An Ounce of Prevention: Considering Strategies to Prevent Fatigue-Related Accidents and Injuries in Maximum Containment Laboratories

Casey Skvorc, PhD, JD (C)
Behavioral Health Screening Official
Division of Occupational Health & Safety
Office of the Director, Office of Research Services
National Institutes of Health
• Fatigue defined
• Symptoms of Fatigue
• Subjective Fatigue
• Mood
• Willpower, Motivation, Professionalism
• Worker Fatigue and Public Safety
• Accidents
• Studies and Surveys
• Fatigue and Accidents
• High Containment Laboratory Workers
• For Consideration and Discussion
What is Fatigue?  How Does it Affect Us?

- Fatigue: a physiological state in which there is a lack of alertness, degradation in mental and physical performance, a decreased capacity to perform cognitive tasks, and increased variability in performance as a function of time on task.

- Fatigue is associated with an increase in likelihood of workplace injuries, increased errors, and slower reaction times.
Symptoms of Fatigue

- Measurable reduction in speed and accuracy of task performance
- Lapses of attention and vigilance
- Delayed reactions
- Impaired reasoning and decision-making, including a reduced ability to assess risk or appreciate consequences of actions
- Reduced ability to appreciate complex situations
- Reduced ability to communicate effectively
- Low motivation
- Impaired short term memory
- People are not the best evaluators of their own alertness state, and can lose awareness of their own fatigue levels.

- Individuals often do not notice the gradual change in performance until it is too late to take corrective action.
Fatigue Affects Mood

• Fatigue can affect overall mood.

• Fatigued individuals often show deteriorations in mood and have reductions in amount and quality of communication and social interaction with other individuals.

• This can have serious consequences for groups that rely on the exchange of information to provide mutual support and to avoid errors.
While it was once thought that fatigue could be overcome simply through the exertion of sufficient willpower, evidence has established that drowsiness is a physiologically-based reality that has little to do with motivation, professionalism, or training.
There have been serious accidents resulting in significant harm to the public safety in recent years in which worker fatigue has been identified as a major factor.
Accidents and incidents due to fatigue
Three Mile Island

On March 28, 1979 at 4 a.m., three operators made the first mistake in a series of errors that led to the worst nuclear accident in U.S. history.

The operators did not notice warning lights and failed to observe that a crucial valve had remained open.
Three Mile Island

- When the morning shift operators entered the control room the next day, they quickly discovered the problems, but it was too late.
- Pipes in the system had already burst, sending radioactive steam and water into the air and into 2 buildings.
- There was an evacuation of 140,000 pregnant women and pre-school age children from the area.
Three Mile Island

- Cleanup of the accident lasted from 1970 through 1993, and cost $975,000,000.

- Worker fatigue has been cited as a key component of multiple human error factors responsible for causing the disaster.
Chernobyl

• On April 28, 1986, in the early hours of the morning, two engineers tested the nuclear reactor at Chernobyl.
• Violating standard operational protocols, they deactivated two safety systems.
• This error of judgment, attributed consistently as a consequence of worker fatigue (though not by the Soviet government) led to the worst nuclear accident in history, at the time.
The Space Shuttle Challenger disaster occurred on January 28, 1986, when it broke apart 73 seconds into its flight, leading to the deaths of its seven crew members.

Before liftoff, NASA officials were advised by their contractors that outside temperature would be too cold for the carrier O-rings to properly function.
• Certain key managers had obtained <2 hours of sleep the night before.

• The decision to proceed with the launch, despite significant safety warnings, was identified as a key element in the explosion of the Space Shuttle.

• The Presidential Commission on the Space Shuttle Challenger Accident cited the contribution of human error and poor judgment related to sleep loss and shiftwork during the early morning hours to the disaster.
The Presidential Commission Report noted the following:

- “Working excessive hours, while admirable, raises serious questions when it jeopardizes job performance, particularly when critical management decisions are at stake.”
When the Exxon Valdez pulled away from the Alyeska oil terminal on the evening of March 23, 1989, its crew had worked 22 hours, loading 53 million gallons of North Slope crude oil in the ship’s cargo tanks. Characterized by the Chairman of the National Safety Board as “Probably the most expensive fatigue-related accident in history.”
Exxon Valdez Oil Spill

- About **258,000** barrels of cargo were spilled when eight cargo tanks ruptured, resulting in catastrophic damage to the environment and losses to the local wildlife.
- In the first year of cleanup more than **$2 billion** were expended. Final clean up costs were about **$3.8 billion**.

Exxon Valdez Oil Spill Facts

On March 23, 1989, at 9:12 p.m. the Exxon Valdez oil tanker left the Alyeska Pipeline to cross Prince William Sound carrying approximately 53 million gallons of crude oil. The tanker was headed for Long Beach, Calif. Three hours later, just after midnight on March 24th, the Exxon Valdez ran into Bligh Reef, spilling 10.8 million gallons of oil into the sound.

- The amount of oil spilled could fill 125 Olympic-sized swimming pools.
- 1,300 miles of coastline were hit by the oil spill.
- The cleanup required about 10,000 workers, 1,000 boats and roughly 100 airplanes and helicopters.
- Four deaths were directly associated with cleanup efforts.
- The spill caused over $300 million of economic harm to more than 32,000 people whose livelihoods depended on commercial fishing.

- Two years following the Exxon Valdez spill, the economic losses to recreational fishing were estimated to be $31 million.
- Twelve years after the spill, oil could still be found on half of the 91 randomly selected beaches surveyed.

Source: Oceana
• The Staff Nurse Fatigue and Patient Safety Study (2005) found a significant relationship between sleep in the prior 24 hours and the risk of making an error.

• Nurses who reported an error or near miss obtained significantly less sleep than nurses who did not report an error or near miss.

• Nurses with <6 hours of sleep in prior 24 hours were 3.4% more likely to have an error or near miss. *In a teaching hospital with 1000 nursing shifts, this translates to 34 events per day.*
The National Sleep Foundation conducted a survey of pilots (202), truck drivers (203), train operators (180), and bus/limo/taxi drivers (210) to compare their sleep habits and coping measures to a control group composed of individuals employed in fields outside transportation.

25% of train operators and 23% of pilots reported fatigue affected their job performance at least once per week, compared to 17% of non-transportation workers.
Pilots and train operators reported a much higher rate of car accidents in their commute to work (6%) compared to the control group (1%).

20% of pilots admit they have made a serious work error due to fatigue, and 18% of train operators and 14% of truck drivers report having a “near miss” because of fatigue.

57% of train operators and 50% of pilots report they rarely or never get a good night’s sleep on work nights.
• 44% of train operators and 37% of pilots report their current work schedule does not allow for adequate time for sleep, compared to about 25% of the control group.

• 13% of pilots reported having a second job, as compared to 10% of the control group.
• Pilot fatigue has been cited as a major contributor in aviation accidents.

• In the US Navy and Marine Corps, pilot fatigue has been identified as the top cause of damage exceeding one million dollars and involving a fatality/permanent disability or destroyed aircraft.
Railway Accidents Attributed to Worker Fatigue

• A Federal Railroad Administration study (2006) found human factor errors to be responsible for about 40% of all train accidents during a 5-year period and that fatigue played a role in approximately 25% of those accidents.

• A 2012 survey of transportation workers by the National Sleep Foundation found 26% of train operators said sleepiness affected their job performance at least weekly. About 18% of train operators reported having a “near miss” at work because of fatigue, and 44% of train operators said their work schedule did not allow enough time for sleep.
On 2011 the Washington Metropolitan Area Transportation Authority (WMATA) commissioned a study of metro rail employees in the operations and maintenance departments.

The Chairman of the Metrorail Safety and Security Committee observed:

- “Unlike somebody who might be intoxicated, people don’t realize they reach a point where they’re fatigued and their judgment is clouded. It is incumbent upon us to put in place guidelines on how many hours people work and how many hours of rest they need. This is one way to prevent bad things from happening.”
Maritime Accidents and Worker Fatigue

- Reports sponsored by the UK Maritime and Coastguard Agency and the Seafarers’ Research Centre (Scotland) surveyed 1,856 maritime workers, and examined ships logs.

- 25% of maritime workers reported falling asleep while on watch duty.

- 50% of maritime workers said their work schedules presented a danger to their personal safety.

- 37% reported their working hours sometimes posed a danger to the safe operation of their ship.
Fatigue and Accidents

Medical residents:

• Czeisler (2009): In a study of 2,700 first-year medical residents, 20% admitted to making a fatigue-related mistake that resulted in an injury to a patient.

• 5% admitted to making a fatigue-related mistake resulting in a patient death.

• Additional studies by Czeisler (2004) found hospitals could reduce the number of medical errors by as much as 36% by limiting an individual doctor’s work shifts to 16 hours and reducing the total work schedule to no more than 80 hours/week.
Commercial Motor Vehicle Drivers:

• The Large Truck Crash Causation Study reported that 13% of Commercial Motor Vehicle drivers were considered to have been fatigued at the time of their crash.

• 750 deaths and 20,000 injuries annually due directly to fatigued commercial vehicle drivers.
Commercial Motor Vehicle Drivers:

• The National Highway Traffic Safety Administration (conservatively) estimates that 100,000 police-reported motor vehicle crashes are the direct result of driver fatigue.

• The Institute of Medicine estimates that drowsy driving is responsible for 20% of all motor vehicle crashes – 1,000,000 crashes, 500,000 injuries, and 8,000 deaths per year in the United States.
Study: Fatigue Affects Baseball Players’ Strike-Zone Judgment

• An analysis of how often MLB batters swing at pitches outside the strike zone during the 2012 season – comparing the first month of the season to the last month – indicated that a hitter’s tendency to swing at pitches outside the strike zone progressively worsened over the course of the season.

• Decline tied to fatigue developed over the course of the season due to a combination of travel and lack of days off between games.
• 24 of 30 teams showed a significant decline in strike-zone judgment over the course of the season.
• The San Francisco Giants were outliers – and won the World Series.
• Players who rated themselves higher on fatigue score less likely to continue playing in their league three years later.
• 72% of players with sleepiness score of 5 or below were playing 3 seasons later – compared to 39% of players with a score of 10, and 14% of players with a score of 15.
• “Sleep predicts sports performance.”
The following public safety industries have standards - ranging from recommended guidelines to regulations - mandating breaks, rest periods, and intervals between work periods:

- Nuclear
- Aviation (pilots, air traffic controllers)
- Railway
- Trucking
- Bus drivers
- Maritime
- Astronauts
- Hospital workers (physicians, nurses, EMTs, air ambulance, ambulance drivers)
For maximum containment laboratory workers, there are currently no known equivalent published standards, regulations, or recommendations specifying:

- Frequency or duration of work breaks
- Rest periods
- Intervals between work shifts
The recognition of the necessity of protecting public safety in the event of an act of bioterrorism has resulted in a significant expansion in the number of high and maximum containment research laboratories in the United States, and the World.
High Containment Laboratory Workers
Maximum containment laboratories are designated for exotic agents that present high individual risk to workers from laboratory-generated aerosols and other exposure and for which there are no, or limited, vaccines or treatment options.
Even with protective measures, working in a maximum containment laboratory can be physically and psychologically stressful.

Personnel who work in positive pressurized suits are:

- Restricted in their movement
- Have limited peripheral vision, and
- May experience prolonged noise from the biocontainment suit air supply line are often confined to small areas for extended periods.
Maximum Containment Laboratory Workers

- Fast-moving breathing air supplied to personal protective suits can cause dehydration.
- The opportunity for personnel to take work breaks, including the use of restroom facilities, can be restricted by complex entry and exit requirements.
- Workers must be vigilant for potential suit tears, faulty equipment, and medical emergencies.
- Such chronic stressors may have an impact on safe employee performance over time.
For Your Consideration

• Are changes to current local practices in maximum containment laboratories indicated?

• What efforts should be made, if any, to provide mandatory training to supervisors and workers information regarding the importance of sleep and rest to prevent fatigue-related accidents and injuries?

• Who should provide this training?
For Consideration and Discussion

- What data are available to track fatigue-related injuries in maximum containment laboratories?

- Does accident and injury tracking take into account the worker’s accrued shift-work hours at the time of the accident/injury?
Should fatigue prevention standards be established specifying the number of hours workers routinely spend in high containment?

- Per shift
- With designated breaks
- With specified time off between shifts
• Should there be separate fatigue prevention standards for different classification of workers?

  • Principal Investigators
  • Post-Doctoral Fellows
  • Technicians
  • Animal Care Workers
  • Volunteers and Guest Laboratorians
For Consideration and Discussion

• Should specific fatigue prevention standards be in effect for:
  – Workers >40, >50, and >60 years of age?
  – Pregnant workers?
  – Workers who have second jobs/moonlighting?
  – Workers whose one-way commute is >60 minutes?
  – Single parents with infants?
  – Other workers with significant additional outside-work demands and stressors?
• Should validated cognitive test measures reflecting alertness and vigilance be developed?
For Consideration and Discussion

• Should workers who are at high risk for sleep apnea (weight, neck circumference, and/or self-report to occupational medical services) be required to undergo sleep studies to assess sleep function?

• If yes, would workers with dx of sleep apnea be required to utilize CPAP equipment to enhance daytime alertness and vigilance?
For Consideration and Discussion

- What self-reporting mechanisms should be in place for workers?
- What job protections should be in place?
- What reporting mechanisms should be in place to report fellow-workers experiencing fatigue?
For Consideration and Discussion

- Should workers be asked if they have a preference for working early morning hours, or late hours – and then accommodated when possible?

- If no industry-wide standards are recommended, who should establish the shift-working conditions for individual maximum containment laboratories?
• Please contact the author for Selected Bibliography.