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EMS Sleep Health Study and Webtool for Scheduling

The U.S. emergency medical services (EMS) system is comprised of more than 20,000 EMS agencies and approximately 1 million EMS clinicians. These agencies and clinicians respond to emergencies 24 hours a day, 365 days a year. Those who work in EMS provide time-sensitive medical care for the acutely ill and injured, stabilize patients, and quickly transport and transfer patients to hospital emergency departments. Given that EMS care is provided around the clock, EMS clinicians are deployed in shifts. Shift work typically occurs outside of traditional daylight work schedules, and, for EMS agencies, includes night shifts and long duration shifts such as 12 hours, 24 hours, and, in some locations, 48 hours or longer. In addition, many EMS clinicians work back-to-back shifts, overtime, shifts that rotate between daytime and nighttime, and several jobs.

Large numbers of EMS personnel report poor sleep quality and mental and physical fatigue. The working conditions for many EMS personnel, including shift work, inhibit them from obtaining adequate sleep, prevent them from having a regular bedtime and wake time, and interfere with their ability to obtain sleep that is regular, satisfying, efficient, and of adequate duration. Interference with one or more of these components of sleep can lead to mental and physical fatigue. Fatigue among EMS clinicians is associated with increased odds of injury, patient-related medical errors and adverse events, and workplace injury.

In 2015 NHTSA awarded a contract to the National Association of State EMS Officials to complete a project targeting fatigue in EMS systems. In this project, NHTSA focuses on the mitigation of fatigue for EMS systems, which enhances post-crash care by better ensuring that EMS professionals safely arrive on the scenes of crashes and provide medical care that results in fewer treatment errors. This project has practical implications as, according to NHTSA's Office of EMS, 12,000 EMS agencies responded to 1,436,763 motor vehicle crashes in 2021. In addition, mitigating fatigue is particularly important for emergency vehicle drivers because fatigue associated with long shift hours negatively affects driving performance. The project included three phases. Phase 1 resulted in the report titled *Fatigue in Emergency Medical Services System*, which created evidence-based guidelines (EBGs) focused on fatigue risk mitigation and was tailored to the unique occupational demands and risks encountered by EMS shift workers. The results included five EBGs for fatigue risk mitigation in EMS.

- Reliable and/or valid fatigue and sleepiness survey instruments should be used to measure and monitor fatigue in EMS personnel.
- EMS personnel should work shifts shorter than 24 hours in duration.
- EMS workers should have access to caffeine as a fatigue countermeasure.
- EMS personnel should have the opportunity to nap while on duty to mitigate fatigue.
- EMS personnel should receive education and training to mitigate fatigue and fatigue-related risks.

Phase 2 developed a fatigue mitigation training program for EMS clinicians and then evaluated the training's effect on fatigue as part of a sleep health study. Phase 3, designed to occur simultaneously with Phase 2, tailored an existing biomathematical model for EMS shift scheduling through a web-based tool. Biomathematical models are frequently used in high-risk industries, such as aviation, to inform the timing, duration, rotation, and recovery periods of shift schedules. This Traffic Tech highlights the results of the Phase 2 and 3 efforts (see Final Reports).

EMS Sleep Health Study

The sleep health study used a cluster-randomized, wait-list control (WLC) study design to evaluate the impact of a novel education and training program tailored to EMS clinician shift workers. Randomization occurred at the agency level with each agency assigned to either immediate access to the intervention (IAI) or WLC. While clinicians in agencies randomized to the IAI group received immediate access to the intervention material, those randomized to the WLC group gained access at 3 months post-randomization. The study lasted 6 months. Open enrollment for EMS agencies began February 2020, paused from March 2020 to June 2020 due to the COVID-19 pandemic, and concluded December 2020. Open enrollment for EMS clinicians within agencies closed 30 days after agency randomization.

The researchers designed and produced a training program comprised of 10 brief education modules. The modules ranged from 10 to 16 minutes each with an average of 13 minutes, for total training of about 2 hours. The topics of each module are listed below.

- Hazards of Fatigue
- Sleep Physiology
- Sleep Health
- Work-Related Stress
- Sleep Disorders
- Fatigue Recognition
- Adequate Sleep
- Diet and Exercise
- Alertness Strategies
- Managing Fatigue

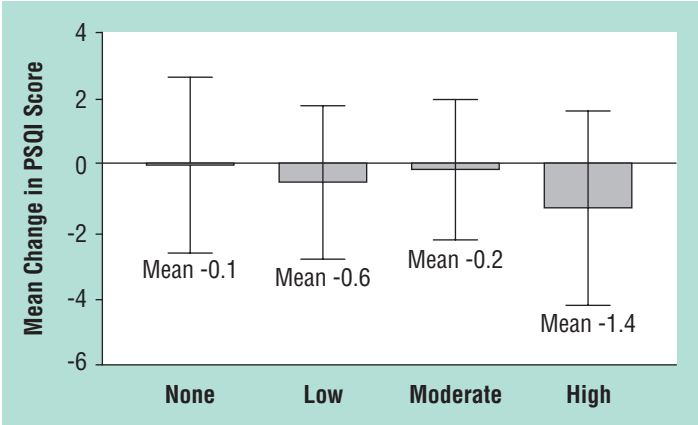
Of the 54 EMS agencies screened, 48 were eligible, and 36 were enrolled. Researchers randomly assigned agencies to the IAI or WLC group. In total, 678 people, 316 from the 16 IAI agencies and 362 from the 20 WLC agencies, completed the enrollment process. Most of the enrolled EMS agencies employed 51 to 199 employees, reported 20,000 or more dispatches in 2019, and did not have formal fatigue risk management programs. Of the 678 EMS clinicians enrolled, 94% (640) completed the baseline survey. Over the 6-month study period, the study experienced a 37% (251) attrition rate.

When examining participant data based on their initial group assignment, the mean scores on the main dependent variable, the Pittsburgh sleep quality index (PSQI), a measure of sleep quality, did not differ by IAI or WLC group status at either the 3- or 6-month followup. Similarly, other measures of fatigue and related attitudes did not differ by IAI or WLC group status at the 3- or 6-month followup.

In a separate analysis, study participants were identified based on their adherence to the study protocol. Participants were divided into different degrees of adherence as defined by the number of modules viewed: Low (1 to 3), Moderate (4 to 7), and High (8 to 10). Comparing adherence independent of group assignment, module viewing was associated with an improvement (decrease) in the mean PSQI sleep quality score at 3-month followup ($p = 0.02$). Compared to participants who viewed no modules, participants in the High module-viewing category experienced the greatest improvement (decrease) in PSQI-measured sleep quality (overall $p = 0.00$, Bonferroni-corrected $p = 0.01$). At 6-month followup, compared to baseline, module viewing was not associated with a change in PSQI-measured mean sleep quality score ($p = 0.17$).

The aim of this two-arm, experimental research study was to assess the impact of a novel education and training program on indicators of sleep and fatigue among EMS clinician shift workers. While analyses showed that the greater the number of education modules viewed by the 3-month followup, the greater the improvement in sleep quality, this relationship was not significant at the 6-month followup and caution should be taken in interpreting it.

Figure 1. Change in Mean PSQI Score by Module Viewing Category at 3 Months Followup



This study faced limitations. Recruitment, enrollment, and attrition were affected by the COVID-19 pandemic as it led to a pause in recruitment efforts. In addition, sleep duration and sleep patterns of many adults changed during the COVID-19 pandemic, with some participants reporting acquiring more sleep and some reporting acquiring less. Finally, lower adherence to protocol is often reported in intervention studies, yet the reasons can differ. The clinicians who viewed most of the material may have been more motivated or interested than those who did not view most of the material. Although the research has limitations, it provides a promising first step in developing fatigue education programming for the EMS community.

EMS Webtool for Scheduling

As discussed above, EMS clinicians are likely to work night shifts, rotating shifts, extended shift hours, and may have limited time to recover between shifts. EMS clinicians, therefore, experience fatigue due to sleep loss as well as circadian misalignment with respect to biological processes that promote wakefulness and alertness during the day and sleep at night. Fatigue Risk Management Systems (FRMS) apply a variety of procedures and tools to mitigate fatigue in work schedules, including instituting schedule changes or recommending strategic napping to reduce potential fatigue. While there are no regulatory guidelines for managing fatigue risk in an EMS setting, biomathematical modeling could serve as a helpful fatigue-mitigating tool in the institution of an EMS-specific FRMS.

Biomathematical models consider factors related to fatigue, such as sleep, time of day, and work schedule, to produce an estimate of performance and alertness that can be useful when making decisions about shift scheduling. The Sleep, Activity, Fatigue, and Task Effectiveness – Fatigue Avoidance Scheduling Tool (SAFTE-FAST) is a computer application derived from a biomathematical model that permits the processing of individual schedules. It is useful for examining proposed schedules to determine vulnerabilities and generates

graphical predictions of performance for objective comparison. SAFTE-FAST has been calibrated for fatigue risk estimation in a range of operational industries, including the military, transportation, and healthcare. SAFTE-FAST was calibrated using objective sleep and work data from EMS clinicians for the purposes of developing fatigue risk levels and effectiveness predictions for this phase of the project. In a separate study, 37 EMS clinicians reported to the University of Pittsburgh's Department of Emergency Medicine the duration of their previous night's sleep and used wrist-worn actigraphy devices to track sleep and activity over the course of one work shift.

This phase of the project developed a webtool that used the SAFTE-FAST predictions to examine proposed schedules for fatigue, which is quantified as effectiveness. Effectiveness is an estimate of performance based on reaction time speed, wherein 100% effectiveness corresponds to a fully rested person's normal best performance. Lower percent effectiveness is related to greater fatigue risk. An effectiveness score of 77% is equivalent to 18.5 hours of continued wakefulness and is associated with a 30% increase (delay or worsening) in reaction time. The Federal Aviation Administration uses 77% as a lower threshold for determining low risk. An effectiveness score of 70% is equivalent to 21 hours of continued wakefulness. The Federal Railroad Administration uses 70% as a threshold for determining fatigue.

Within the webtool, users select information for each required field in a toolbar. Once all fields have been entered, a risk level with options to see details auto-populates below the input bar along with another empty toolbar in case users wish to enter another schedule. The input categories include Shift Start Time, Shift Duration, Commute Time, Days on Duty, Days off Duty, Number of Shift Repeats, and whether Napping Is Permitted. When expanded, the output includes a breakdown of risk levels across all schedule repeats as risk may change over time. The output also includes the average effectiveness and minimum effectiveness of the overall schedule. Minimal risk overall indicates minimum effectiveness greater than 77%. Low risk indicates minimum effectiveness between 70 and 77%. Medium risk indicates minimum effectiveness is less than 70% for less than 20% of the entire shift, and high risk indicates effectiveness less than 70% for more than 20% of the shift. For schedules with a moderate or high overall risk level, a set of recommendations based on the specific features of the schedule populates below the additional analysis.

A beta test of the webtool user interface was conducted during the final stages of development of the webtool. The goal was to evaluate how well the webtool worked technically and to get feedback from a sample of intended users. Four beta testers provided feedback on usefulness and ease of use. The testers found the webtool easy to understand, but they were impatient with the number of steps required to get results. The testers wanted more flexibility in schedule input options and less instructions or text in the results. This feedback informed changes to the tool. The tool is currently available online at: https://emsfatiguerisk.ibrinc.org/.

Conclusion

While fatigue in EMS remains an important issue, this project produced three products that could be used to develop or inform EMS-specific FRMS: EBGs, a training program that shows promise in reducing fatigue, and a webtool to help reduce fatigue through scheduling. These components alone would not be a replacement for an effective FRMS, but they may help raise awareness of fatigue issues as well as highlight the relationship between shift scheduling and fatigue. Additionally, further development and refinement of the training and scheduling tool could improve effectiveness, and more wide-scale dissemination and evaluation could help reduce fatigue in EMS.

Final Reports

Devine, J. K., Hursh, S. R., & Brown, B. (2022, December). *Developing a webtool for fatigue in emergency medical services scheduling* (Report No. DOT HS 813 390). National Highway Traffic Safety Administration.

Patterson, P. D., Martin, S. E., Weaver, M. D., Brassil, B. N., Hsiao, W. H., Okerman, T. I., Seitz, S. T., Patterson, C. G., Messina, O. R., Herbert, B. M., & Robinson, K. (2022, December). *The emergency medical services sleep health study* (Report No. DOT HS 813 391). National Highway Traffic Safety Administration.

Patterson, P. D., & Robinson, K. (2019, August). *Fatigue in emergency medical services systems* (Report No. DOT HS 812 767). National Highway Traffic Safety Administration. https://rosap.ntl.bts.gov/view/dot/42185

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