitchell PA, Fernandez WG. EMS providers' perceptions of safety climate and adherence to safe work practices. *Prehosp Emerg Care* 2012;16(1):53–8.
31. 31 Conrad KM, Reichelt PA, Lavender SA, Gacki-Smith J, Hattle S. Designing ergonomic interventions for EMS workers. concept generation of patient-handling devices. *Appl Ergon* 2008;39(6):792–802.
32. 32 Lavender SA, Conrad KM, Reichelt PA, Gacki-Smith J, Kohok AK. Designing ergonomic interventions for EMS workers, Part I. transporting patients down the stairs. *Appl Ergon* 2007;38(1):71–81.
33. 33 Studnek JR, MacCrawford J, Fernandez AR. Evaluation of occupational injuries in an urban emergency medical services system before and after implementation of electrically powered stretchers. *Appl Ergon* 2012;43(1):198–202.
34. 34 McGinnis S, Moore J, Armstrong D. *The Emergency Care Workforce in the U.S.* New York: Rensselaer, 2006.
35. 35 Chapman SA, Lindler V, Kaiser JA, Nielsen CS, Bates T, Hailer-O'Keefe L. *Emergency Medical Services Workforce for the 21st Century Project*. Washington, DC: National Highway Traffic Safety Administration, 2008.
36. 36 Studnek J, Margolis G. What we know about the EMS workforce. *JEMS* 2006;31(1):30.
37. 37 Heightman AJ. EMS workforce. A comprehensive listing of certified EMS providers by state & how the workforce has changed since 1993. *JEMS* 2000;25(3):108–12.