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Tired of Occupational Injuries?

Integrating technology with safety management to address worker fatigue

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In recent years, occupational safety and health professionals have increasingly recognized human fatigue as a safety hazard. Human fatigue can be defined as a state of reduced mental or physical capability that results from sleep loss, circadian challenge, exertive or repetitive task factors, or some combination thereof. Fatigue in the workplace can manifest through impaired decision-making, delayed reaction times, and decreased coordination, all of which can adversely impact task success and safety risk. Research suggests that fatigued individuals perform worse on various tasks than 90% of rested people,[1] which may help explain why (a) approximately 13% of workplace injuries can be attributed to fatigue[2] and (b) night shift workers are three times more likely to be injured.[3]

In light of these data, organizations in the oil and gas, chemical, nuclear power generation, rail, trucking, manufacturing, healthcare, aviation, and other safety-critical industries are seeking to better understand how to detect and reduce worker fatigue. As traditional prescriptive approaches to fatigue management have their limits, organizations can instead leverage technology-enabled insights to help more efficiently identify, measure, and mitigate fatigue risks. By embracing a data-driven, risk-based approach to fatigue management, organizations can help reduce costly occupational injuries and illnesses, promote efficiency, and perhaps even improve worker satisfaction and retention—all within the general confines of existing company management systems that address occupational, process, pipeline, or some other functional safety category.

Traditional Challenges to Managing Worker Fatigue

Fatigue in the workplace is common. Research suggests that one-third or more of normal adults suffer significant chronic sleep loss.[4] Shiftwork, extended shifts and work weeks, long commutes, and lack of rest breaks are also common in U.S. workplaces and can contribute to fatigue risks. Fatigue can also be difficult to measure. Because various fatigue signs and symptoms can stem from multiple sources, no single fatigue measure can serve as a gold standard.

Individuals and organizations alike have traditionally met their fatigue management responsibilities with prescriptive approaches where limitations and requirements are imposed across organizational units. Two of the most common prescriptions are hours-of-service (HoS) restrictions and minimum rest break requirements. These prescriptions are simple and can help limit some risk associated with work-related fatigue; however, they do not commonly or specifically address fatigue risks associated with typical human sleep patterns, duty cycles, and non-work-related time, such as that spent commuting. These factors are often left to individuals to manage outside the workplace. This potential dichotomy—manage work fatigue but come to work fatigued—can pose significant challenges to risk management.

Integrated, Risk-Based Approaches to Managing Fatigue

Organizations can supplement prescriptive HoS limitations with more advanced risk-based approaches to managing fatigue that can extend to individual workers. Risk-based approaches rely on data, operational experience, and scientific principles to identify fatigue

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[1] Pilcher, J. J. & Huffcutt, A. I. (1996). Effects of sleep deprivation on performance: A meta-analysis. Sleep, 19(4), 318–326.

[2] Uehli, K., Mehta, A. J., Miedinger, D., Hug, K., Schindler, C., Holsboer-Trachsler, E., & Künzli, N. (2014). Sleep problems and work injuries: A systematic review and meta-analysis. Sleep Medicine Reviews, 18(1), 61–73.

[3] Bjerner B, Holm A, & Swensson A. (1955). Diurnal Variation in Mental Performance: A Study of Three-Shift Workers. British Journal of Industrial Medicine, 12, 103–10.

[4] Bonnet, M. H. & Arand, D. L. (1995). We are chronically sleep deprived. Sleep, 18, 908–911.

hazards and assess the risk associated with them. Approaches to fatigue management can be made more specific and efficient by leveraging technology to support fatigue hazard identification and mitigation.

Modern consumer off-the-shelf (COTS) technology offerings can potentially provide real-world, low-cost, and unobtrusive data-driven insights into human physiology and performance in the workplace. More specifically, such technologies (e.g., wrist-based wearables) can be used to monitor and notify individual employees of objective measurements concerning their physiology and performance and related fatigue risk via device-based physiological measures (e.g., resting heart rate, heart rate variability, hydration) that have been linked to fatigue.[5] Furthermore, these same technologies can be used to monitor and report on sleep quantity and quality metrics that may speak directly to the notion of "coming to work fatigued," or work readiness.

By monitoring worker physiology and performance through such metrics in real-time, these offerings can help organizations identify the thresholds at which explicit wearable-derived fatigue may compromise task performance or safety. Industry standards that prescribe development and implementation of such thresholds do not currently exist, and it is important to acknowledge that the accuracy and quality of fatigue-centric metrics may vary across viable COTS wearable offerings. It is possible, however, for real-time fatigue status, as defined through a wearable solution, to directly inform interventions (e.g., caps on HoS, rest-break frequencies and durations, modified work tasks, etc.) in support of a risk-based enterprise fatigue management system.[6]

It is important to note that the acquisition of individual physiological and data-driven task relevant health performance data alone does little to help organizations manage fatigue. Organizations must also be able to distill the often vast array of physiological and health performance data derived from relevant technologies into a translatable set of metrics that can directly inform administrative controls and decision-making. Fortunately, the full process of collecting, analyzing, and turning data into actionable risk-based controls does not need to be cost- or labor-intensive. Organizations can typically incorporate fatigue-monitoring technology and supporting back-end data analytics into their existing safety management systems. An efficient risk-based strategy for managing fatigue would leverage existing knowledge of safety professionals and the administrative systems already in place across an organization, including integrated management systems, standalone safety management systems, or other more detailed safe work practices, policies, and procedures.

How Exponent Can Help

Exponent's multi-disciplinary team of human factors scientists, biomechanists, and risk management experts can help organizations efficiently leverage existing management systems to integrate modern and typically low-cost COTS technology solutions to develop and implement worker fatigue risk management systems. Such a data-driven risk-based approach to fatigue management at the level of the individual can help reduce costly occupational injuries and illnesses, promote efficiency, and perhaps even improve worker satisfaction and retention.

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[5] Jeklin, A. T., Perrotta, A. S., Davies, H. W., Bredin, S. S. D., Paul, D. A., Warburton, D. E. R. (2021). The association between heart rate variability, reaction time, and indicators of workplace fatigue in wildland firefighters. International Archives of Occupational and Environmental Health, DOI: 10.1007/s00420-020-01641-3 – Online ahead of print

[6] Eguchi, Y., Kawanami, S., Horie, S., Yamato, H. (2011). Assessments by HR and %HRR of occupational work exertion for alternating periods of rest and manual labor. Journal of Occupational Health, 53, 343-349.

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