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Working hours, sleep, and fatigue in the public safety sector: A scoping review of the research

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Abstract

Background: The public safety sector includes law enforcement officers (LEO), corrections officers (CO), firefighter service (FF), wildland firefighting (WFF), and emergency medical services (EMS), as defined in the National Occupational Research Agenda (NORA) of the National Institute for Occupational Safety and Health (NIOSH). Across these occupations,

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AUTHOR CONTRIBUTIONS

Penelope Allison and Hope M. Tiesman participated in the conception and design of the study and drafted the manuscript. All authors: (1) revised the paper for important intellectual content, (2) provided final approval of the version to be published, (3) and participated in the agreement to be accountable for all aspects of the work.

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

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Ethics review and approval and informed consent were not required by NIOSH's IRB.

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DISCLAIMER

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention.

DISCLOSURE BY AJIM EDITOR OF RECORD

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shiftwork, long-duration shifts, and excessive overtime are common. Our objective was to identify research gaps related to working hours, sleep, and fatigue among these workers.

Methods: We used a scoping review study design that included searches of MEDLINE, Embase, CAB Abstracts, Global Health, PsychInfo, CINAHL, Scopus, Academic Search Complete, Agricultural and Environmental Science Collection, ProQuest Central, Cochrane Library, Safety Lit, Homeland Security Digital Library, and Sociological Abstracts using a range of occupational search terms and terms related to working hours, sleep, and fatigue.

Results: Out of 3415 articles returned from our database search, 202 met all inclusion criteria. Six common outcomes related to working hours, sleep, and fatigue emerged: sleep, fatigue, work performance, injury, psychosocial stress, and chronic disease. Nearly two-thirds (59%, $n = 120$) of the studies were observational, of which 64% ($n = 77$) were cross sectional and 9% were ($n = 11$) longitudinal; 14% ($n = 30$) of the studies were reviews; and 19% ($n = 39$) were experimental or quasi-experimental studies. Only 25 of the 202 articles described mitigation strategies or interventions. FFs, LEOs, EMS, and WFFs were the most studied, followed by COs.

Conclusions: In general, more longitudinal and experimental studies are needed to enrich the knowledge base on the consequences of long working hours, poor sleep, and fatigue in the public safety sector. Few experimental studies have tested novel approaches to fatigue mitigation in diverse sectors of public safety. This gap in research limits the decisions that may be made by employers to address fatigue as a threat to public-safety worker health and safety.

Keywords

correctional officers; emergency medical services; fatigue; firefighters; law enforcement officers; police officers; sleep; wildland firefighters; work hours; work schedule

1 | INTRODUCTION

The public safety sector includes law enforcement, corrections, fire service, wildland firefighting, and emergency medical services (EMS), as defined in the National Occupational Research Agenda (NORA) of the National Institute for Occupational Safety and Health (NIOSH).[1] Employment in the public safety sector in the United States reached over 2.8 million in 2018, representing 1.8% of the workforce across all the various US industry sectors.[2] In 2018, the public safety sector was roughly divided as: 40% law enforcement officers (LEOs), 26% correctional officers (COs), 19% firefighters (FFs), and 15% EMS. In addition to those employed workers, there is a significant number of volunteers serving as FFs, wildland firefighters (WFFs), and as EMS clinicians.[3-6] Public safety workers are exposed to a variety of occupational hazards that put them at increased risk for acute injuries, workplace violence, chronic and infectious diseases, and motor-vehicle crashes.

In the public safety sector, shiftwork and long work hours are standard practice to allow a around the clock response to protect and serve the public.[7] According to estimates from the U.S. Bureau of Labor Statistics, 50% of workers in protective services are employed in nonstandard work schedules.[8,9] Rotating shifts and overtime are often required for COs. Most FFs work long duration shifts, such as 24 or 48 h. During wildland fires, WFFs

can work 24–72 h shifts and may stay on duty up to 14 days straight.[10] Most in EMS report working long duration shifts and many work excessive amounts of overtime.[11-14] Nonstandard work hours, defined as hours outside of the traditional 9 a.m. to 5 p.m. daylight period,[15] have been associated with increased risk for on-duty injuries and chronic diseases such as cancer and cardiovascular disease among these workers.[16-19] Fatigue-related errors may also impact the communities and civilians these workers protect and serve.[20]

This manuscript is part of a series of papers developed following the NIOSH Working Hours, Sleep and Fatigue Forum in September of 2019.[21] The purpose of the full series is to identify research gaps around working hours, sleep, and fatigue specific for industry sectors and vulnerable working populations in the United States. Collectively, the papers provide overviews of the current state of research, identify health and safety risks, highlight effective interventions, and suggest future research directions. The objective of this manuscript is to report on the findings from a scoping literature review that sought to identify research gaps related to working hours, sleep, and fatigue, including contextual and co-occurring factors, linked with the occupational safety, health, and performance of workers in the public safety sector.

2 | MATERIALS AND METHODS

2.1 | Study design

We used a scoping review study design given that: (1) the goals and objectives of the papers in this series were not focused on changing policy or protocol—as is a common goal of systematic reviews, meta-analyses, and evidence-based guideline projects[22-25]; and (2) the timeline given to accomplish this review was not conducive for broader reviews such as a systematic literature review.[22-29] Scoping reviews often precede the conduct of systematic reviews to address the question: “Is there enough literature out there to perform a systematic review and/or meta-analysis?”[30] Scoping reviews are also used to quickly identify gaps in research and direct attention to these gaps[30,31]; which are two goals of this study.

2.2 | Search strategy

Searches were conducted iteratively in consultation with a librarian at the Centers for Disease Control and Prevention (CDC), and modified periodically as necessary. Key search terms were identified by two authors (Penelope Allison and Hope M. Tiesman) in consultation with the CDC librarian. The terms included occupational titles related to LEOs, COs, FFs, WFFs, and EMS (e.g., police, correctional officer, firefighter, paramedic) and terms related to working hours, sleep, and fatigue (e.g., work schedule, sleepless, fatigue). The occupational titles in the search were largely based on American vernacular to focus on working populations in the United States, although relevant international literature was also identified and included. In November 2018, a preliminary literature search of Scopus resulted in 1398 articles. In consultation with the librarian, a wider search was conducted with refined search terms and additional databases (i.e., MEDLINE, Embase, CAB Abstracts, Global Health, PsychInfo, CINAHL). This search was last updated on July 22, 2020. The broader search resulted in 2075 articles which included very few articles related to WFFs or COs. Due to the paucity of WFF- and CO-related articles, search

terms were broadened and additional databases were included (Academic Search Complete, Agricultural and Environmental Science Collection, ProQuest Central, Cochrane Library, Safety Lit, Homeland Security Digital Library, and Sociological Abstracts). This additional search resulted in 673 articles related to WFFs (last updated August 7, 2020) and 146 articles related to COs (last updated July 21, 2020). The final search terms and criteria are included as an online supplement. In addition to the articles identified through keyword searches, 18 additional key articles were identified by experts (Figure 1).

Studies were included if: (i) the study population included occupations in the public safety sector (FF, WFF, LEO, CO, or EMS); (ii) they were related to sleep, fatigue, or work schedule; and (iii) the study was published in a peer-reviewed scientific journal. Some gray literature was added for WFFs and COs because there was very little peer-review literature available for these occupations. We further limited our search to articles written in English and published in 2008 or later. Given the breadth of our objective, there was not an obvious starting point for the search. The articles spanning 12 years provided a sufficient amount of literature. This was also discussed among subject matter experts as best representing the most current state of research. Academic theses and dissertations, as well as conference abstracts were excluded.

A total of 3415 titles and abstracts were identified for screening. Two reviewers (Penelope Allison and Hope M. Tiesman) independently screened all titles, abstracts, and keywords to determine relevance to working hours, sleep, and fatigue in public safety. Discrepancies between the reviewers' determinations were discussed to reach agreement as to whether the articles would be included. A total of 202 met all inclusion criteria.

3 | RESULTS

We organized the findings from this scoping review into six outcomes that emerged as themes from the public safety workers literature: sleep, fatigue, work performance, injury, psychosocial stress, and chronic disease. Of the 202 articles that met all our inclusion criteria, 185 were peer-reviewed and 16 were from nonpeer reviewed sources. Nearly two-thirds (59%, $n = 120$) of the studies were observational, 14% ($n = 30$) were reviews, and 19% ($n = 39$) were experimental or quasi-experimental studies. Among the observational studies, 64% ($n = 77$) were cross sectional and 9% ($n = 11$) were longitudinal. Only 25 of the 202 articles (12%) described mitigation strategies or interventions. The distribution of articles by public safety occupation was FFs ($n = 65$), LEOs ($n = 51$), EMS ($n = 38$), WFFs ($n = 37$), and COs ($n = 8$). Details about these articles are presented in Table 1 (FFs and WFFs), Table 2 (LEOs and COs), and Table 3 (EMS).

3.1 | Sleep

Studies reported that work demands in public safety impair sleep. Among FFs, 59% reported sleep deprivation and 23% reported insomnia symptoms.[46,48] Prevalence of poor sleep quality was reported among more than half of EMS (64%) and LEO (51%) populations.[145,185] COs with posttraumatic stress disorder (PTSD) reported more sleep difficulty.[132] The lingering effects of impaired sleep have been studied among WFFs,

where selfreports of sleepiness were significantly greater after rest days compared to initial deployment.[75]

Research on poor sleep in the public safety sector was often associated with shiftwork and psychosocial stress and primarily focused on LEOs, FFs, and EMS. Research foci and findings differed across occupations. In LEOs, sleep problems may mediate the relationship between job stress and metabolic syndrome.[144] Circadian disruption observed in both the central and peripheral clocks in LEOs working night shift may have implications for medical disorders.[155] Among FFs, fire alarm response was associated with fatigue, light sleep, insufficient sleep, and sleep inertia soon after waking.[97] Excessive daytime sleepiness among FFs was associated with 48-h work shifts, nonprivate sleep areas, and working a second job.[65] Also in FFs, the association between alcohol misuse and sleep disturbance was moderated by distress tolerance (perceived ability to tolerate negative or aversive emotional states).[106] During planned wildfire burn operations, sleep quantity and quality were not compromised in shifts <12 h in duration.[115] In a multiday wildfire suppression, sleep quantity was restricted, and pre- and post-sleep fatigue was higher, compared with nonfire days.[114] WFFs had suboptimal sleep quality and quantity more frequently during high-intensity, Initial Attack fire deployments, but also during nonfire (Base) work periods.[86] In a simulated wildfire suppression, there were no significant differences found in sleep architecture between sleep-restricted WFFs and sleep-restricted WFFs who worked in hot daytime conditions.[50] Compared with EMS basic life support personnel, those in advance life support units, which respond to the most traumatic emergency calls, were found to have the highest prevalence of poor sleep.[185]

Two studies addressed mitigation strategies. One study compared methods of delivery for a sleep health education and sleep disorders screening program for FFs.[36] As compared to train-the-trainer and online delivery methods, the expert-led program resulted in the most knowledge gained and a higher willingness to seek clinical evaluation among those who screened at a high risk for a sleep disorder. The second study examined the use of phototherapy at night and reduced exposure to morning light among LEOs, and reported improved adaptation to night shift and more stable psychomotor performance over seven consecutive night shifts.[130]

3.2 | Fatigue

In contrast with poor sleep, fatigue also encompasses reduced mental and physical energy.[211] Fatigue was most mentioned in systematic reviews and randomized trials. Several interventions were identified for EMS and WFFs, demonstrating very different challenges.

An evidence-based guideline project comprised of seven systematic reviews resulted in recommendations that address numerous fatigue mitigation strategies including shift duration, access to caffeine, on-shift napping, and training and education on fatigue and sleep.[198] Use of reliable and/or valid survey instruments to assess fatigue/sleepiness in the workplace was also recommended[198]; a recommendation resulting from a detailed review of the psychometric properties of numerous fatigue and sleep assessment surveys.[200] Other EMS studies uncovered in this review focused on workplace tools or equipment that may contribute to or reduce fatigue, such as a device that assisted manual chest compression in

patient resuscitation, and a mobile phone text message platform for reporting fatigue The latter found that assessing selfrated feelings of fatigue in real-time during scheduled shifts, followed up with real-time intervention-style messaging led to lower reported fatigue at the end of 12-h shifts[201] and improved sleep quality at 90-days follow-up.[14] A systematic review of task load (perceived difficulty of accomplishing a task) interventions as a fatigue mitigation strategy found a lack of quality evidence and inconsistency in defining and measuring task load and workload.[207]

Among WFFs, two studies reported on ingestion of glutamine, an amino acid with anti-inflammatory effects that may improve work performance. Both reported glutamine resulted in reduced subjective fatigue and improved physiologic response to heat stress compared with placebo during 2-day firefighting simulations.[89,93] Another study demonstrated the feasibility of using wearable technology to collect typically difficult to obtain physiologic workload and productivity data from WFFs.[96] A simulation study demonstrated shortened travel distances were successful to reduce fatigue among a subgroup of WFFs (i.e., hotshot crew) who usually experience extensive travel and long work hours.[40]

3.3 | Work performance

Negative effects of poor sleep and fatigue may interfere with work performance in public safety.[212] In EMS, those who selfreported fatigue were 1.5 times more likely to report errors and adverse outcomes, more than twice as likely to report on-duty injuries, and three times more likely to engage in safety compromising behaviors.[187] Among FFs, even minimal sleep disruption from nighttime calls affected processing speed, visual-motor coordination, and reaction time[109] and shiftwork decreased neurocognitive function (visual attention, cognitive flexibility, verbal memory, and visual, psychomotor, and motor speed).[78,208] In a simulated wildfire suppression, 4 h of sleep restriction did not adversely affect work performance under selfpaced conditions.[113] Under simulated wildfire working conditions with sleep restriction, ambient heat did not consistently impair work performance, physiological (e.g., heart rate), or perceptual responses (e.g., exertion).[117] In a 3-day simulated wildfire suppression with hot wildfire conditions, two nights of sleep restriction did not influence task performance or physiological responses.[118] In LEOs, those with a sleep disorder had a higher probability of making serious administrative errors, falling asleep while driving, making a safety violation, and exhibiting uncontrolled anger toward suspects.[166] In another LEO study, sleepiness was linked with increased odds of public complaint, indicating that fatigue affects public encounters.[170] Among COs, fatigue has been linked with inability to monitor inmates and remain attentive.[142] In contrast, LEOs working a three-shift, forward rotating shift pattern had a significantly reduced sleep duration, but cognitive performance and vigilance were not impacted[173] A study of air EMS providers showed that after 12- and 24-h shifts, there were no differences in cognitive performance by shift duration.[190]

Intervention studies to reduce physical and mental fatigue reported mixed results. Among EMS, the use of a mechanical device which provided real-time feedback to manage fatigue during the care of patients suffering from cardiac arrest, resulted in more effective and steadier chest compressions during CPR administration.[184] While a systematic review of the evidence shows that caffeine has been shown to mitigate declines in performance associated

with shift work,[209] one study found the effects of energy beverage consumption among LEOs diminished firearm accuracy.[161] A systematic review found improved marksman reaction time with caffeine use, but not marksmanship accuracy.[175]

3.4 | Injury

Public safety workers had high rates of fatal and nonfatal injury, which may be linked with long hours and fatigue, among other factors that may put these workers at risk for injury. In 2018, transportation incidents were a leading cause of death for LEOs.[162] In 2017, FFs sustained an estimated 58,835 nonfatal injuries [strains and sprains (48%), cuts, and bruises (15%), smoke/gas inhalation (7%), and thermal stress (5%)].[90] From 2005 to 2009, the number of nonfatal injuries involving COs ranked third only to LEOs and security guards.[213] EMS workers are at increased risk for lost-time from work injuries,[111] especially motor-vehicle crashes, assaults, and falls.[193,205]

We found evidence linking traumatic injuries and long work hours and shiftwork among LEOs, WFFs, and EMS. Night shift and subjective fatigue have been associated with increased risk for injury and long-term injury leave among LEOs.[141] Additionally, a driving simulation study demonstrated that driving performance was significantly impaired following five consecutive night shifts as compared to after three off-duty days.[180] Among EMS, shift duration was a critical factor for increased injury risk, with shifts <24 h more favorable for safety.[11,12] Considering the role of body mass in on-duty injury, obese male career FFs who were sleep-deprived were twice as likely to have an on-duty injury compared with those who got enough sleep.[79] Associations between fatigue and injury among WFFs are less evident, but studies have found injuries increased at the end of the day and may be due to fatigue.[42,43,61] Research studies linking injuries with fatigue were not found for COs.

There were only a few intervention studies identified and all of them involved FFs. A study of balance in FFs found that the combined effect of physical effort and heat stress led to an increased likelihood of slips, trips, and falls on the fireground.[58] A prospective study found a sleep health program resulted in significantly fewer reported injuries among FFs.[110] A proactive risk management program intervention among FFs reduced injuries, and workers' compensation claims and costs, but did not result in significant changes in injury rates.[99]

3.5 | Psychosocial stress

Maintaining public safety often involves working nights and long hours. The work environment is stressful, with inactivity and anticipation interspersed with peaks of physical activity and psychological strain during emergency responses.[97,182] Workers are routinely exposed to traumatic incidents that may have long-term psychological effects. The hazardous nature of the work also requires constant psychological vigilance throughout the work shift, with direct effects on fatigue.[7]

One systematic review found adverse psychological symptoms were consistently associated with lack of support, job demands, job pressure, and administrative/organizational pressure, and long working hours.[165] Shiftwork may intensify the effects of these exposures and increase anxiety, depression, PTSD,[183,188] suicidality,[108] sleep disturbances,[46] and excessive alcohol use.[64,66] Sleep quality was correlated with PTSD, depression, anxiety, social anxiety

disorder, panic disorder, and alcohol use disorder in public safety personnel.[129] LEOs with borderline or poor sleep quality reported increased depressive symptoms, and high levels of personal and organizational stress.[140] Irregular schedules, night shifts, sleep disturbances, and work hours were associated with increased burnout risk in LEOs.[164] Sleep and mental health problems were associated with a higher risk of burnout in FFs, although sleep duration in overnight work mediated both of these relationships.[125] Several studies involved simulated wildfire suppression work, sleep restriction (either a 4- or 8-h sleep opportunity), and cortisol and pro- (IL-6, IL-8, IL-1β, TNF-α) and anti-inflammatory (IL-4, IL-10) cytokines. In firefighters with sleep restriction, morning IL-6 was positively associated with evening cortisol[120]; negative mood was positively associated with inflammatory and cortisol levels[123]; increases in fatigue, perceived stress, and depressed mood were associated with elevated TNF-α, IL-8, and IL-10[122]; and had elevated afternoon and evening cortisol compared to those without sleep restriction.[124] Without sleep restriction, physical signs and symptoms and elevated IL-6 were positively associated and depressed mood was inversely related to decreasing cortisol and IL-6, TNF-α, and IL-10.[122] Fear, work/family conflict, public misperceptions of the profession, and media scrutiny were identified as stressors for COs.[132]

Two intervention studies in LEOs examined mindfulness-based techniques. These techniques reduced symptoms of burnout, sleep disturbances, and anxiety,[137] with effects lasting up to 5 months.[147] A 6-week yoga intervention in FFs showed a decrease in perceived stress.[49] Studies also suggested that selfefficacy is a significant moderator of the relationship between perceived stress and psychophysical exhaustion,[83] highlighting the need for more programs to help public safety workers develop coping skills for trauma and stressors in their work environment. A pilot study demonstrated the usefulness of heart rate variability and accelerometry data to detect stressful events experienced by FFs on duty.[87]

3.6 | Chronic disease

Chronic disease has been identified as a leading cause of morbidity and mortality for public safety workers, with evidence connecting shiftwork with several chronic diseases, including cardiovascular disease, cancer, and metabolic syndrome.[72,182,214] Night shiftwork may increase cancer risk by disrupting circadian rhythms.[176,215] Studies have found associations between shiftwork and cancer among FFs and in urban LEOs.[51,176] There is limited research on shiftwork and chronic disease among EMS, WFFs, and COs.[181]

Sudden cardiac death (SCD) was found to be a leading cause of on-duty death among FFs, LEOs, WFFs, and COs.[53,104] Cardiovascular disease (CVD) research on FFs has focused on physiological aspects and work performance, such as cardiorespiratory fitness and excessive blood pressure response.[38,55,57,77,102] These studies found a strong association between strenuous emergency duties and increased SCD risk, and signs of cardiac fatigue following firefighting. Sleep disorders have been associated with CVD, diabetes, and poorer health in FFs.[35] Research on WFFs is challenging due to the work environment, but studies have found an increased SCD risk among WFFs which may be linked to particulate exposures.[85] A risk assessment for WFF exposure estimated increased CVD risk ranging from 16% to 30%.[94] In simulated physical wildfire work, sleep restriction was associated with acute

inflammatory stress responses, including higher IL-8 among those with 8 h sleep compared to those with restricted sleep (4 h), and increased IL-6 in both groups.[121]

LEOs had increased CVD risk, and a high prevalence of traditional risk factors such as hypertension, hyperlipidemia, and sedentary lifestyle.[182] Endothelial dysfunction, a precursor to atherosclerosis, was studied in LEOs. Male officers who worked afternoon or night shifts had larger declines in endothelial function compared to officers working day shift.[135] Another study found that officers working night shift had higher levels of biomarkers for subclinical CVD (leukocytes, TNF-α, and homocysteine) compared to officers working day shift.[149]

Few studies described mitigation strategies for chronic diseases. One study found that LEOs who participated in weekly, peer-led sessions about CVD risk factors attained significant improvements and reduced selfreported stress.[156] A study of COs found that healthy nutrition and physical activity may help reduce BMI despite increased overtime.[133] Finally, significant weight loss was observed during a pilot program for FFs using commercially-available apps, a student coach-in-training, and evidence-based recommendations.[76]

4 | DISCUSSION

This scoping review of the public safety literature identified abundant observational studies, but few experimental studies on the outcomes of sleep, fatigue, work performance, injury, psychosocial stress, and chronic disease. Although observational studies provide useful information about associations between potential risk factors and outcomes, study variables can be controlled to evaluate an intervention in experimental studies and results could form a basis for mitigation strategies. The depth and breadth of the literature identified in this scoping review varied across the occupations (FFs, WFFs, LEOs, COs, and EMS). FFs, LEOs, EMS, and WFFs were the most studied, followed by COs. Only 12% (n = 25) of the identified articles described mitigation strategies or interventions, calling attention to the need for more evaluation research to reduce the adverse effects of working hours, sleep, and fatigue in the public safety sector. Based on the selected literature, we offer the following research priorities for each public safety occupation.

4.1 | Fire service

Fire-fighting activities take a physical toll on FFs with repercussions such as SCD, acute and chronic injuries, depletion of sleep, and potential mental health outcomes such as depression and PTSD.[46,48,53,55,90,97] Studies of FF cardiac performance can offer critical information for interventions that may effectively address modifiable CVD risk factors (e.g., high blood pressure, high cholesterol, poor diet, or sedentary lifestyle) within the occupational climate.[38,55,57,76,77,102] Sleep disorders have been associated with a host of adverse outcomes in FFs including motor vehicle crashes, CVD, diabetes, depression, anxiety, and burnout.[35,125] Expert-led sleep health education and sleep disorders screening programs have demonstrated that FFs are willing to seek clinical evaluations and these programs have led to reduction in injury outcomes.[36,110] Interventions to improve sleep may also help prevent declines in cognitive function that could impair work performance and possibly result in an on-duty injury.[78,109,208] Effective sleep hygiene interventions are also

needed to minimize the detrimental effects of shiftwork and circadian rhythm disruption. Research is also needed on the role that fatigue plays in incident investigations and the contribution of secondary employment to that fatigue.

4.2 | Law enforcement

Significant advances have been made over the past decade in policing scholarship relevant to sleep, shiftwork, fatigue, and long work hours. The work of Violanti et al.[177] in particular has associated shiftwork with increased risk of cardiovascular disease and metabolic syndrome. In addition to the negative health impacts of shiftwork, long work hours, sleep restriction, and fatigue, performance degradation has also been observed. For example, driving performance of LEOs may be impaired under sleep restricted and fatigued states,[150] which has clear safety implications for both LEOs and the public at large. Mitigation strategies addressing these concerns have begun, with studies investigating optimal shift lengths[127] and evaluating fatigue risk-management training interventions.[151] For example, James et al.[151] found that a fatigue risk-management training intervention resulted in significant increases in police participants' selfreported ratings of sleep, health, and wellness. Despite these advances, significant research gaps remain. Randomized control trials evaluating potential mitigation strategies are needed to identify ways to reduce police fatigue and limit the risk of long-term health and wellness problems as well as performance decrements on the job. In addition, once there is evidence behind potential mitigation strategies, determining how to best promote and deliver these practices in law enforcement agencies of all sizes will be pivotal to moving research into practice.

4.3 | EMS

Results from our review show that, research is needed to clarify the unique challenges with sleep, fatigue, and shiftwork in the EMS occupation. Research gaps include: (1) observational studies that characterize work- and nonwork-related factors linked to sleep health and workplace fatigue; (2) prospective or longitudinal studies on the relationships between exposure to diverse shiftwork schedules and worker health or safety; and (3) experimental studies that test known or novel interventions that may improve sleep health and/or mitigate fatigue. Future efforts to mitigate fatigue and to improve sleep among EMS workers may involve well-designed observational studies as well as experimental research. These new research efforts, where feasible, should involve EMS workers as study participants to increase the availability of direct evidence. This type of evidence will increase awareness of work-related dangers in prehospital care and provide vital information to tailor interventions to the unique characteristics of EMS work.

4.4 | Wildland firefighting

Because WFFs work in extreme environments and travel across the country responding to emerging incidents, conducting research is difficult. Published research examining WFF sleep, injuries, fatalities, nutrition, and work demands is sparse, and even less is known about psychosocial stress outcomes.[63] After large destructive fires in Australia, volunteer FFs continued to report psychological morbidity 7 years later, indicating long-term impacts on mental health.[52] The wildland fire environment includes many risks and hazards including fire entrapments, heat-related illnesses and injuries, vehicle-related injuries, falls,

falling trees and rocks, and exposure to smoke and noise.[43] WFFs may be at increased risk for these events due to psychosocial stress, inadequate sleep, fatigue, and long work hours, but research is lacking.[33] Additional research is also needed to understand how these risks impact long-term health conditions and how to improve WFF health and wellness.

4.5 | Corrections

The body of literature on working hours, sleep, and fatigue of COs remains sparse. Several studies have established that COs generally experience poor sleep[153] with those who have PTSD symptomatology reporting a greater degree of sleep difficulty.[132,154] A connection has been made[142] between CO fatigue and impaired performance—inability to monitor inmates and remain attentive on the job—however, considerably more research is needed to understand the depth and impact of sleep restriction, fatigue, and shiftwork on CO health, safety, and performance. CO work ranks among one of the most dangerous in terms of injury rates and researchers should find ways to prevent burnout and ultimate staffing shortages among this under-researched group. A significant research gap exists regarding interventions to promote CO sleep, health, and wellness. Much like in policing, successful interventions that promote CO health are likely to have subsequent impacts on overall safety and performance.

These findings and recommendations can contribute to agenda setting for the public safety sector—including professional organizations, employers, unions, researchers, and the workers themselves. This study agenda could include health and safety concerns, pilot testing of survey instruments or educational and safety training materials, dissemination of research findings, development of next steps for research translation, and identification of research and practices from other professions that may be useful in public safety. Additional research on working hours, sleep, and fatigue is essential to reduce the pervasive risk for illness, injury, and other adverse outcomes in public safety sector occupations. Reducing these risks benefits workers most directly, organizations by informing effective practices and reducing costs, and more broadly, the public at large through a more robust and safer workforce.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable–no new data generated.

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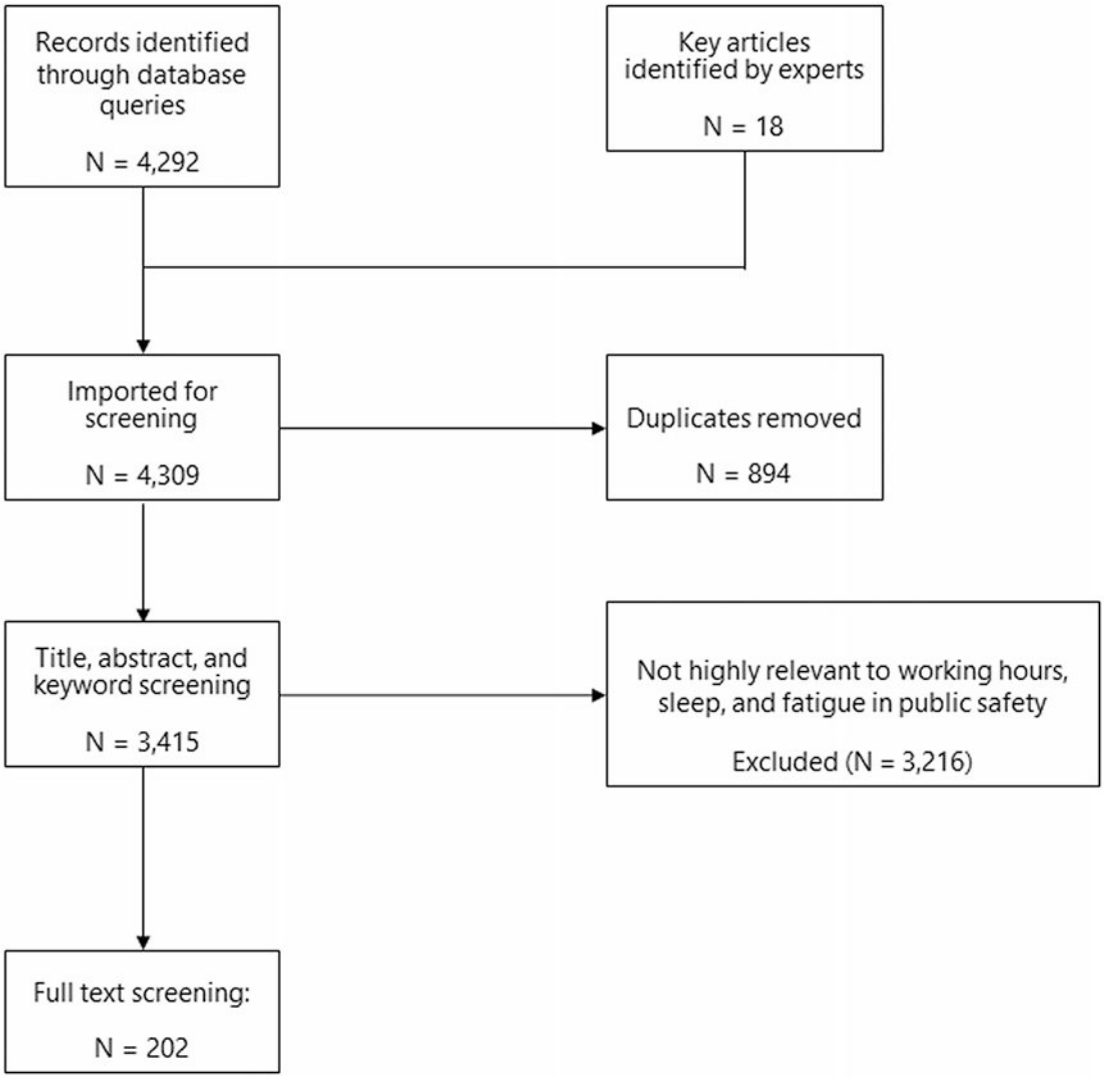

FIGURE 1.
Overview of literature review

TABLE 1

Characteristics of firefighter and wildland firefighter literature

	Occupation	Study type	Study design	Exposure	Outcome
Abbasi et al.[32]	FF	OBS	Cross sectional	Sleep	Injury
Aisbett et al.[33]	WFF	REV	Review	Sleep	Work performance
Banes[34]	FF	REV	Review	FF occupation	Chronic disease
Barger et al.[35]	FF	OBS	Cross sectional	Sleep	Injury, psychosocial stress, chronic disease
Barger et al.[36][a]	FF	OBS	Cross sectional	Sleep health education and sleep disorders screening	Sleep
Baur et al.[37]	FF	OBS	Cross sectional	Body mass index	Chronic disease
Baur et al.[38]	FF	OBS	Cross sectional	Cardiorespiratory fitness	Chronic disease
Belleville et al.[39]	WFF	OBS	Cross sectional	Natural disaster	Psychosocial stress
Belval et al.[40][a]	WFF	OBS	Modeling, simulation	Working hours	Fatigue
Billings and Focht[41]	FF	OBS	Cross sectional	Working hours	Sleep
Britton et al.[42]	WFF	OBS	Cross sectional	Job assignment	Injury
Britton et al.[43]	WFF	OBS	Cross sectional	Mechanism of injury	Injury
Broyles et al.[5]	WFF	OBS	Cross sectional	WFF occupation	Injury
Butler et al.[44]	WFF	OBS	Descriptive	WFF occupation	Mortality
Butler et al.[6]	WFF	OBS	Descriptive	WFF occupation	Mortality
Carey and Thevenin[45]	FF	OBS	Prospective pilot study	On-duty fire and medical calls	Chronic disease
Carey et al.[46]	FF	OBS	Descriptive	FF occupation	Sleep, psychosocial stress
Carey et al.[47]	FF	QEXP	Pretest-posttest	Firehouse environmental stimuli	Chronic disease, sleep
Choi et al.[19]	FF	OBS	Cross sectional	Working hours	Chronic disease
Choi et al.[48]	FF	OBS	Cross sectional	Working hours	Sleep, psychosocial stress
Cowen[49][a]	FF	QEXP	Pretest-posttest	FF occupation	Psychosocial stress
Cvirn et al.[50]	WFF	EXP	Randomized controlled trial	Sleep restriction, heat, physical activity	Sleep
Daniels et al.[51]	FF	OBS	Retrospective cohort	FF occupation	Mortality
Doley et al.[52]	WFF	OBS	Repeated measures	Coping	Psychosocial stress
Drew-Nord et al.[53]	FF	REV	Review	FF occupation	Chronic disease

	Occupation	Study type	Study design	Exposure	Outcome
Drew-Nord et al.[54]	FF	OBS	Cross sectional	Cardiopulmonary fitness testing	Chronic disease
Farioli et al.[55]	FF	OBS	Retrospective cohort	FF occupation	Chronic disease
Ferguson et al.[56]	WFF	EXP	Randomized controlled trial	Wildfire tasks	Fatigue
Fernhall et al.[57]	FF	QEXP	Pretest-posttest	FF training exercise	Chronic disease
Games et al.[58][a]	FF	EXP	Randomized controlled trial	Heat and ambient temperature	Injury
Gendron et al.[59]	FF	OBS	Cross sectional	Physical training	Chronic disease
Giuliani et al.[60]	FF	OBS	Cross sectional	Change in muscle strength, individual characteristics	Fatigue
Gordon and Lariviere[61]	WFF	OBS	Cross sectional	Physical and psychological factors	Injury
Greenlee et al.[62]	FF	OBS	Cross sectional	FF activities, heat stress	Work performance, psychosocial stress
Groot et al.[63]	WFF	REV	Systematic Review	WFF occupation	Psychosocial stress, chronic disease
Haddock et al.[64]	FF	OBS	Descriptive	Alcohol use	Psychosocial stress, chronic disease
Haddock et al.[65]	FF	OBS	Descriptive	FF occupation	Sleep
Haddock et al.[66]	FF	OBS	Cross sectional	Alcohol use	Psychosocial stress, chronic disease
Hall et al.[67][b]	FF, EMS	EXP	Within-subject	Alarm, mobilization	Psychosocial stress
Hall et al.[68][b]	FF, EMS	EXP	Within-subject	Working hours	Psychosocial stress
Hall et al.[69][b]	FF, EMS	OBS	Repeated measures	Working hours	Psychosocial stress
Horn et al.[70]	FF	OBS	Repeated measures	Fatigue	Injury
Jahnke et al.[71]	FF	QUAL	Qualitative	FF occupation	Sleep, injury, psychosocial stress, chronic disease
Jahnke et al.[72]	FF	REV	Review	FF occupation	Chronic disease
Jang et al.[73]	FF	OBS	Cross sectional	Working hours	Sleep
Jay et al.[74]	WFF	OBS	Retrospective	Suspected sleep disordered breathing	Sleep, work performance
Jeklin et al.[75]	WFF	OBS	Longitudinal	Working hours	Sleep, fatigue
Jerome et al.[76][a,c]	FF, EMS	QEXP	Feasibility study, intervention	Weight management program	Chronic disease
Korre et al.[77]	FF	OBS	Cross sectional	Body mass index	Chronic disease
Kwak et al.[78]	FF	QEXP	Pretest posttest	Working hours	Work performance
Kaipust et al.[79]	FF	OBS	Cross sectional	Sleep	Injury
Lim et al.[80]	FF	OBS	Cross sectional	Musculoskeletal pain, working hours, psychosocial stress	Sleep

	Occupation	Study type	Study design	Exposure	Outcome
Lim et al.[81]	FF	OBS	Repeated measures	Working hours	Psychosocial stress
MacDermid et al.[82]	FF	OBS	Cross sectional	Working hours	Work performance
Makara-Studzinska et al.[83]	FF	OBS	Cross sectional	Perceived stress	Psychosocial stress
Marks et al.[84]	WFF	OBS	Cross sectional	Working hours	Work performance
McNamara et al.[85]	WFF	OBS	Cross sectional	Particulate matter	Chronic disease
McGillis et al.[86]	WFF	OBS	Cross sectional	Nonfire and fire deployment	Sleep, fatigue
Meina et al.[87][a]	FF	OBS	Repeated measures	FF occupation	Psychosocial stress
Min et al.[88]	FF	OBS	Cross sectional	Working hours	Chronic disease
Moore et al.[89][a]	WFF	EXP	Double-blinded cross-over	Glutamine supplement	Fatigue
NFPA[4]	FF	DESC	Descriptive	FF occupation	(Fire department profile)
NFPA[90]	FF	DESC	Descriptive	FF occupation	Injury
NWCG[91]	WFF	DESC	Descriptive	WFF occupation	Mortality
NWCG[92]	WFF	DESC	Descriptive	WFF occupation	Mortality
Nava et al.[93][a]	WFF	EXP	Double-blinded crossover	Glutamine supplement	Fatigue
Navarro et al.[94]	WFF	OBS	Observational	Wildfire smoke exposure	Chronic disease
Park et al.[95]	FF	EXP	Randomized controlled trial	Fatigue	Injury
Parker et al.[96][a]	WFF	OBS	Field study	WFF occupation	Work performance
Paterson et al.[97]	FF	QUAL	Qualitative	Fire alarm response	Sleep
Pau et al.[98]	FF	QEXP	Pretest-posttest	Fatigue	Injury
Poplin et al.[99][a]	FF	OBS	Longitudinal	Risk management program	Injury
Riedel et al.[100]	FF	OBS	Retrospective	Working hours	Injury
Riedel et al.[101]	FF	OBS	Retrospective	Working hours	Injury
Sheaff et al.[102]	FF	OBS	Cross sectional	Physiological characteristics	Work performance, chronic disease
Smith[103]	FF	OBS	Descriptive	FF occupation	Chronic disease
Smith et al.[104]	FF	REV	Review	FF occupation	Chronic disease
Smith et al.[105]	FF	OBS	Cross sectional	Psychosocial stress, sleep	Alcohol use
Smith et al.[106]	FF	OBS	Cross sectional	Alcohol use, distress tolerance	Sleep
Smith et al.[107]	FF	OBS	Cross sectional	Work stress, work-family conflict	Psychosocial stress

	Occupation	Study type	Study design	Exposure	Outcome
Stanley et al.[108]	FF	OBS	Cross sectional	FF occupation	Psychosocial stress
Stout et al.[109]	FF	QEXP	Pretest posttest	Sleep	Work performance
Sullivan et al.[110][a]	FF	EXP	Prospective randomized, field-based intervention	Sleep health program	Injury
Suyama et al.[111]	FF, LEO, EMS	OBS	Cross sectional	Public safety occupation	Injury
Taylor et al.[112]	FF	EXP	Repeated-measures experimental	Physiological burden of PPE	Injury
The5ftfirefighter[10]	WFF	DESC	Descriptive	WFF occupation	Work environment
Touitou et al.[16]	FF	REV	Review	FF occupation	Work performance
Vincent et al.[113]	WFF	EXP	Randomized controlled trial	Sleep	Work performance
Vincent et al.[114]	WFF	OBS	Cross sectional	Work schedule	Fatigue, sleep
Vincent et al.[115]	WFF	OBS	Cross sectional	Work schedule	Sleep
Vincent et al.[116]	WFF	OBS	Cross sectional	Work schedule	Work performance
Vincent et al.[117]	WFF	EXP	Randomized controlled trial	Sleep, ambient heat	Work performance
Vincent et al.[118]	WFF	EXP	Random allocation	Sleep	Work performance
Vincent et al.[119]	WFF	REV	Review	WFF occupation	Sleep
Wolkow et al.[120]	WFF	EXP	Randomized controlled trial	Sleep	Psychosocial stress
Wolkow et al.[121]	WFF	EXP	Randomized controlled trial	Sleep	Chronic disease
Wolkow et al.[122]	WFF	EXP	Randomized controlled trial	Sleep	Psychosocial stress
Wolkow et al.[123]	WFF	EXP	Randomized controlled trial	Sleep	Psychosocial stress
Wolkow et al.[124]	WFF	EXP	Randomized controlled trial	Sleep	Psychosocial stress
Wolkow et al.[125]	FF	OBS	Cross sectional	Sleep	Psychosocial stress
Yook et al.[126]	FF	OBS	Cross sectional	Occupational stress	Sleep, chronic disease

Note: The occupational titles in our search were largely based on American vernacular to focus on working populations in the United States, although relevant international literature was also identified and included.

Abbreviations: DESC, descriptive; EXP, experimental; FF, firefighter; NFPA, National Fire Protection Association; NWCG, National Wildfire Coordinating Group; OBS, observational; QEXP, quasi-experimental; QUAL, qualitative; REV, review; WFF, wildland firefighter.

[a] Study describes mitigation strategies and/or interventions.

[b] Participants were FFs and EMS. The respective percentages are unknown.

[c] Participants were 80% FFs and 20% EMS.

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[d] Participants were 45% FFs, 45% LEOs, and 10% EMS.

TABLE 2

Characteristics of law enforcement officer and correctional officer literature

	Occupation	Study type	Study design	Exposure	Outcome
Amendola et al.[127][a]	LEO	EXP	Randomized block	Working hours	Sleep, fatigue, work performance, psychosocial stress, chronic disease
Andersen and Papazoglou[128]	LEO	REV	Review	LEO occupation	Psychosocial stress
Angehrn et al.[129][b]	LEO	OBS	Cross sectional	Sleep	Psychosocial stress
Boivin et al.[130][a]	LEO	EXP	Longitudinal	Phototherapy, shielding from morning light, regular sleep/darkness episode in day	Sleep
Bringas-Molleda et al.[131]	CO	OBS	Cross sectional	Psychosocial stress	Psychosocial stress
Brower[132]	CO	REV	Review	CO occupation	Sleep, psychosocial stress
Buden et al.[133]	CO	OBS	Cross sectional	Working hours	Chronic disease
Burnett et al.[134]	LEO	OBS	Cross sectional	Working hours	Psychosocial stress
Charles et al.[135]	LEO	OBS	Longitudinal	Working hours	Chronic disease
Charles et al.[136]	LEO	OBS	Cross sectional	Working hours	Chronic disease
Christopher et al.[137][a]	LEO	EXP	Randomized controlled trial	Mindfulness training	Psychosocial stress
Dietch et al.[138][c]	LEO	OBS	Longitudinal	Occupational trauma	Sleep, psychosocial stress
Elliott and Lal[139]	LEO	OBS	Cross sectional	Working hours	Chronic disease
Everding et al.[140]	LEO	OBS	Cross sectional	Sleep quality	Fatigue, psychosocial stress, chronic disease
Fekedulegn et al.[141]	LEO	OBS	Cross sectional	Fatigue	Injury
Ferdik and Smith[142]	CO	REV	Review	CO occupation	Work performance
Fikenzer et al.[143]	LEO	OBS	Cross sectional	Risk factors	Chronic disease
Garbarino and Magnavita[144]	LEO	OBS	Prospective cohort study	Occupational stress, sleep	Chronic disease
Garbarino et al.[145]	LEO	REV	Systematic review/meta-analysis	LEO occupation	Sleep
Grant et al.[146]	LEO	OBS	Cross sectional	LEO occupation	Psychosocial stress
Grupe et al.[147][a]	LEO	QEXP	Feasibility study, intervention	Mindfulness training	Psychosocial stress
Hartley et al.[148]	LEO	OBS	Cross sectional	LEO occupation	Chronic disease
Holst et al.[149]	LEO	OBS	Cross sectional	Working hours	Chronic disease
James and Vila [150]	LEO	EXP	Controlled experiment	Working hours, fatigue	Work performance

	Occupation	Study type	Study design	Exposure	Outcome
James et al.[151][a]	CO	QEXP	Pretest posttest	Fatigue management training	Sleep
James et al.[152]	LEO	OBS	Repeated measures	Distracted driving	Work performance
James et al.[153]	CO	OBS	Cross sectional	CO occupation	Sleep
James et al.[154]	CO	OBS	Cross sectional	CO occupation	Psychosocial stress
Koshy et al.[155]	LEO	OBS	Longitudinal	Working hours	Sleep
Kuehl et al.[156][a]	LEO	EXP	Randomized prospective trial	Health and safety program	Sleep, injury, chronic disease
Lees et al.[157]	LEO	REV	Systematic review	LEO occupation	Sleep, fatigue, psychosocial stress
Ma et al.[18]	LEO	OBS	Cross sectional	Sleep	Chronic disease
Ma et al.[158]	LEO	OBS	Cross sectional	Occupational stress	Sleep
Ma et al.[159]	LEO	OBS	Cross sectional	Sleep	Chronic disease
Ma et al.[160]	LEO	OBS	Cross sectional	Sleep	Chronic disease
Monaghan et al.[161][a]	LEO	EXP	Randomized, blinded, crossover	Energy beverage	Work performance
NLEOMF[162]	LEO	DESC	Descriptive	LEO occupation	Injury
Neil-Sztramko et al.[163]	LEO	REV	Review	Working hours	Chronic disease
Peterson et al.[164]	LEO	OBS	Cross sectional	Working hours, sleep	Psychosocial stress
Purba and Demou [165]	LEO	REV	Systematic review	LEO occupation	Psychosocial stress
Rajaratnam et al.[166]	LEO	OBS	Cross sectional and longitudinal	Sleep	Work performance
Ramey et al.[167]	LEO	OBS	Cross sectional	Perceived stress, vital exhaustion	Chronic disease
Ramey et al.[168]	LEO	OBS	Cross sectional	Working hours	Sleep
Ramey et al.[169]	LEO	OBS	Cross sectional	Working hours, perceived stress	Chronic disease
Riedy et al.[170]	LEO	OBS	Longitudinal	Working hours, sleep, fatigue	Work performance
Riedy et al.[171]	LEO	OBS	Modeling, repeated measures	LEO occupation	Sleep
Senjo[20]	LEO	OBS	Triangulated (data, surveys, personal interviews)	Working hours	Fatigue
Swenson et al.[172]	CO	REV	Review	CO occupation	Sleep, fatigue, work performance
Taylor et al.[173]	LEO	OBS	Repeated measures	Working hours	Sleep, work performance
Tiesman et al.[174]	LEO	OBS	Retrospective	LEO occupation	Injury
Torres and Kim[175]	LEO	REV	Review	LEO occupation	Work performance
Vena et al.[176]	LEO	OBS	Retrospective cohort mortality	LEO occupation	Chronic disease

	Occupation	Study type	Study design	Exposure	Outcome
Violanti et al.[177]	LEO	OBS	Cross sectional	Working hours	Chronic disease
Violanti et al.[178]	LEO	OBS	Retrospective	Working hours	Injury
Violanti et al.[179]	LEO	OBS	Retrospective	Working hours	Injury
Waggoner et al.[180]	LEO	OBS	Cross sectional	Working hours	Work performance
Wirth et al.[181]	LEO	REV	Review	LEO occupation	Chronic disease
Zimmerman[182]	LEO	REV	Review	LEO occupation	Chronic disease

Note: The occupational titles in our search were largely based on American vernacular to focus on working populations in the United States, although relevant international literature was also identified and included.

Abbreviations: CO, correctional officer; DESC, descriptive; EXP, experimental; LEO, law enforcement officer; NLEOMF, National Law Enforcement Officers Memorial Fund; OBS, observational; QEXP, quasi-experimental; REV, review.

[a] Study describes mitigation strategies and/or interventions.

[b] Participants were 52% law enforcement officers, 15% firefighters, 14% correctional workers, 14% paramedics, and 5% communications officials.

[c] Participants were 63% current or former police. Other participants were World Trade Center responders not identified by occupation.

TABLE 3

Characteristics of emergency medical services literature

	Occupation	Study type	Study design	Exposure	Outcome
Bentley et al.[183]	EMS	OBS	Cross-sectional, case–control analysis	Work in EMS	Psychosocial stress
Buleon et al.[184][a]	EMS	EXP	Randomized controlled crossover	Real-time feedback device on chest compression	Work performance
Cash et al.[185]	EMS	OBS	Cross sectional	EMS certification level	Sleep, psychosocial stress
Dawson et al.[186]	EMS	REV	Review	EMS occupation	Sleep, fatigue
Donnelly et al.[187]	EMS	OBS	Cross sectional	Working hours, fatigue	Work performance, injury
Fjeldheim et al.[188]	EMS	OBS	Cross sectional	Risk and resilience factors	Psychosocial stress
Flaa et al.[189]	EMS	OBS	Repeated measures	Working hours	Sleep
Guyette et al.[190]	EMS	QEXP	Pretest-posttest	Working hours	Fatigue, work performance
Khan et al.[191]	EMS	OBS	Cross sectional	Working hours	Sleep, psychosocial stress
Kovic et al.[192][a]	EMS	EXP	Randomized crossover trial	CPR device	Fatigue
Maguire and Smith[193]	EMS	OBS	Retrospective cohort	EMS occupation	njury
Martin-Gill et al.[194]	EMS	REV	Systematic review/meta-analysis	EMS occupation	Sleep, fatigue, work performance, injury, chronic disease
Neufeld et al.[195]	EMS	OBS	Cross sectional	Working hours	Chronic disease
Nosker et al.[196]	EMS	OBS	Validation study	EMS occupation	Fatigue
Patterson et al.[13]	EMS	OBS	Cross sectional	EMS occupation	Sleep, fatigue
Patterson et al.[12]	EMS	OBS	Cross sectional	Sleep, fatigue	Work performance, injury
Patterson et al.[197][a]	EMS	OBS	Cross sectional	Working hours	Sleep, fatigue
Patterson et al.[14][a]	EMS	EXP	Randomized controlled trial	Text-message fatigue reduction tool	Fatigue
Patterson et al.[198][a]	EMS	REV	Review	EMS occupation	Fatigue
Patterson et al.[199]	EMS	REV	Systematic review	EMS occupation	Fatigue
Patterson et al.[11]	EMS	REV	Systematic review	EMS occupation	Fatigue
Patterson et al.[200]	EMS	REV	Systematic review	EMS occupation	Fatigue
Patterson et al.[201][a]	EMS	EXP	Randomized controlled trial	Text-message fatigue reduction tool	Fatigue
Patterson et. al.[202]	EMS	OBS	Prospective observational cohort	Working hours	Work performance
Patterson et al.[203]	EMS	REV	Systematic review/meta-analysis	EMS occupation	Chronic disease

	Occupation	Study type	Study design	Exposure	Outcome
Patterson et al.[204]	EMS	OBS	Observational	Working hours	Chronic disease
Reichard et al.[205]	EMS	OBS	Descriptive	EMS occupation	Injury
Shriane et al.[206]	EMS	OBS	Cross sectional	Working hours	Sleep
Studnek et al.[207]	EMS	REV	Systematic review	EMS occupation	Fatigue
Suminska et al.[208] [b]	FF, EMS	OBS	Longitudinal	Working hours	Work performance
Temple et al.[209] [a]	EMS	REV	Systematic review/meta-analysis	EMS occupation	Fatigue
Weaver et al.[210]	EMS	OBS	Retrospective cohort	Working hours	Injury
Weaver et al.[17]	EMS	OBS	Retrospective cohort	Working hours	Injury

Note: The occupational titles in our search were largely based on American vernacular to focus on working populations in the United States, although relevant international literature was also identified and included.

Abbreviations: EMS, emergency medical services; EXP, experimental; OBS, observational; QEXP, quasi-experimental; REV, review.

[a] Study describes mitigation strategies and/or interventions.

[b] Participants were 53% EMS and 47% FFs.