Wake-Up

Call

Toward an Industrial Hygiene Approach to Work-Related Fatigue

BY IMELDA WONG

Work-related fatigue has been estimated by the National Safety Council to cost employers approximately $151 billion annually in reduced productivity related to sleep deficiencies, sleep disorders, and shift work. However, this is just a fraction of the true cost, as chronic sleep deprivation and nonstandard work schedules have been linked with increased risk of depression, obesity, cardiovascular disease, cancer, and other illnesses with ultimate effects on work productivity, worker health, and safety. Fatigue can slow reaction times, reduce attention or concentration, limit short-term memory, and impair judgment, increasing the risk for fatigue-related incidents such as work injuries. Work-related fatigue can also have a devastating public safety impact, particularly in occupations with high-risk consequences. For example, the nuclear meltdown at Three Mile Island and the grounding of the Exxon Valdez oil tanker are two major disasters in which human fatigue was cited as a contributing factor. On a more frequent scale, tired workers drive on public roads, raising public health and safety concerns. Specifically, drowsy driving increases the risk for motor vehicle crashes by 250 percent and results in $109 billion in societal costs every year due to fatalities and injuries from fatigue-related crashes (see publications from *SLEEP* and the Governors Highway Safety Association, listed under "Resources" on page 29).

Overnight, rotating, or irregular shifts; long work hours; and resulting sleep impairment or disruption often contribute to work-related fatigue. It has been estimated that almost 30 percent of U.S. workers are employed in schedules that are outside a "regular daytime shift" and 37 percent of workers get less than the recommended seven hours of sleep (see data from NIOSH Worker Health Charts and a consensus statement published in the *Journal of Clinical Sleep Medicine* in the "Resources" section). According to research published in *Occupational and Environmental Medicine*, while just over 50 percent of night shift workers report not getting sufficient sleep, almost 33 percent of day shift workers also report obtaining less than seven hours of sleep per night—numbers that suggest this problem can affect any worker, regardless of work schedule.

A survey of causes and consequences of employee fatigue published by the National Safety Council found that 43 percent of U.S. workers do not get enough sleep such that it affects their ability to perform critical tasks, which can affect not only their safety at work but also that of their coworkers. The same survey found that 90 percent of employers felt that work-related fatigue had negatively impacted their organizations in terms of reduced productivity and absenteeism. Half of surveyed employers reported they would adjust an employee's schedules or tasks to reduce the risk of fatigue-related, safety-critical events. However, more than 70 percent said that they typically issue a warning or disciplinary action, suggesting that workplace mitigation strategies for fatigue may more often involve reactive, punitive measures rather than prescriptive or preemptive organizational control strategies.

Fatigue is pervasive and nondiscriminating, potentially affecting any worker at any job in any organization. However, despite its high prevalence and increased risk of severe and widespread adverse occupational health and safety consequences, fatigue is not treated with the same industrial hygiene approach as other workplace hazards.

A UNIQUE AND COMPLICATED HAZARD

On the surface, work-related fatigue may appear to be simple to address and mitigate. Fatigue is multifaceted and can stem from various work and nonwork factors. In the occupational realm, we are familiar with factors such as work schedules, workload, and work intensity, but there are factors specific to individuals, such as age, that can also have a significant effect on fatigue at work. Life or lifestyle factors such as commuting or caring for dependents can be additional stressors and require extra time from already busy days.

A common strategy to mitigate work-related fatigue is to change hours of work or encourage workers to get enough sleep. However, work-related fatigue is complicated and poses several challenges to address from an industrial

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hygiene perspective. Several factors can contribute to fatigue, which makes it difficult to quantify or evaluate with a single standard measure. Unlike work hazards like chemical or biological exposures, there are no threshold levels, making it difficult to determine "how much is too much." An article published in 2017 in *Consulting Psychology Journal: Practice and Research* finds that among the biggest challenges in managing work-related fatigue are the pervasive attitudes perpetuating long work hours and unhealthy sleep beliefs and behaviors, which often emanate from the leadership level. Since there is such a wide variability of these factors across sectors, organizations, and individuals, there is no one consistently effective solution that can fit all situations.

APPLYING THE FOUR TENETS OF IH

An industrial hygiene approach can be used in the anticipation, recognition, evaluation, and control of factors contributing to work-related fatigue to help address these challenges.

Anticipation of a workplace hazard begins with a worksite analysis to identify what activities and areas are susceptible to hazardous conditions. In the case of work-related fatigue, this involves identifying potential sources like work scheduling, job tasks (physically or mentally demanding or monotonous work, for example), and environmental factors such as heat or noise. Discussions with management, safety professionals, and workers within the organization can provide additional information on circumstances surrounding events such as near misses or unreported incidents. Incident reports can also help to identify main contributors of work-related fatigue. Provision of educational resources about sleep and fatigue, such as the NIOSH online training for nurses on shift work and long work hours (available at **bit.ly/niosh nurses**), may help workers recognize sources of fatigue outside of the workplace.

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Recognition of worker fatigue is commonly associated with noticeable physical signs such as nodding off or yawning. However, fatigue risk can be critical long before those signs occur. Loss of concentration, mental lapses, irritability, impaired judgment, or increased propensity for risk-taking behaviors may occur prior to obvious physical signs. Microsleeps, which can last from one to 15 seconds, are also hard to detect not only because of their short duration but the lack of noticeable overt signs. During microsleeps, a person's eyes may remain open, but their brain will not process information. This can result in lapses in attention and increased risk during safety-critical events, particularly when vigilance is needed (while driving, for example). Therefore, recognizing other signs of fatigue may be warranted in the prevention of safety-critical events.

There are a number of ways to **recognize and evaluate** work-related fatigue. The most basic approaches are subjective evaluations with surveys or self-assessments, which are relatively easy and inexpensive to administer. However, as we become more fatigued, our ability to self-assess performance decrements diminishes. To counter this, objective measures such as workplace safety reports can be used to identify scheduling practices, working conditions (for example, hot temperatures), or job tasks (like monotonous work) where there is a higher risk for fatigue-related incidents.

More recently, innovations in fatigue-detection technologies have resulted in a rapid influx of commercially available devices. These devices should be used with caution as many are not scientifically validated; may not work under extreme environmental conditions such as heat, noise, or dust; or may not be accepted by workers. While most fatigue-detection technologies are used in the transportation sector, there are opportunities for adoption in other sectors. For example, predictive technologies such as biomathematical models can identify times of high fatigue risk based on work scheduling rosters. Fitness-for-duty tests, another type of predictive tool for fatigue risk, are based on some biological measure (for example, eye movement) or reaction to a hand-eye coordination test and are usually taken by the worker prior to starting their shift. More recently, continuous, real-time feedback devices can monitor fatigue risk based on driving performance (for example, laneway deviation) or biological measures such as blink rate or brain wave activity. These devices not only alert the worker of high fatigue risk, but some can also alert an off-site safety manager, thereby providing a layered approach to fatigue mitigation. Information regarding considerations for choosing fatigue technologies and tips for implementation is available from recent *NIOSH Science Blog* posts at **bit.ly/nioshfmdt** and **bit.ly/tips fmdt**, respectively.

The most comprehensive systems are hybrid solutions that combine information from existing in-house data sources, such as work schedules or overtime records, with fatigue-detection technologies. These systems are thought to be more effective for recognition and evaluation of fatigue

risk because they account for multiple sources and indicators of fatigue. The few studies based on hybrid solutions have achieved more consistent and accurate outcomes as compared to single-method detection devices (see the 2020 report published by SWOV and research published in the *International Journal of Intelligent Transportation Systems Research* in the "Resources" section). In addition, the use of several different forms of fatigue recognition and evaluation measures can provide a series of backups in the event that one measure fails to detect high fatigue risk. Data collected could be used for multiple purposes such as to predict and alert for times of high fatigue risk, to review for coaching purposes, or to help improve the operating system. The drawbacks of hybrid solutions are that they add layers of complexity and coordination and may increase costs. It may also be difficult or time consuming to interpret all the different sources of information.

To develop fatigue risk **controls**, we need to consider the job tasks for which they will be implemented. For example, a series of control measures would be needed with complex tasks, but simple controls may be warranted for less involved tasks. We also need to distinguish work-related fatigue as either an acute or chronic exposure. Such exposures can vary widely, from responding to emergency situations to years of exposure to night shift work. Identifying this distinction will help determine different occupational health and safety risks and the appropriate control measures, which could range from providing additional resources during times of emergencies to alleviate the strain on workers to establishing health and safety programs to maintain worker health for the duration of job tenure.

Common control measures at the organization level include shift scheduling practices with considerations for job or task rotation; within- and between-shift breaks; and training or education on sleep and fatigue management for workers and employers. Incorporation of fatigue-mitigation strategies should follow the hierarchy of controls as guidance to determine which measures should be considered.

TOWARD A MORE HOLISTIC APPROACH

A guidance statement published in 2012 by the American College of Occupational and Environmental Medicine in the *Journal of Occupational and Environmental Medicine* describes a fatigue risk management system (FRMS) as "a scientifically-based, data-driven addition or alternative to prescriptive hours of work limitations which manage employee fatigue in a flexible manner appropriate to the level of risk exposure and the nature of the operation" (**bit.ly/fatiguejoem**). These comprehensive systems are designed to be a tailored approach for organizations to anticipate and address fatigue risks. An effective FRMS establishes a leadership-driven safety culture and shared responsibility for managing fatigue among employers and workers. Other critical parts of an FRMS are readily accessible policies and procedures, training and education, nonpunitive incident reporting, and regular evaluation so that safety systems can be adjusted to meet changing organizational needs. New research published in *Accident Analysis and Prevention* at **bit.ly/frmsreview** shows that these systems have increasingly become the preferred method of reducing fatigue-related safety-critical events in large organizations and specific industries such as aviation. However, they are not as prevalent in smaller organizations, possibly in part due to their complexity. As more resources and tools—such as the National Safety Council's Fatigue Risk Management Program template—become freely available, organizations can identify systems already in place to manage fatigue as well as areas that may need to be prioritized.

THE FUTURE

While fatigue may be a complex construct, there are many tools available to tailor the anticipation, recognition, evaluation, and control of this hazard among different organizations. By following the basic tenets of the industrial hygiene approach, work-related fatigue can be successfully managed and mitigated, keeping workers healthy, safe, and productive throughout their careers.

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Send feedback to **synergist@aiha.org**.

RESOURCES

Accident Analysis and Prevention: "How Effective Are Fatigue Risk Management Systems (FRMS)? A Review," **bit.ly/frmsreview** (2021).

CDC: NIOSH Worker Health Charts, **bit.ly/nioshwhc2015** (2015).

Consulting Psychology Journal: Practice and Research: "Can't Sleep, Won't Sleep: Exploring Leaders' Sleep Patterns, Problems, and Attitudes" (2017).

Governors Highway Safety Association: "Wake Up Call: Understanding Drowsy Driving and What States Can Do," **bit.ly/ghsa2016** (PDF, 2016).

International Journal of Intelligent Transportation Systems Research: "Driver Drowsiness Measurement Technologies: Current Research, Market Solutions, and Challenges" (2019).

Journal of Clinical Sleep Medicine: "Recommended Amount of Sleep for a Healthy Adult: A Joint Consensus Statement of the American Academy of Sleep Medicine and Sleep Research Society," **bit.ly/jcsmsleep** (2015).

Journal of Occupational and Environmental Medicine: "Fatigue Risk Management in the Workplace," **bit.ly/fatiguejoem** (February 2012).

National Safety Council: "Fatigue in the Workplace: Causes and Consequences of Employee Fatigue" (2019).

NIOSH: "Hierarchy of Controls," **bit.ly/niosh-controls**.

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