Worker Fatigue

Understanding the Risks in the Workplace

By Susan Sawatzky

Fatigue is a risk to worker safety and health. For moderate- and high-risk environments, one can present a strong business case to justify comprehensive management of fatigue risks. OSH management has evolved to a point where proactively managing nonphysical hazards such as fatigue is recognized as good business practice.

So why aren't more organizations in North America effectively managing fatigue as a hazard? To understand the relative inertia in dealing with fatigue, one must understand current barriers and recognize the importance of managing the hazard of fatigue across all levels of operations. Fatigue is a hazard that can exist at the worker level, due to worker health issues or workers who improperly prioritize sleep, and at an organizational level, when fatigue risks are inherent in the scope of operations. Recognizing the different sources of this hazard allows for comprehensive and effective mitigation strategies.

North America is not the first to have recognized or moved toward managing fatigue issues. Thus, myriad proven best practices exist for effectively managing fatigue. Yet, many companies lack an awareness of the need to assess existing risks to proactively manage fatigue using these best practices. Different strategies are needed for low, moderate and high levels of fatigue risk exposure.

Properly managing fatigue in a high-risk environment typically involves multiple levels of control, implemented with strong education and training, to allow for a cultural shift in existing safety management. This shift requires awareness and knowledge at all levels of the organization. It often starts with OSH professionals who understand fatigue issues and develop comprehensive plans to effectively create change.

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How Fatigue Affects Worker Safety

Let's begin by examining how fatigue fits into the world of OSH. Fatigue can create a significant hazard in many workplaces because of the way it affects a worker's ability to safely perform job duties. Fatigue can impair workplace performance in four key areas.

1) **Alertness:** To notice or react to changes in a work environment; to remain vigilant.

2) **Emotional stability:** To remain emotionally calm and stable when dealing with critical situations.

3) **Mental ability:** To remember, think clearly, make decisions and communicate.

4) **Physical ability:** To perform with adequate reaction times and overall coordination.

Short-term effects of fatigue can lead to significant safety hazards as the worker's ability to safely and effectively perform work is impacted. Figure 1 presents examples of physical, mental and emotional effects of short-term fatigue.

OSH professionals can use findings from occupational research on fatigue's impacts to create a strong business case for the need to address

IN BRIEF

- **This article explores how fatigue affects worker safety and health.**
- **The author presents a business case for addressing fatigue in workplaces and barriers to overcome.**
- **Strategies for success in implementing a fatigue risk management system are discussed as well.**

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FIGURE 1
Fatigue Impairs Workplace Performance in Four Key Areas

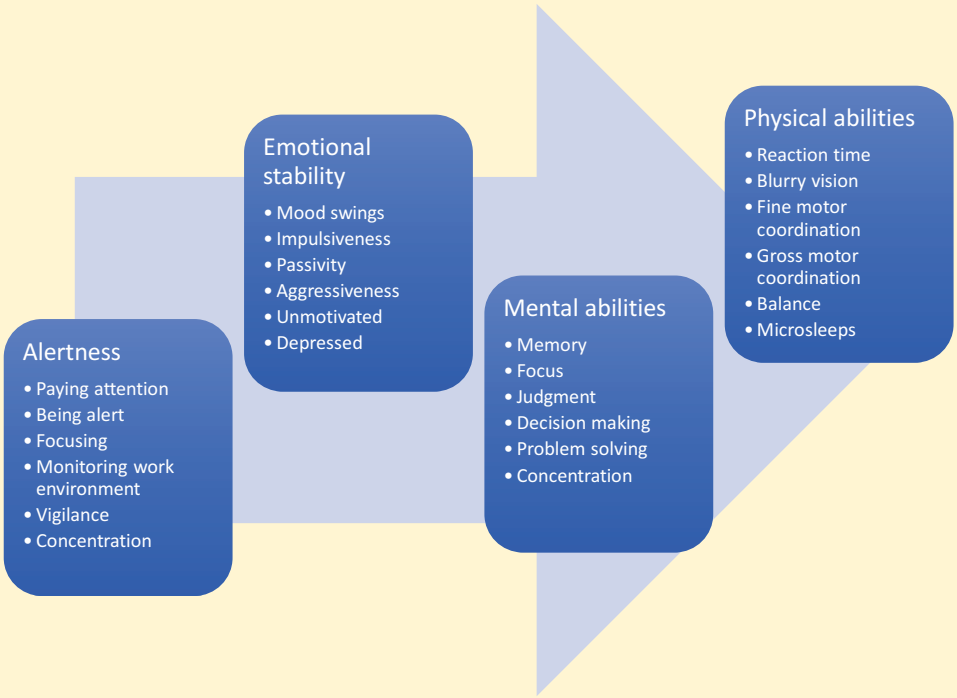
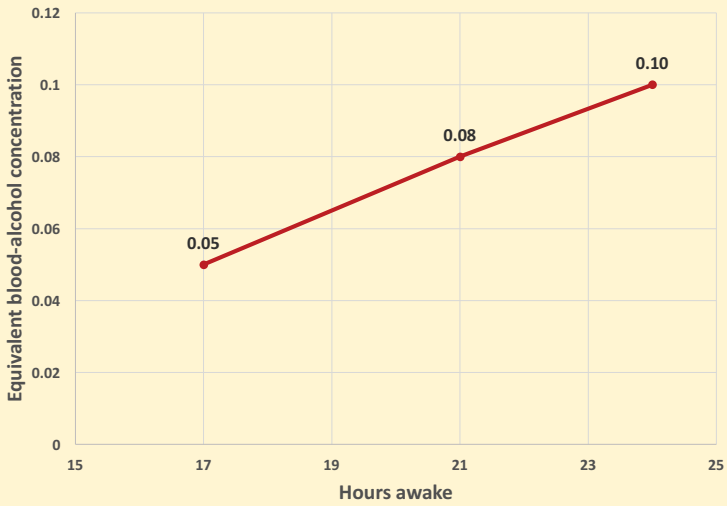


FIGURE 2
Fatigue Impairment: Equivalent Blood Alcohol



Note. *Adapted from "Fatigue Alcohol and Performance Impairment," by D. Dawson and K. Reid, 1997,* Nature, 388*(235).*

this OSH risk. For many types of operations, risk profiles make it financially beneficial and easy to justify investing in a comprehensive fatigue risk management strategy. For example, fatigue is four times more likely to contribute to workplace impairment than drugs or alcohol. However, unlike for drugs and alcohol, which can be measured to assess risk, measuring and combating fatigue in the workplace is often more difficult (Chan, 2011). This impairment can lead to higher frequency and severity incidents. In fact, many sources list fatigue as one of the top five causal factors in workplace incidents (University of Sydney, 2010).

Long hours often contribute to fatigue and can increase the risk for incidents. Research suggests that those who work more than 64 hours per week face 88% excess risk (Vegso, Cantley, Slade, et al., 2007). Even working more than 50 hours per week increases the risk of making an error by almost two times (Rogers, Hwang, Scott, et al., 2004).

Shift work can lead to significant incident risks, particularly when sleep debt accumulates. Compared to the day shift, incidents increased by 15% during the evening shift and 28% during the night shift (Caruso, 2012). Overall, the excess risk of work injury attributed to shift work was 14.4% for women and 8.2% for men (Wong, McLeod & Demers, 2010).

Fatigue risks are often demonstrated in tasks that are perceived as boring or monotonous, and in tasks that require constant vigilance to remain safe. Driving is a common task that involves both elements. As a result, driving is a task often highlighted when assessing fatigue risks. National Transportation Safety Board (NTSB, 2016) estimates that 20% of all fatal collisions involve driver fatigue.

Time of day was the single best predictor of decreased driving performance as a driver is four times more likely to have a fatal crash if s/he is driving between 10 p.m. and dawn (FMCSA & Transport Canada, 1996). In fact, most single vehicle crashes occur during the circadian trough (12:00 to 7:00 a.m., with 1:00 to 4:00 a.m. being the highest); the second highest number of crashes occur during the circadian dip, which occurs from 1:00 to 3:00 pm (Mitler, Carskadon, Czeisler, et al., 1988).

Dawson and Reid (1997) conducted a groundbreaking study that raised awareness on fatigue-related safety issues. They compared the effects of fatigue with the effects of alcohol in terms of performance impairment. In this study, researchers took 40 participants and conducted two counterbalanced experiments. The first group was kept awake for 28 hours, and the second group was asked to consume 10 g to 15 g of alcohol at 30-minute intervals. The researchers then tested the levels of both cognitive and physical impairment at half-hour intervals using a computer-administered test of hand-eye coordination. The results (Figure 2) show how individuals were impaired by fatigue.

Individuals who had been awake for 17 hours performed with similar impairments to those with a blood alcohol content (BAC) of 0.05%. Based on the study, one could extrapolate that those awake for approximately 21 hours performed similarly to the legal impairment level of 0.08% BAC. Individuals awake for 24 hours were impaired equivalent to those well over the legal limit at 0.10% BAC (Dawson & Reid, 1997).

When these findings are added to the knowledge that many shift workers have minimal or no sleep the day they begin their shift, we can infer that many night workers are highly impaired in their physical and mental abilities having been awake for more than 24 hours by the end of their first night shift.

How Fatigue Affects Worker Health

Fatigue has been shown to have numerous effects on human health. For example, International Agency for Research on Cancer of the World Health Organization identified shift work with circadian disruption as a probable carcinogen (Straif, Baan, Grosse, et al., 2007). Most of the statistics on health effects are based on shift workers whose sleep habits are typically outside of normal circadian rhythms. Sleeping and being awake outside of normal daily rhythms appear to have the largest impact on human health (NINDS, 2016). Figure 3 illustrates findings from several studies on human health and fatigue.

Building a Business Case

An OSH professional who recognizes the detrimental effects of fatigue on worker safety and health can build a strong business case for the need to better mitigate risks created by moderate and high levels of fatigue. The business case should highlight the effect of fatigue in terms of factors such as increased incident costs, lost productivity and reduced employee retention. Studies indicate that fatigue occurs in almost 40% of workers, resulting in lost productive time in 65% of these workers (Newton & Jones, 2010). Another study suggests that the effects of fatigue result in nearly 2.5 hours of lost productivity each week per employee (Ricci, Chee & Lorandeau, 2007). Table 1 (p. 48) illustrates some recognized human and business effects of unmanaged fatigue.

Assessing an Organization's Fatigue Risk Exposure

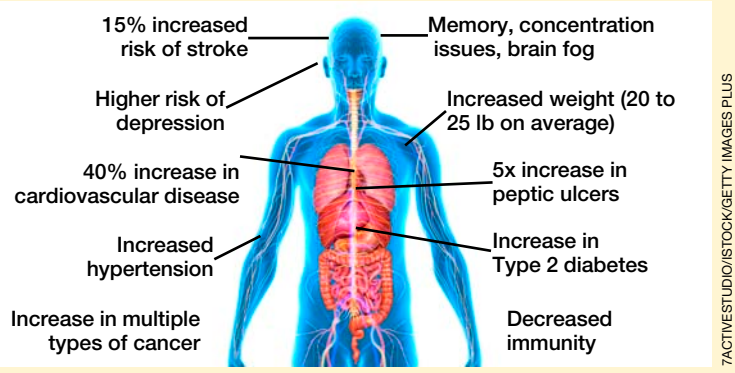
Like most hazards in an occupational environment, identifying the hazard is a crucial first step in devising controls. Being able to understand and communicate fatigue as a safety issue is critical to influencing the development and implementation of fatigue risk management strategies. Multiple factors influence the likelihood that fatigue will create risk. By recognizing these key factors, an organization can begin to accurately assess fatigue risks inherent to their current operations. Factors likely to influence fatigue include work scheduling, work tasks, work environments, work factors and other factors (Figure 4, p. 48).

•Work scheduling is a primary area to assess for fatigue risks. The OSH professional should examine shift scheduling and frequency, regular and modified rotations, overtime, call-out and on-call practices. Controls in this area should focus on managing operational needs while providing optimum opportunities for workers to get restorative sleep. The organization should base these controls on modern scientific understanding, such as recognizing the importance of circadian rhythms and sleep cycles.

•Work tasks are another area to examine when assessing fatigue risks. Many tasks increase the likelihood of inducing fatigue and reducing alertness. Intuitively, people know that physically or mentally demanding work is more likely to be fatiguing; however, these tasks are not those most likely to reduce alertness when a worker is accustomed to doing them. Tasks that are perceived as boring and monotonous are most likely to induce drowsiness. When conducting such work, a worker's mind may wander, reducing alertness and presenting drowsiness, especially if the worker is already somewhat fatigued.

One critical area to consider are tasks that are boring and monotonous, yet require constant vigilance and attention. As noted, driving is such a task. Driving is also a task in which moments of fatigue, particularly microsleeps (momentary uncon-

FIGURE 3
Serious Health Concerns



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Note. *Data from "Adverse Metabolic Consequences in Humans of Prolonged Sleep Restriction Combined With Circadian Disruption," by O.M. Buxton, S.W. Cain, S.P. O'Connor, et al., 2012,* Science Translational Medicine, 4*(129);* Sleep Disorders and Sleep Deprivation: An Unmet Public Health Problem, *by H.R. Colten and B.M. Altevogt (Eds.), 2006, Washington, DC: National Academies Press; "A Prospective Cohort Study of Shift Work and Risk of Ischemic Heart Disease in Japanese Male Workers," by Y. Fujino, H. Iso, A. Tamakoshi, et al., 2006,* American Journal of Epidemiology, 164*(2), pp. 128-135; "Short Sleep Duration as a Risk Factor for Hypertension: Analyses of the First National Health and Nutrition Examination Survey," by J.E. Gangwisch, S.B. Heymsfield, B. Boden-Albala, et al., 2006,* Hypertension, 47*(5), pp. 833-839; "Prospective Cohort Study of the Risk of Prostate Cancer Among Rotating-Shift Workers: Findings From the Japan Collaborative Cohort Study," by T. Kubo, K. Ozasa, K. Mikami, et al., 2006,* American Journal of Epidemiology, 164*(6), pp. 549-555; "Night Work and Breast Cancer Risk: A Systematic Review and Meta-Analysis," by S.P. Megdal, C.H. Kroenke, F. Laden, et al., 2005,* European Journal of Cancer, 41*(13), pp. 2023-2032; "Shift Work Increases the Frequency of Duodenal Ulcer in H Pylori Infected Workers," by A. Pietroiusti, A. Forlini, A. Magrini, et al., 2006,* Journal of Occupational and Environmental Medicine, 63*(11), pp. 773-775; "Sleep Drives Metabolite Clearance From the Adult Brain," by L. Xie, H. Kang, Q. Xu, et al., 2013,* Science, 342*(6156), pp. 373-377.*

TABLE 1
Human & Business Effects of Fatigue

Human impacts of fatigue	Business impacts of fatigue
Lack of awareness and attention to work surroundings	Increased risk exposure leading to increase in number and severity of incidents
Inability to notice and appropriately react to workplace hazards	Increased work insurance premiums
Demonstrated impact on health and increase in certain types of illnesses (e.g., heart disease, stroke, diabetes)	Increased sick leave and absenteeism
Lower motivation and difficulty sustaining effort	Lower productivity
Reduced awareness of fatigue impairment over time	Increased overtime costs
Higher likelihood of making costly errors and being involved in an incident	Costly decision-making errors
Reduced desire to be social and reduced communication skills	Lower employee morale and increased employee grievances
Difficulty remembering and retaining information	Increased employee turnover and retention issues
Impaired physical abilities, reduced reaction times and reduced coordination	Damaged business reputation

Note. *Data from "Fatigue Management: Productivity Enhancement and Risk Mitigation Solutions," by T. Faveri, 2006, Toronto, Ontario: Deloitte; and "Fatigue Risk Management in the Workplace" (ACOEM Guidance Statement), by S. Lerman, W. Eskin, D. Flower, et al., 2012,* Journal of Occupational and Environmental Medicine, 54*(2), 231-258.*

FIGURE 4
Key Fatigue Factors

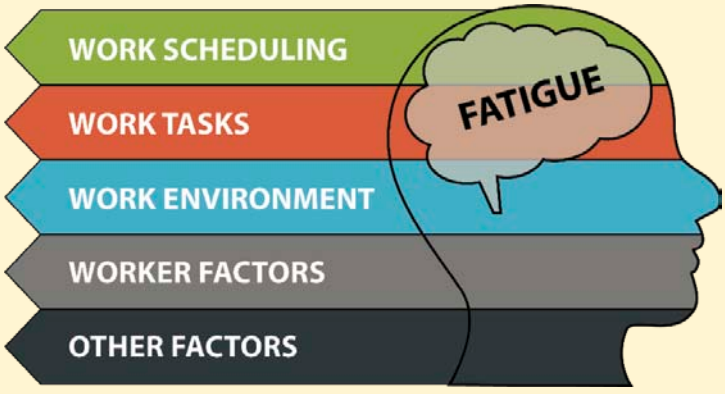
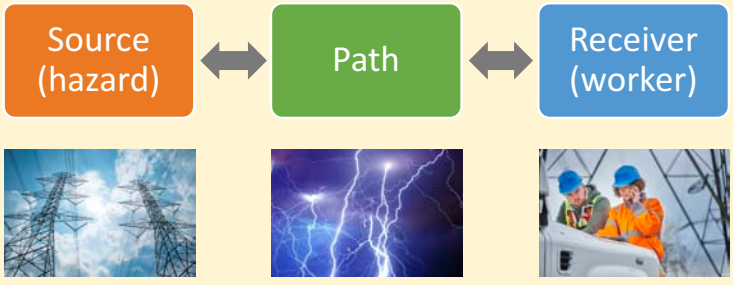


FIGURE 5
Source-Path-Receiver Model



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trolled naps), are likely to have the greatest impact on safety.

- Work environments also affect alertness and fatigue. Nonoptimal work environments, even in controlled work settings, can add to worker fatigue. For example, working in extreme temperatures can be tiring and can dehydrate workers. Chaotic or stressful work environments can increase mental fatigue as well.
- Worker factors are those risks created through the workers themselves. Some individuals are more susceptible to drowsiness or fatigue. Factors that influence this susceptibility include age, overall health, lifestyle choices, sleep disorders, chronotypes, habits and medications.
- Other factors that may influence fatigue at work include travel or working in a circumpolar region that has significant daylight hour variations based on seasonal changes.

To assess these risk factors, an OSH professional can examine key areas for each factor and quantifiably rate risks to identify areas in greatest need of comprehensive controls.

An OSH manager can collect and analyze specific organizational metrics such as absenteeism rates, overtime, incidents, productivity and employee health.

Companies considering a fatigue risk management system should ensure that metrics are collected and compared prior to and after implementation of the system. This will help demonstrate the system's positive effects and reveal areas for its improvement.

Barriers to Success

Given the evidence that fatigue impairs a person's ability to work safely and affects health, one must ask why fatigue is not currently recognized as a significant safety issue in many industries and organizations.

The prevalent 24/7 culture seems to accept fatigue as a sacrifice for modern-day living. Fatigue often is viewed as merely an inconvenience to people's abilities to work and play around the clock. The short- and long-term effects are not usually recognized.

Fatigue is something most people are familiar with. Many people do not know what it is like to be addicted to drugs or alcohol, but most can relate to the feeling of being tired. Yet, people often discount safety and health risks in tasks with which they are familiar.

Awareness and education regarding the safety and health risks of fatigue are lacking. Many people are unaware of the detrimental effects of fatigue. For example, incidents involving driver fatigue are often single vehicle and not typically reported by the news media, unlike alcohol-related incidents that often involve multiple individuals or vehicles.

In some work environments, it is widely believed that a person can overcome fatigue through strength or perseverance; it is seen as a weakness to be conquered. In these settings, few people recognize that fatigue is a physiological impairment that only sleep can eliminate.

Many industries offer monetary incentives for working longer hours or working late. Workers are paid extra for night shifts, overtime and on-call hours. Even industry practices such as paying piecemeal versus hourly can encourage worker fatigue (and encourage workers to shortcut safety to improve speed).

Industries that manage fatigue often use a simplistic approach and do not effectively manage this complex issue. For example, commercial transportation employers use an hours-of-service approach that typically does not consider modern understanding of circadian rhythms and their effect on fatigue. Furthermore, hours-of-service approaches do not consider individual worker factors such as age, sleep disorders or health issues.

Other industries use a fit-for-work approach that accounts only for worker variances and does not consider operational factors that lead to fatigue. In these settings, it is the employee's responsibility to show up to work well rested, regardless of the hours s/he has been required to work. These simplistic approaches often create a false sense of security that fatigue hazards are being effectively managed.

Aside from the transportation industry, recognition of fatigue-causing incidents is limited. Lack of industry data is one reason for limited awareness. Few industries collect evidence on fatigue and its relation to safety. To better understand the effects of fatigue on safety, most industries need to alter their investigation and documentation procedures.

No medical test is currently available to physiologically demonstrate fatigue. Thus, an investigator must use specific procedures to determine whether fatigue is a causal factor in an incident. One must gather information about hours of sleep and exertions to determine whether fatigue played a role in the incident. An OSH professional can use investigation procedure checklists that highlight performance impairment indicators in combination with targeted questions to assess fatigue as a contributing causal factor. However, few industries employ these strategies, and even when fatigue is identified as a contributing factor, no structure is in place for industry reporting and data collection.

To truly improve safety with respect to fatigue factors, a cultural shift is needed. Everyone (management, supervisors, workers) within a company must recognize fatigue as a safety hazard and mitigate it through various controls. For this to occur, workers must be willing to admit fatigue and a corporate consensus must exist for dealing with it. This shift usually comes about with effective fatigue education and training.

Managing Fatigue: Strategies & Best Practices

As noted, organizations must first recognize fatigue as a workplace hazard. By doing so, people can view fatigue as a hazard in the source-path-receiver model. That is, fatigue can exist and be managed at its source, along its pathway or at the receiver.

Let's examine this model by comparing both an easily recognized hazard, such as high levels of electrical energy on a work site, and fatigue.

Source

To begin examining risks and controls, let's look at the source of a chosen hazard (electrical), in this case, the transformer box. The site can implement controls at the source (e.g., fencing the area, displaying warning signage, insulating the transformer box, clearly marked levers to activate and deactivate the transformer).

Fatigue is a hazard at the source when it is an inherent risk due to the nature of operations. For example, if a remote site has rotations of seven 12-hour day shifts and seven 12-hour night shifts, fatigue is an inherent risk due to the hours employees must work and their likely commute. Fatigue hazards can also exist at the source due to the work being conducted. For example, work that is highly monotonous or includes high-risk tasks such as driving could reduce alertness or induce fatigue in a worker.

Controlling the fatigue hazard at its source would involve optimizing scheduling to ensure that workers receive as much sleep opportunity as possible given operational demands. Other controls at the source include providing accommodations close to the site, optimal camp situations with proper sleep accommodations for those working night shifts, or napping rooms that workers can use if they become impaired by fatigue.

Pathway

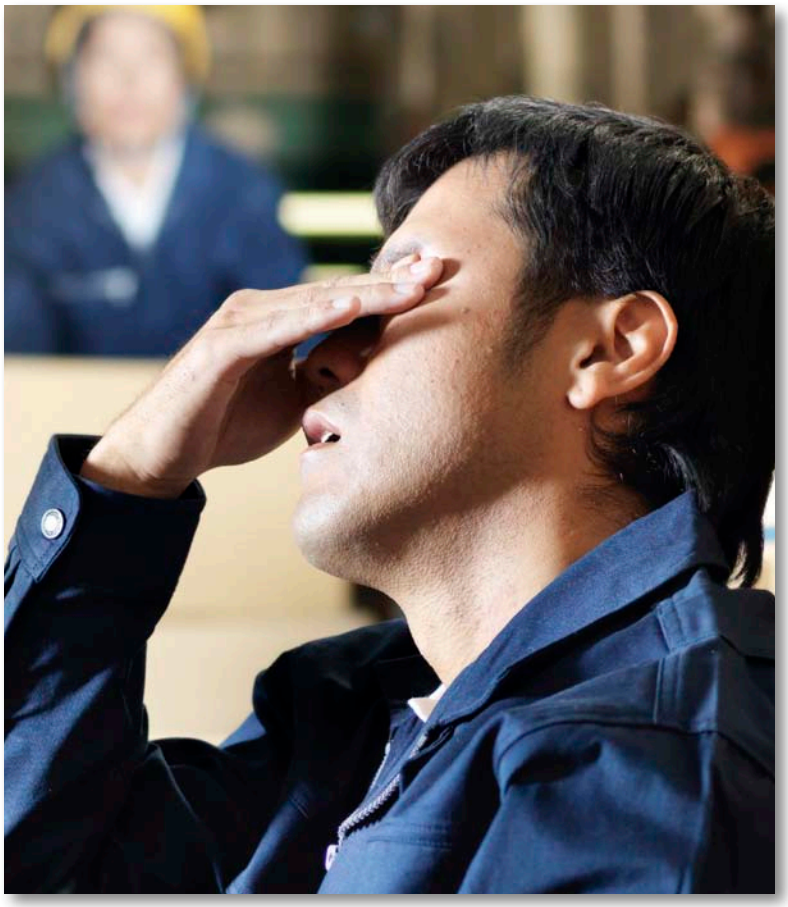
Hazards can also exist and be controlled along their traveled pathway. Using the high-energy electrical hazard example, the pathway could be arcing that occurs from a power line to a worker (e.g., when operating a mobile crane close to the lines). Methods of controlling this hazard could include implementing barricades to prevent equipment from entering hazardous areas, having lines de-energized before equipment enters the area, or using a spotter to signal the driver to ensure that s/he does not go near the power lines.

Fatigue exists on the pathway in the critical time between when a worker becomes drowsy or fatigued, and when that impairment causes the worker to commit a critical error. This error could result in a near-hit or an actual incident.

This type of fatigue is controlled in multiple ways. For example, a safety culture that recognizes fatigue as a hazard would encourage a worker to self-identify his/her tiredness, or a supervisor to watch for fatigue and intervene as needed. Once fatigue is identified, the company could employ strategies (e.g., regular breaks) to reduce fatigue or to change the work.

Receiver

The final area in which a hazard can cause injury is at the receiver. Using the example of electrical energy, this would occur when the electrical energy comes into contact with the worker. Controls at this level often involve lower-level controls, such as training and PPE. For example, training a worker to understand and properly work with high energy electrical sources or providing PPE such as insulated gloves and boots to reduce the likelihood of shock.



Despite extensive occupational research showing that fatigue affects safety and health, many industries do not acknowledge or control fatigue-related hazards.

At the receiver level, fatigue can be caused by a worker who has sleep apnea, health or personal issues, or who has obligations or makes life choices that prevent that person from getting enough sleep even if s/he has enough time off from work. This fatigue is managed at the worker level through worker education and training on the importance of prioritizing rest, employee assistance programs, and health benefits that teach workers how to prioritize sleep and to treat medical issues that may interfere with sleep. These strategies require a strong safety culture and commitment to controlling fatigue.

As with all hazards in the source/path/receiver model, the most effective controls are introduced at the source, while the least effective controls are those implemented at the receiver.

Structuring & Integrating Fatigue Risk Management Strategies

A fatigue risk management strategy is an integrated set of management practices, beliefs and procedures for monitoring and managing fatigue risks in the workplace. It is based in safety management system theory with an emphasis on risk management. This strategy:

- should be integrated into existing safety management systems;
- emphasizes risk management with controls designed to specifically address risk areas identified;
- includes recommended mitigation strategies that align with the levels of operational risk identified;
- integrates strong training/education components for all levels and stakeholders aimed at increasing fatigue knowledge and breaking down any existing attitude barriers;
- creates processes for identifying or ruling out fatigue as a contributing factor to incidents;
- supports continuous improvement via monitoring of implemented strategies and fatigue metrics;
- provides feedback designed to enhance existing controls.

Training is a critical component in managing fatigue risks. Training must occur at all levels of the organization. Senior leadership should be aware of the risks and current strategies being employed. Managers and supervisors should be able to recognize signs of fatigue. All levels, including workers, should be aware of best practices for managing the signs of fatigue.

Education is key to understanding fatigue as a risk factor and assessing fatigue impairment. The company must empower supervisors and workers to act when the level of fatigue is deemed too high to safely continue safety-sensitive work. Whether the mitigation involves delaying/rescheduling the work or calling in another worker, procedures must exist to both assess fatigue and mitigate in extreme circumstances.

The complexity of a fatigue risk management strategy should align with the level of risk identified within the organization. For example, the strategy in an organization with low fatigue risk (e.g., an office environment) may be as simple as an employee awareness program. An organization with a higher fatigue risk may require a more sophisticated strategy, such as one based on the five-level-defenses-in-depth fatigue management model (Dawson & McCulloch, 2005).

This model is a conceptual framework for managing fatigue. It is based on Reason's (1997) hazard control framework that proposes that multiple layers of controls are necessary to comprehensively mitigate a hazard. The strategy creates five levels of control with predictive, proactive and reactive control strategies embedded in multiple areas throughout the organization including operational planning, safety management systems and incident investigation reviews (Dawson & McCulloch, 2005).

Schedule optimization is one potential strategy. Schedules that not only accommodate operational needs but also reflect worker needs for sleep opportunity are usually a good starting place for most companies. Other strategies include planning safety-sensitive work tasks in accordance with known worker circadian rhythms. For example, a 24-hour operation should avoid planning safety-sensitive work between 2:00 and 5:00 a.m. or between 1:00 and 3:00 p.m. Planning this type of work for early morning or early evening better reflects when workers are most alert and functioning optimally. Other strategies include providing accommodations closer to the work site or having buses or vans

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to drive personnel rather than workers independently driving long distances after long workdays.

Overall, an organization's fatigue best practices should reflect risks identified. In other words, companies should review current operations and determine areas in which fatigue risks are higher. They can then develop specific strategies to address these risks and implement the strategies in a way that aligns with existing safety management systems.

Conclusion

Despite extensive occupational research showing that fatigue affects safety and health, many industries do not acknowledge or control fatigue-related hazards. To push past the existing inertia of lacking fatigue management, current cultural and work-related barriers must be overcome. These barriers are propagated by lack of knowledge and awareness by workers, within industries and organizations, and among OSH professionals. These barriers are further supported by existing work practices and safety cultures. Workplace education on fatigue management can help break down these barriers.

Successfully implementing fatigue risk management strategies also requires recognition of the issue's complexity and the multiple levels within an organization in which the hazard is both introduced and able to be controlled. Recognition of risk exposures at the source, along the pathway and at the receiver level allows for thoughtful mitigation through hierarchical control strategies.

As industries progress in recognizing and controlling nonphysical hazards within their work environments, fatigue risk assessment and strategies will become a more common component of safety management systems. In the same way general OSH has evolved, fatigue management must evolve and improve so that it becomes as common as it is in other countries. Only then we will begin to see fewer fatigue-related incidents and injuries. **PS**

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