Predictive Safety

Four Steps to Fatigue Risk Management

Many workplace accidents are related to fatigue. The risk posed by fatigue is worth examining, better understanding, and working to eliminate.

Step 1: Education

What Is Fatigue?

It is difficult to find an all-encompassing and universally accepted definition of fatigue. Fatigue can be defined as "a state of impaired mental and/or physical performance and lowered alertness arising as a result or combination of hard physical and mental work, health and psychosocial factors or inadequate restorative sleep. Fatigue can be either work or non-work related or a combination of both."[1] Fatigue involves "increasing difficulty in performing physical or mental activities." Another formal definition is "mental or phyiscal exhaustion that stops a person from being able to function normally" or "a persistent lack of energy that impairs the ability to function."

Whatever formal definition we use, it is important to remember that fatigue is more than just being tired. Fatigue significantly impacts our alertness and hence our productivity and safety at work. When we discuss worker fatigue, it is useful to consider the total of fatigue related to work-time arrangements, to environmental factors, and to the operator's personal factors:

$$F_T = F_{SS} + F_{EW} + F_{PF}$$

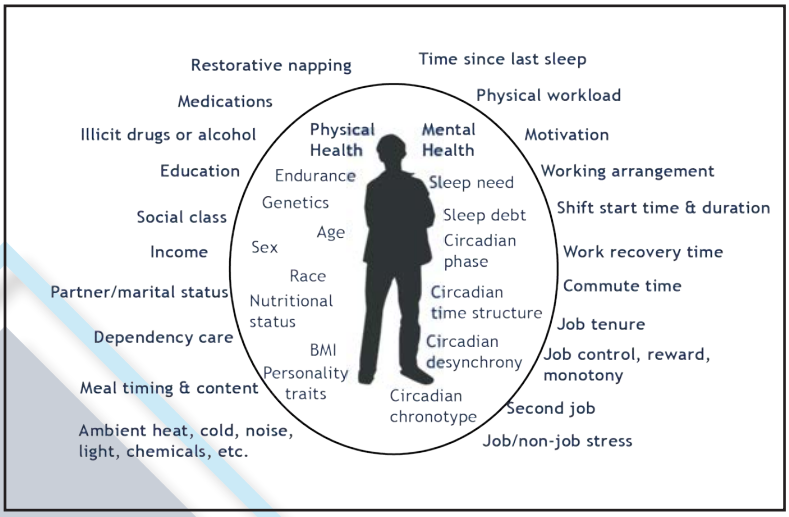
F_T: Total operator fatigue

F_{SS}: Shift system and rostering (working time arrangements that cause circadian rhythm disruptions, sleep deprivation)

F_{EW}: Ergonomic, environmental, and work factors (task requirements, physical work loads, workstation design, physical factors like thermal stress or noise)

F_{PF}: Personal factors (health status, lifestyle, nutrition, social and family life, part-time jobs)

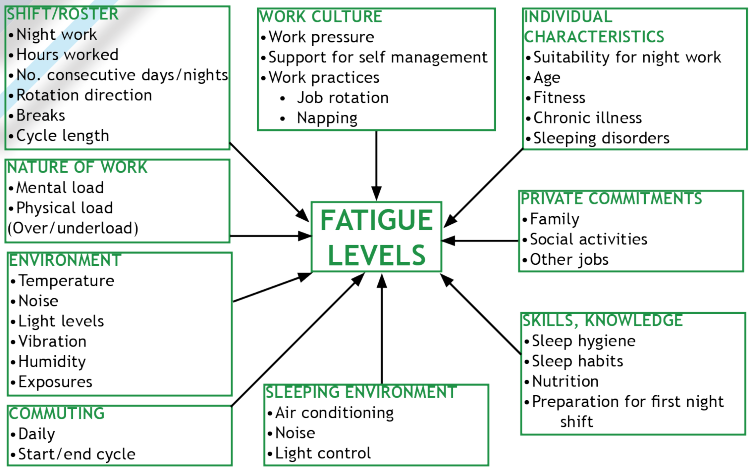
Even this model might not be a complete representation of all the factors that contribute to fatigue, but it points toward a need for a broad and holistic approach to managing this issue.



Fatigue has an adverse effect on every aspect of human performance. And any factor involved in human performance may contribute to our personal fatigue risk.

High levels of fatigue cause reduced performance and productivity in the workplace and increase the risk of accidents and injuries. Fatigue affects the ability to think clearly, which is vital when making safety-related decisions and judgments. People who are fatigued are unable to gauge their own level of impairment. As a result, fatigued people are unaware that they are not functioning as well or as safely as if they were not fatigued.

Here is another way to look at potential causes of fatigue. It is important to consider these factors in determining the fatigue risk that your workers may be subject to:



Fatigue can also result in long-term health issues such as digestion problems, heart disease, anxiety and depression.[2] "Signs of fatigue include tiredness even after sleep, psychological disturbances, loss of energy and inability to concentrate. Fatigue can lead to incidents because workers are not alert and are probably less able to respond to changing circumstances."[1]

It may be easy to recognize some of these signs, especially if you find a third-shift worker asleep on the job, or through a root cause analysis after an incident you find that an operator wasn't alert or able to concentrate on the task as needed. More difficult, perhaps impossible, to recognize are the more subjective causes of fatigue that are external to the work environment, whether related to an employee's private commitments, sleeping or eating habits, or other individual characteristics.

One of the major factors contributing to worker fatigue particularly related to shift work is the disruption of the circadian rhythm. The human biological system operates on an internal clock in which different functions run on different cycle lengths. The circadian rhythm, for example, is a rhythm that cycles approximately every 24 hours, with various functions either rising or falling at various times throughout the 24-hour period. For example, high body temperature and heart rate are associated with increased alertness and performance and occur during daylight hours. Sleep, on the other hand, is associated with a lowering of body temperature, heart rate, and cortisol, which decrease in the evening, then rise in the morning before we awaken.[3]

The physiological tendency to sleep at night and to be awake during the day is powerful; difficulties occur when work-time arrangements cause individuals to work against this tendency. Altering the normal sleep/wake cycle affects both the ability to remain alert and the ability to sleep. Non-traditional work hours (night or early morning) create a misalignment between the internal clock on the normal activity and sleep schedule.[4]

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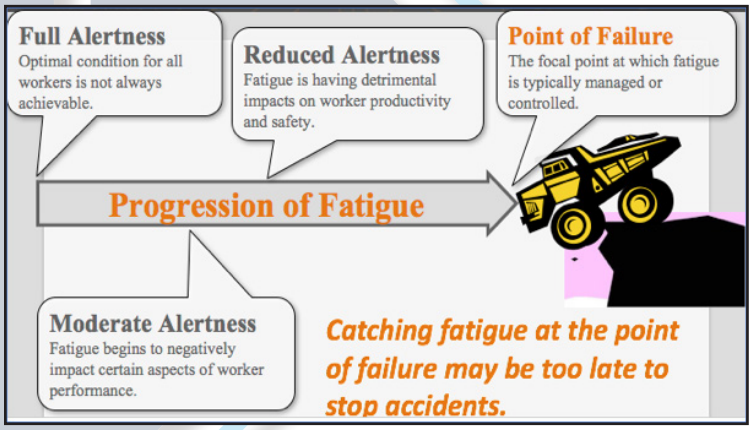
Step 2: Measurement

How Is Fatigue Detected?

Understanding the "progression of fatigue" helps us see why it is so important to focus on measurement before management. While we expect employees to arrive at work at a full alertness level, and many employees do, this optimal condition doesn't always happen and may actually not be possible for all workers. At a moderate alertness level, fatigue begins to negatively impact certain aspects of worker performance and at the reduced alertness level, fatigue is having detrimental effects on worker productivity and safety.

Unfortunately, it is not until the point of failure where fatigue has caused or contributed to an incident or a near miss that we tend to focus on solutions, controls, or other ways to "manage" fatigue risk.

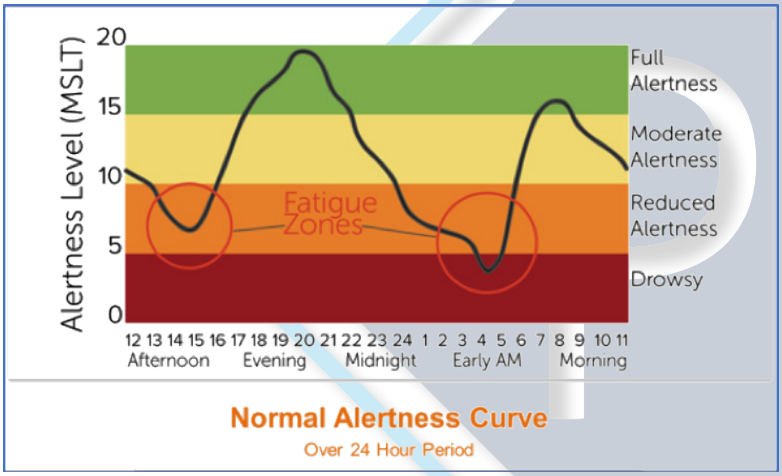


Once companies decide they will invest in prevention and attempt to proactively measure and manage fatigue risk, an in-depth analysis of fatigue risk is required. Companies can conduct a Fatigue Risk Assessment (FRA), which shows primary risk factors that contribute to an overall fatigue risk, based on:

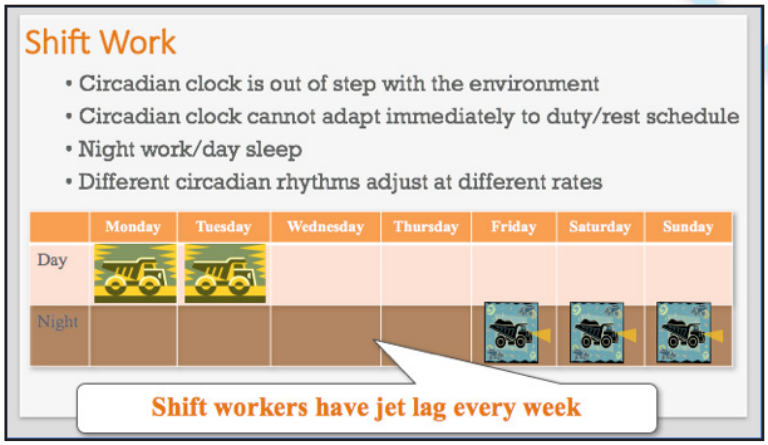
- Shift patterns
- How breaks are organized
- Countermasures for fatigue mitigation
- Commute times for workers
- Hydration/nutrition options during shift
- Temperature in workplaces
- Review of employee health issues
- Lifestyle questionnaire

Plus, an FRA involves assessments and surveys with a sample population of employees on site. This type of assessment takes approximately one week, and up to two additional weeks to analyze the data and compile the results. Once completed, the findings and recommendations are presented to management.

We are all driven by this circadian rhythm or "body clock," which is simply a cycle that tells our bodies when to sleep, wake, eat, exercise, rest, etc., and our activities based on the circadian rhythm regulate many of our psychological processes. This circadian rhythm also creates natural fatigue zones that occur usually around 2:30 PM and 4:00 AM.



Given that all humans encounter these natural fatigue zones, shift workers experience an even more difficult fatigue challenge. Retraining our internal, built-in "body clock" is not easy, and shift work creates what is called "circadian desynchroniziation."



Shift workers' circadian rhythm is out of step with the environment, and no matter how hard they try, they will always struggle adjusting to a new work-and-rest schedule. In fact, everyone's circadian clock adjusts at slightly different rates, so a common effect of shift work, especially among workers on rotating shifts, is "jet lag." Even workers who work only at night experience this circadian lag every week, beginning on their days off.

There are additional calculating factors in a formal fatigue risk assessment. Each of these factors are quantifiable and able to be measured in our attempt to manage fatigue in the workplace:

- *De-synchronization of sleep/work cycle with circadian rhythm:* Trying to work when the body is in a sleep cycle or trying to sleep when the body is in an active cycle
- *Build-up of sleep debt over sequential shifts:* Insufficient sleep between shifts to completely reset sleep debt
- *Total hours/shifts worked:* Moving the circadian cycle backward increases fatigue risk; insufficient time between shift pattern changes

Step 3: Management

After educating ourselves on the multitude of factors that could cause or contribute to fatigue, and realizing how important it is to measure or detect fatigue, companies can move toward proactively managing or applying countermeasures to fatigue risk in the workplace.

Managing fatigue is a three-fold challenge. First, there is no objective, standard definition of fatigue until the point of failure. Second, fatigue is a non-static variable, making it difficult to measure. And third, a majority of behaviors impacting fatigue are not work-related and occur outside of the workplace.

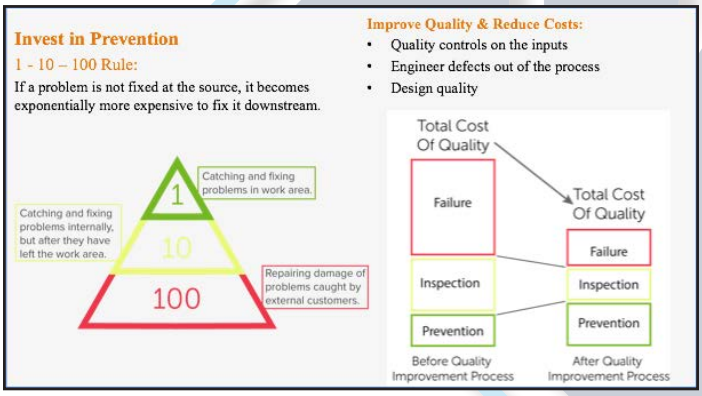
We can think of fatigue as an input variable in the organization's work stream: fatigue impacts the quality of an organization and its results, it is inherent within all human resources, and it impacts worker health, often keading to absenteeism and contributing to workplace accidents.

Using "Cost of Quality" concepts, we can apply a Quality Improvement Model:[5]

The Cost of Quality is a business model that shows that continuous improvement efforts can reduce future costs. Larger investments in prevention end up driving even larger savings in quality-relatd failures down the road.

By investing in prevention, companies can address problems at the source and prevent future expenses that are exponentially higher when addressing them downstream, or after an incident occurs.

The 1-10-100 Rule is a business efficiency model that can be used in quality analysis. Basically, it looks at the cost of prevention compared to the costs of correction, compared to the costs at our after a point of failure.



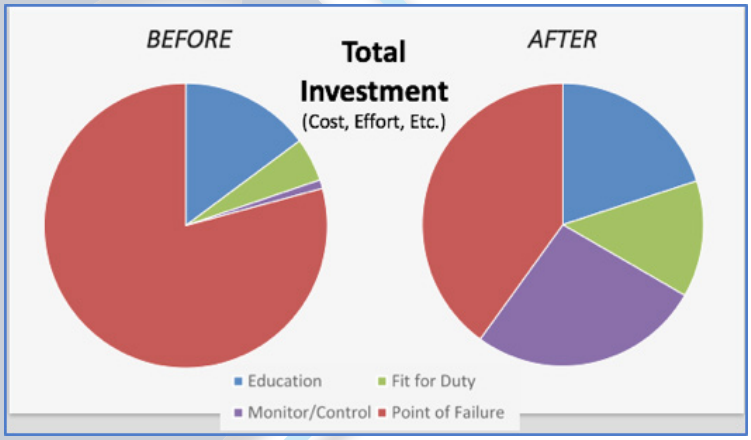
When we apply these models to our interest in managing fatigue, it becomes clear that an investment in measuring and managing worker fatigue is going to reduce potential costs and risks of failures related to fatigue in the workplace.

Here's another way to look at benefits of managing fatigue from a Cost of Quality perspective. The investment (both in cost and effort) *before* deciding to manage fatigue shows:

- Low focus on human factors
- High expense at the point of failure
- Little correlation to total environment

Most of this deals with responding to points of failure, a company's recactions to workplace incidents, whether resulting in property damage, first-aid injury, lost time, workers' compensation, lost productivity, a more serious injury, or fatality.

The investment both in cost and effort after deciding to manage fatigue shows a much more balanced distribution across education and fatigue risk management efforts. It also provides a high focus on human factors, better visibility to fatigue risk, and robust data reporting and analysis. But most importantly, there is a significantly smaller point of failure cost. The benefit of prevention efforts, like education and other fatigue management activities) clearly outweigh the costs associated with failure.



Part of managing fatigue is appropriately using countermeasures to reduce fatigue's effects and to enhance or encourage alertness. Countermeasures can be *behavioral*, meaning recurring or routine actions that encourage alertness, or they can be *nutritional*, related to the intake of food or drink. Most importantly, staying hydrated is key. Dehydration accelerates fatigue symptoms, so access to potable water must be not only be ensured but used frequently. Plus, employees can use clean, cold water to refresh themselves by washing their face and hands. Staying mobile is also a behavioral countermeasure that can fend off fatigue symptoms. For workers who sit for long periods, taking frequent short walks and stretching is advised. For employees who are active, brief intervals of isometric exercise can help keep the body fresh and the mind alert. If possible, brief

periods of rest or sleep can also reinvigorate a fatigued worker. Some workplaces may also provide "light stations," where employees can combat fatigue symptoms by bathing in bright white light.

Besides hydration, nutritional countermeasures include consuming caffinated beverages, like coffee or tea, and energy drinks and soft drinks in moderation. Although they may boost energy levels, energy drinks should be used sparingly because they contain very high doses of caffeine and other stimulants. When consumed to excess, they can disrupt nightly sleep and actually contribute to daytime fatigue (which may then lead to consuming more energy drinks). However, reasonable doses of caffeine taken at appropriate intervals can be appropriate countermeasures to fatigue symptoms. In addition, food intake and nutrition is important. Foods that are high in fat and carbohydrates, including sugards, should be restricted; instead, fatigue symptoms can be better managed with nutritious and protein-rich foods, like protein bars, nuts, and dried fruit.

Fatigue Risk Level	Countermeasure Types		
	Recurring (Behavioral)	Once per shift (Behavioral)	Nutritional
Significant	Drinking water, exercise, chewing gum	Coffee break	Limit high carbs
HIGH	Drinking water, exercise, washing hands and face, rotating jobs	Coffee break, light station	Limit high carbs
SEVERE	Drinking water, exercise, washing hands and face, using the Buddy System	Coffee break, light station, nap	Limit high carbs

A simple countermeasure strategy for employees to follow can empower them to manage their own fatigue symptoms as well as maintain their autonomy. Behavioral countermeasures are either recurring or occasional (once a shift), and employees can tailor their nutritional countermeasures according to their needs and preferences, except that they should always limit their intake of foods high in carboyhydrates and fats.

Step 4: Monitoring

How Is Fatigue Risk Continuously Managed?

Management is a process, not a goal. To manage any program or system effectively, ongoing monitoring, evaluation, and adjustment are required. The need to measure and maintain holds true for fatigue management. Ongoing evaluation is necessary to determine whether a program or system remains effective and relevant.

Ideally, the measurement of the effectiveness of fatigue management should appropriately balance leading indicators and outcome measures. Two examples of leading indicators are the number of individuals diagnosed with and treated for sleeping disorders, and the number of individuals who self-report fatigue when at work. Outcomes involve the usual measures such as incident and accident rates, equipment damage, and feedback from employees.

The elements of fatigue monitoring are:

- Conducting a Fatigue Risk Assessment to calculate site-level risk and identify individual risk profiles
- Establishing a pre-shift or pre-task alertness testing protocol
- Implementing other management tools, such as real-time notifications (using a fatigue risk warning system) and countermeasures for fatigue risk mitigation

A fatigue risk warning system, such as that integral to Predictive Safety's PRISM fatigue management platform, works by calculating fatigue risk according to several inputs. Some inputs are based on the data points in a Fatigue Risk Index, which includes things like shift times and lengths against typical circadian rhythms. Other inputs

come from employees, like telling the system at clock-in how much sleep they had, and through taking brief alertness tests, like Predictive Safety's AlertMeter®, which can interface with the fatigue risk warning system. When the system detects abnormal inputs or determines that a heightened fatigue risk exists for an employee, it triggers an alert to supervisors, who can ensure the impaired or fatigued employee stops work and applies appropriate countemeasures.

Measuring sleep habits is important in considering personal fatigue risk that could impact whether a worker is fit for duty. For instance, in the PRISM system, a worker with three or fewer hours' sleep between shifts would be considered to have a high-risk fatigue status, while three to six hours' sleep would trigger a warning and require the worker to complete the alertness test. Getting more than six hours' sleep between shifts is ideal and indicates a fatigue status of "normal."

Fatigue in the workplace is as important to monitor as drug and alcohol use, if not more so, for three key reasons:

1. Shift workers are always susceptible to fatigue symptoms. Fatigue cannot be eliminated from shift work.
2. Unlike discretionary drug and alcohol use, proper sleep is not always possible.
3. Fatigue can affect brain function similarly to alcohol intoxication, which includes impairing judgment. This may result, for example, in a fatigued employee judging his or her own fatigue as less severe than it really is.

Another advantage of calculating individual fatigue risk with a range of inputs is that it can allow shift scheduling to be more "bio-compatible," or more suited to employees' circadian rhythms. For example, workers who generally demonstrate higher alertness levels in the evening than others can be scheduled for evening shifts.

Informed shift scheduling can help reduce fatigue risk during known "fatigue zones," or circadian ebbs. Fatigue zones are two four-hour stretches in a 24-hour period, from 3:00 a.m. to 7:00 a.m., and from 1:00 p.m. to 5:00 p.m., at some point during which people often feel tirerd, before their energy levels pick up again.

Findings and Conclusion

A study of Predictive Safety's PRISM fatigue management system at a South African iron mine showed that monitoring and managing fatigue risk had an immediate impact on mine employees' hours worked during high-risk fatigue zones. Consequently, over the course of the next year, shift attendance improved about 3% and incident rates per produced metric ton dropped about 35%.[6] When asked about their experience using the fatigue management system, 84% of workers and supervisors agreed that fatigue risk monitoring increased their awareness of job safety and performance. In addition, 80% of workers and supervisors agreed that fatigue risk management increased their ability to manage their own fatigue levels at work. Plus, 94% of workers thought that monitoring fatigue risk would help managers and supervisors understand the workforce better and help to improve their working conditions, and 96% of workers reported feeling better about their work environment knowing that their co-workers were being monitored for alertness/fatigue.[6]

Fatigue is both a personal and occupational risk factor. It is a complex mental state characterized by a lack of alertness and reduced mental and physical performance often accompanied by drowsiness. It is associated with spending long hours awake, an inadequate amount of sleep over an extended period or an insufficient quality of sleep, high physical and mental loads, and a number of non-work-related factors. From a practical viewpoint, it is doubtful that fatigue in the workplace can be eliminated altogether, but it certainly can be controlled and limited by proper management. Fatigue management is a shared responsibility between the organization and its employees, and all stakeholders should participate in order to provide the safest and healthiest working environment possible. To achieve this, a holistic approach based on best practices is required.

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References

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