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From Dean's Desk:

Prologue

Over ten years ago an article from CNN London suggested that sleep deprivation is as bad as alcohol impairment. The study, published in the British Journal of Occupational and Environmental Medicine, reported that researchers in Australia and New Zealand found that sleep deprivation can have some of the same hazardous effects as being alcohol impaired. The article continues stating they found that people who drive after being awake for 17 to 19 hours performed worse than those with a blood alcohol level of .05 percent. That's the legal limit for drunk driving in most western European countries, though most U.S. states set their blood alcohol limits lower. The study said 16 to 60 percent of road accidents involve sleep deprivation. The researchers said countries with drunk driving laws should consider similar restrictions against sleep-deprived driving. The problem of fatigue is gaining more and more attention. In the world of industrial safety, where the consequences can be significant for the individual involved as well as those who work and even live in the area, fatigue is beginning to gain the attention it deserves. One might not think that leadership development involves fatigue, it certainly does. We are including in our programs sessions on work –life balance, as well as the concept of Safety Quality and Productivity being in balance, where fatigue is a major component of maintaining that balance. This is our second article on this topic and we sincerely hope you find it informative and valuable.

Fatigue and alertness – Schedules and Awareness

Andrew Phinney A. C. Macris

Introduction

Our last article focused on Fatigue and Alertness, with the promise of following up with a term referred to as bio-rosters, shiftwork scheduling and managing shiftwork and lifestyles. This article does just that and also includes a brief discussion of the business case that supports the use of technologies available today to manage and mitigate fatigue. It is important to note that there is so much more that could be discussed on this topic, so if you wish additional information please contact Andrew Phinney or me and we will get back to you. Hope you enjoy the article.

Evaluating work schedules for alertness quality

Perhaps the most important contributor to an alert worker is the quantity and quality of their sleep patterns. Rotating shift workers (those who work days, then nights, then back to days) are presented with the greatest challenges to remain alert on the job. The most common problem with this type of schedule is that it fails to provide enough time for sleep between shifts, and most importantly often fails to provide adequate time off between day-to-night or night-to-day transitions.

For most of the working world their 24-hour schedule is defined by their imposed work schedule. When we eat, sleep, commute, play, or enjoy family time is always a function of the confines of the work schedule. We know that our basic sleep requirements are 7.5 hours, so consider the schedule you or your workers might be operating on; is there adequate time for a worker to end his shift, drive home, have a meal, wind down, get 7.5 hours of sleep, have a morning routine, morning meal, and travel back to work? On this simple principal alone we recommend not to exceed 12 hour work shifts. If overtime or a long commute becomes a regular part of the schedule, sleep is the first thing that is shorted and fatigue risks ramp up.

Day-to-night transitions present even greater challenges to getting adequate sleep due to the increased risk of Circadian rhythm de-synchronization. To minimize these affects, the individual must rotate their sleep forward 1.5 hours (one sleep cycle) each night until their 7.5 hour sleep window is adjusted over to day sleep and night

work. This is known as Phase Shifting and requires a minimum of 3 days off after ending day shifts and beginning night shifts. Even when these phase-shifting efforts are taken, workers will still experience extended hours of fatigue in the early morning hours of these night shifts.

Night-to-day transitions, or reverse phase shifting, are the most difficult. In this case we recommend a recovery day on the first day after your night shifts end where you would get about six hours sleep in the morning then return to bed at a "normal" time that night for an additional 7.5 hours. This "lost day," as some view it, is the fastest way to get back on to normal circadian synchronization.

Unfortunately accountants, factory managers, union leaders, and mathematicians, most of whom had no knowledge of the most basic circadian principles, designed many work schedules in use today. These are the work schedules that set the stage for fatigue and fatigue-related incidents.

Bio-rosters, alertness friendly work schedules

The term bio-roster refers to a work schedule designed with human circadian physiology in mind. These are typically designed for 24-7 operations, where the workplace never stops, and where workers "rotate" through day and night shifts. Using the known physiological requirement of sleep quantity and phase shifting, coupled with the 24-7 operational requirements of many industries, Chrono-biologists have developed many variations of bio–rosters. These schedules allow for all workers to have sufficient time off between day and night shifts, plus sufficient time for 7.5 hours sleep. It sounds simple but there are actually hundreds of variations to these types of schedules, many of which are very popular with workers. Using established fatigue modeling techniques, each roster can be "scored" in its effectiveness as a bio-roster, making some bio-rosters "more physiologically alertness friendly" than others. There's one very well scoring bio-roster that has proven very prevalent throughout industry; it works 12 hour shifts, days and nights, and allows for 8 full days off in a row for every worker, every month.... and no, it does not require any more workers than a typical 4 crew system!

Worker Awareness, the front line of defense against fatigue

When we consider ways to inform workers of their fatigue risks, no single solution is right for all workers in all industries and in all situations. It is important to remember that each fatigue awareness solution performs a different function in the entire fatigue management system, and they generally fall into one of four different categories of technologies:

Preemptive Technologies are proactive measures to create the conditions favorable to alertness. These can include bio-roster (circadian rhythm-friendly work schedules, discussed above and introduced in our previous UPDATE article), education and training of workers on lifestyle habits that can complement the bio-roster, and lifestyle notification systems.

Education and worker training is certainly not a new concept, and we are well aware of the limited retention rate of classroom training and seminars. Therefore, as an ongoing mechanism to remind workers of their responsibility to counter the effects of fatigue, there are lifestyle notification systems. These systems have proven to be one of the most effective means of creating a routine awareness of worker's responsibility to manage their work, sleep, diet and exercise schedule. These systems can be as simple as a 24-7 planner of a worker's shift schedules, with the recommended sleep, diet, and exercise schedules that they should follow in order to experience the highest levels of alertness on and off the job. The planners come in various sizes to be posted on the refrigerator, carried in a pocket, or posted in common work areas. They are known as "passive" notification systems because the worker has to refer to it and attempt to follow the lifestyle as best as they can.

Lifestyle notification systems have recently moved into the electronic age, where "active" notification of each worker is executed through SMS text and Smartphone applications. These technologies have proven very popular with industry as each employer can set what alerts they want to send to their workers. Each alert is delivered at the exact time, based around that individual's work schedule. Imagine your employee, that you know is going into a fatigue zone, getting a text message to alert them of that fatigue along with what actions to take to minimize fatigue related incidents. No longer relying on the limited

or no-retention of months-past classroom training, you have now created a staff with effective fatigue awareness. (1)

Predictive Technologies are designed to pick up where Preemptive Technologies leave off. In certain industries schedules can be somewhat unpredictable, even when bio-rosters are in place. Constant excessive overtime or random waves of high overtime created by fluctuating work hour demand can limit the effectiveness of preemptive technologies. In these cases predictive technology is incorporated that uses real-time work hour data to generate daily fatigue risk calculations. The most effective predictive technologies that are in practical use are Clock-in Clock-out systems that use actual recent work schedules to calculate fatigue risks. (2) These systems are also capable of notifying supervisors of who may be in high risk, and can also automatically assign a fatigued worker to a less risky task.

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The future of predictive technologies will monitor sleep quality and quantity, physical exercise, and a variety of physical vital signs to make real time fatigue prediction in an almost constant manner.

Both preemptive and predictive fatigue technologies are designed to avert and/or alert of potential fatigue **before** it occurs and, as such, are critical technologies in an effective fatigue management program.

Performance Technologies are real-time performance tests that can measure alertness in individuals that have been identified as having a high probability of fatigue as determined by a predictive or preemptive technology. Usually used in conjunction with predictive systems, these tests can often clear or confirm an individual from a specific work task. (3)

Detection Technologies are the last step in the technology progression, as they are designed to detect fatigue that has already set in and is in the process of occurring. These are typically invasive technologies such headbands that are evaluating EEG activity or specialized cameras that are measuring eyelid speeds and amplitudes.

The technologies available to combat fatigue come in many forms, price ranges, and effectiveness. The general rule of thumb is to start with preemptive efforts, and if needed progress to predictive, performance, and finally detection efforts. The concept is that if the preemptive measures are employed with effectiveness, there are fewer people becoming fatigued and less need for performance and detection technologies. Certain high-risk industries that have a zero tolerance for fatigue may want to employ all of the technology groups.

Workers' role in fatigue awareness:

As important as bio-compatible work schedules are, they can only set the stage for the possibility of an alert work force; the workers themselves need to follow some basic lifestyle principals in order to take advantage of the bio-roster. To get the most out of the bio-roster they need to be aware of and execute the practices of getting enough sleep, phase shifting, nap timing and duration, correct meal timing and types, and exercise timing and types. They also need to be aware of the inherent fatigue risks that come with shift work, even when they do everything correctly. They need to be aware of and practice countermeasures to the inevitable fatigue they will experience on the second half of night shifts. Remember that even with bio-rosters, fatigue risks still present themselves during and after work hours. Personal knowledge of a worker's own fatigue risk is the first line of defense against fatigue related accidents. It allows them to seek assistance, switch to a less risky task, or take other action to counter the fatigue and lower the risk of incidents.

Management's role in Worker awareness:

While it is incumbent upon management to initiate and implement an effective fatigue management program in their organization, the job is not done until the workers are fully aware of their role in the process. While the sciences of chronobiology and worker fatigue are rife with studies, statistics, fatigue modeling technologies, white papers, scholarly publications, and research projects, it is the knowledge base of the end user, that individual on your payroll that's working with your equipment in your facility, that becomes the front line of defense against fatigue related incidents. To this end a number of methodologies and technologies have been devel-

oped specifically to inform workers of their risks and responsibilities.
Traditional training sessions are key part of the process; this typically includes a cursory review of basic circadian principals, sleeping skills, and lifestyle choices that promote alertness. It is well known that while training is widely used in many levels of professional development, the retention rates over the long term are typically quite low, and weeks or months after training much of the information is forgotten. Real-time alerts of predicted fatigue zones, proper sleep times, meal times, and lifestyle choices present the optimal level of information for each individual to remain alert.

The Business Case

While different people will read this article with different perspectives, we feel it is important to include in addition to the science of circadian rhythms, as well as the importance of implementing such programs for worker wellbeing; there must also be a business case for doing the right thing. It is common in the discipline of human factors/human performance for the majority of people to 'sort of believe' that programs, and processes that benefit the worker are the 'right thing to do.' Not very often are they able to couple the right thing to do with a business case. In fact there is the opposite tendency to feel that while these programs are the right thing to do, they represent barriers to productivity. They are sometimes perceived as distractions to 'the work at hand.'

We want to highlight a different perspective, one that reinforces that the right thing to do also converts to the right business decision too. The concept is one we have written about over the past several years. We refer to it as Safety Quality and Productivity or SQP. We characterize it as a three-legged stool because if any one of the three legs is given any lesser emphasis, the whole stool falls over. The business reality is that Safety and Quality are on a par with Productivity in the big picture. In several projects we have demonstrated that shortcuts in safety and quality end up costing more to respond/recover to the outcomes of those shortcuts than any productivity gained by taking the shortcuts. The same argument applies to circadian rhythms and everything discussed herein. Fatigue manifests itself in many ways and the results, in the context of safety, quality and productivity, can be significant. Therefore in the context of providing a better work environment, doing the right thing converts into making the smart business decisions.

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Andrew L. Phinney has over 25 years of consulting, teaching, and management experience over a cross section of industries including engineering, information technology, and service.

He has developed unique fatigue management solutions for multi-crew shift work operations, and is currently developing alertness schedule and lifestyle applications for various mobile platforms.

Andrew holds a Master of Science in Management Information Systems, and is a principal of The Scheduling Group, LLC.

The science of human fatigue is comprehensive and quite voluminous. This article along with the previous one provide highlights of the science and technology. For a more complete discussion on the topic, we urge you to contact Andrew at:

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THOUGHT TO CONSIDER

There is wisdom in turning as often as possible from the familiar to the unfamiliar: It keeps the mind nimble, it kills prejudice and it fosters humor.

Source— in our next issue

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