



Fatigue as a Human Factors Safety Risk

2026 PAPUC Safety Conference
September 10, 2026



Fatigue Risk Management
Solutions for Safety Teams

Who We Are



**INSTITUTES FOR
BEHAVIOR RESOURCES, INC.**
shaping a better world

- Non-profit research and behavioral sciences company
- Scientific consultants
- Providers of SAFTE-FAST



- Fatigue Risk Management (FRM) Software System
- In-house development & support staff
- Agile and low-cost service integrator

Who am I?

IBR Chief Sleep Scientist

Jaime K Devine

Ph.D. in Neuroscience

Areas of Expertise:

- Sleep Medicine
- Operational Fatigue and Performance
- Health Psychology



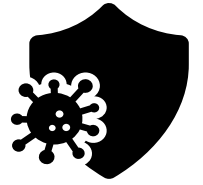
What is Fatigue?

A complex state of diminished alertness that is primarily caused by lack of sleep

Why is sleep important?



Memory
and brain
health



Immune
function



Mood and
mental health



Ability to
think



Physical
function and
wellness

National Safety Council Fatigue Cost Calculator



Fatigue Cost Calculator

Fill in specifics to your organization

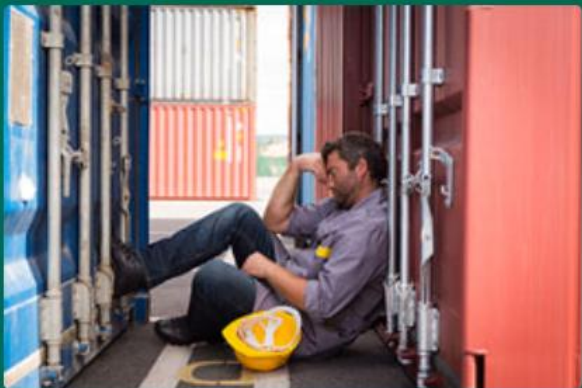
TOTAL ANNUAL COST: \$93,301



Absenteeism

COST:

\$19,911



Decreased Productivity

COST:

\$43,398



Healthcare

COST:

\$29,991

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Report

Fatigue is a threat to safety.

National Safety Council. "Fatigue in Safety-Critical Industries: Impact, Risks & Recommendations" (2018).



NSC Fatigue Report

Employers report the impact of fatigue on their organization

Industry	Feel the impact of fatigue	Experience productivity decreases	Experience safety incidents
Construction	94%	71%	45%
Manufacturing	89%	73%	44%
Transportation	97%	66%	45%
Utilities	91%	64%	41%
All industries	90%	67%	32%

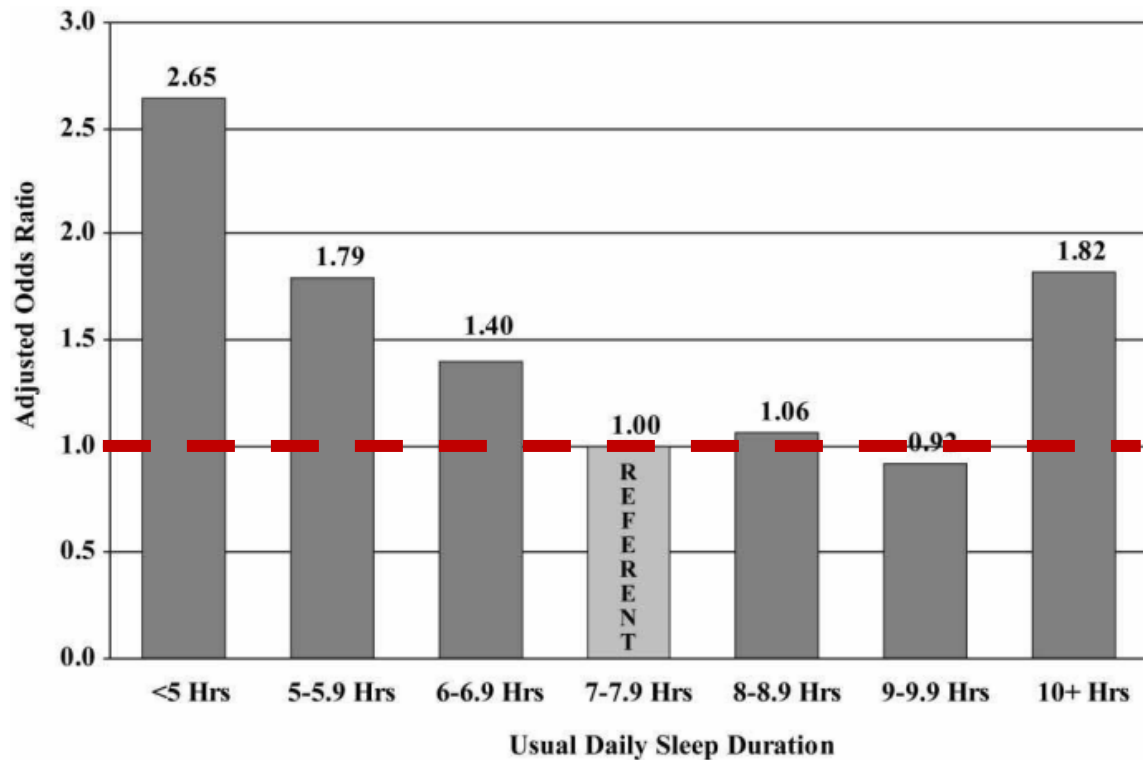
Adults need about 8 hours of sleep per night to function



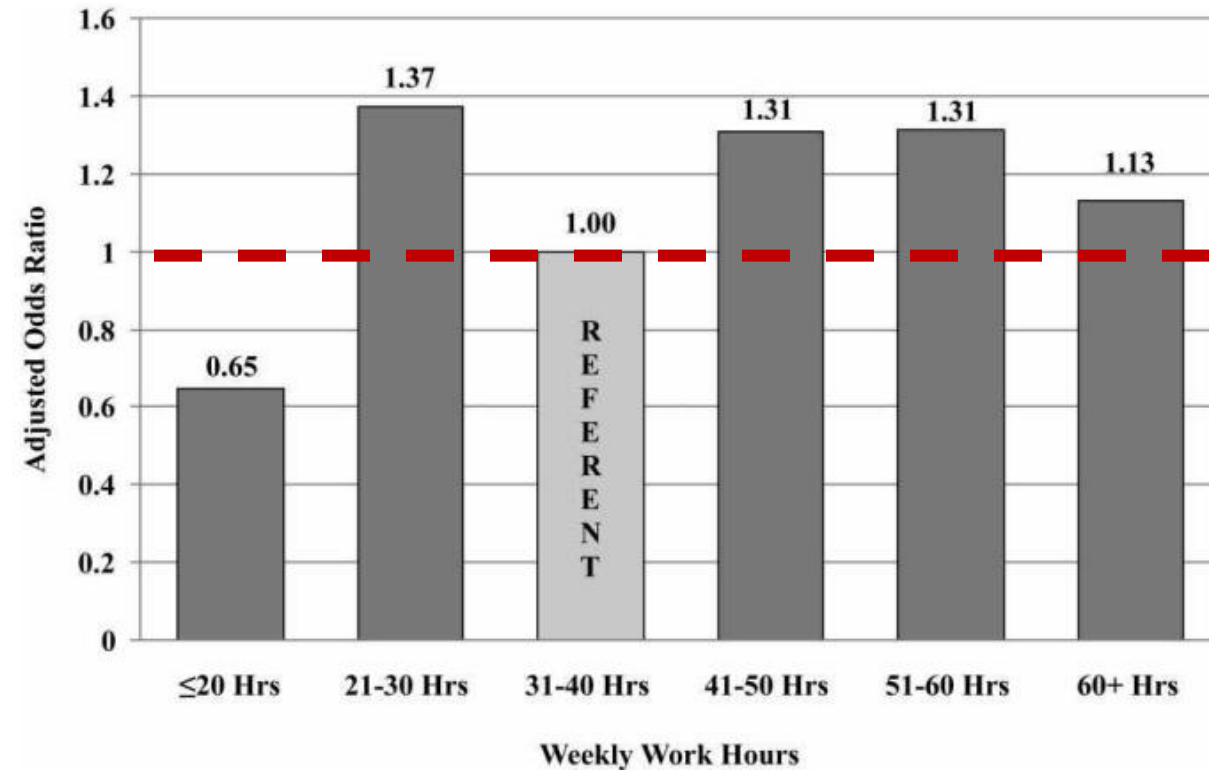
Fatigue is a threat to safety.

Lombardi, et al. "Daily sleep, weekly working hours, and risk of work-related injury: US National Health Interview Survey (2004–2008)." Chronobiology international (2010).

Injury Risk and Hours of Sleep

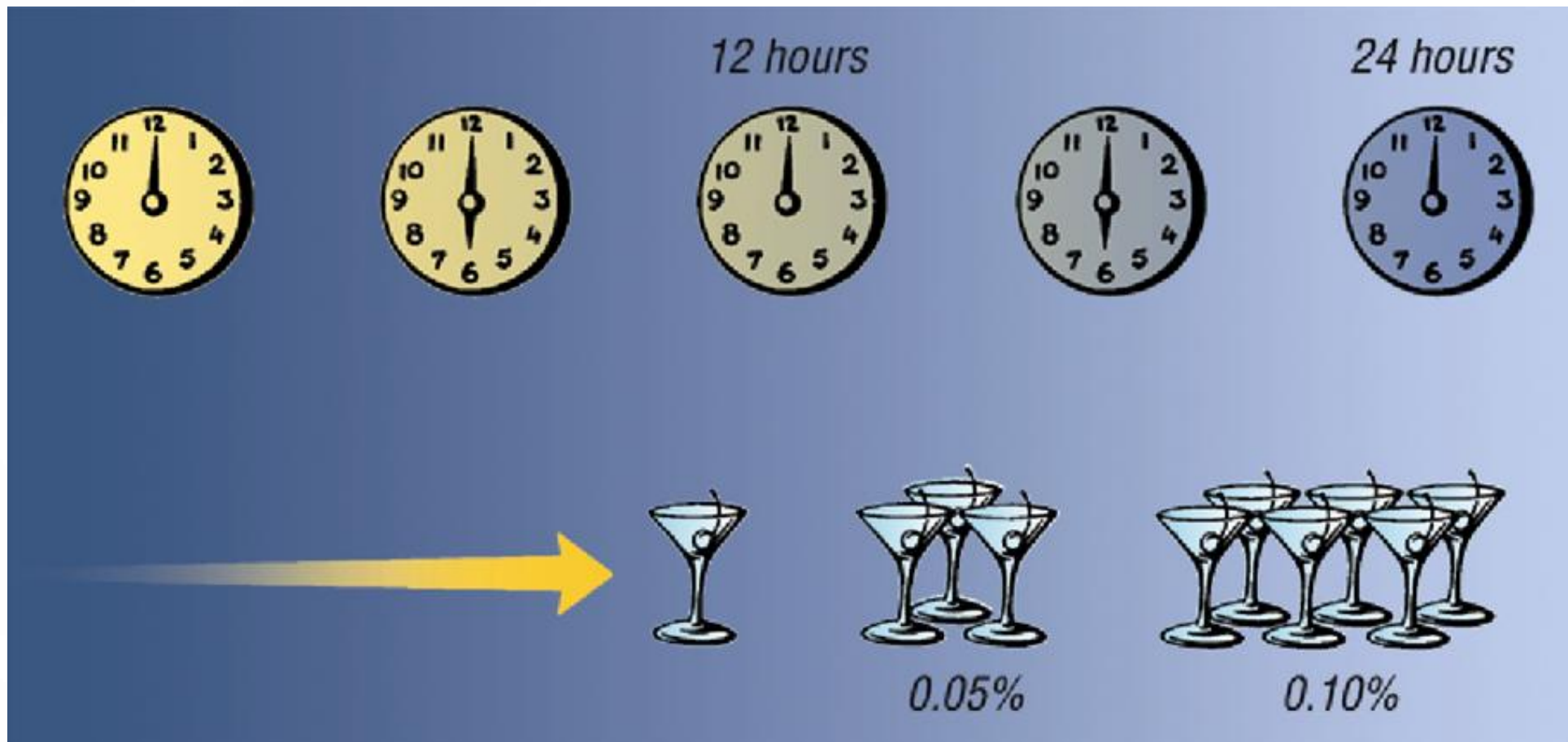


Injury Risk and Working Hours



Performance deficits due to sleep loss are similar to deficits due to alcohol consumption

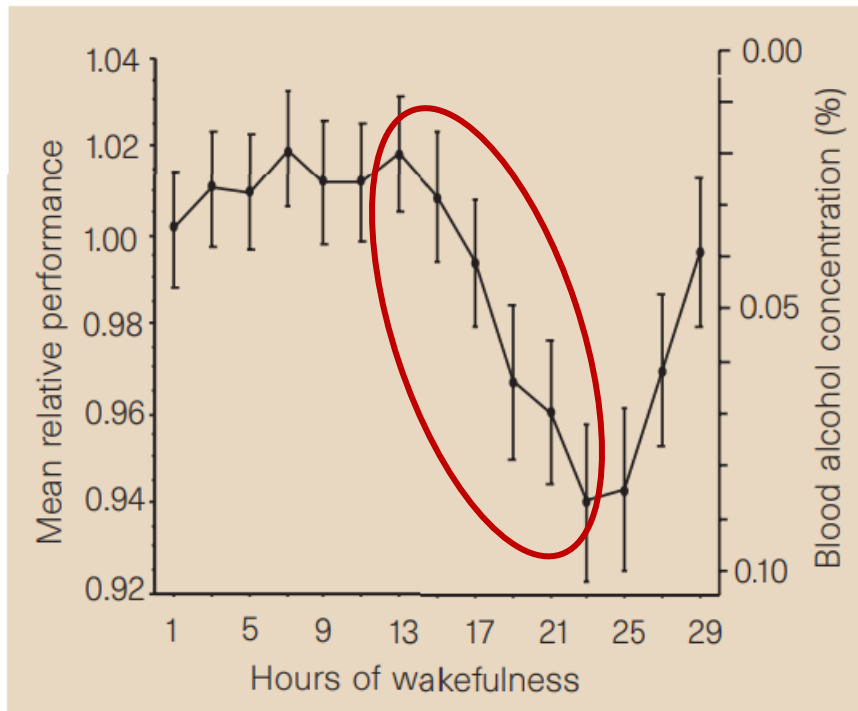
From North American Fatigue Management Program for Commercial Motor Vehicle Operators



Sleep Loss vs. Blood Alcohol Concentration (BAC)

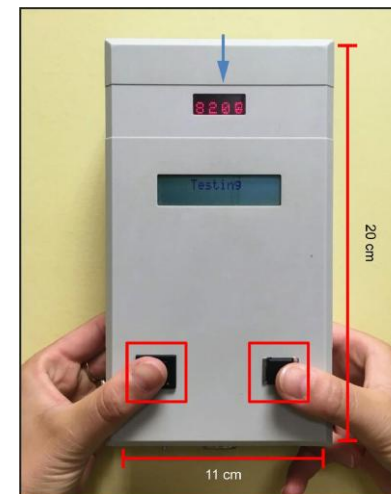
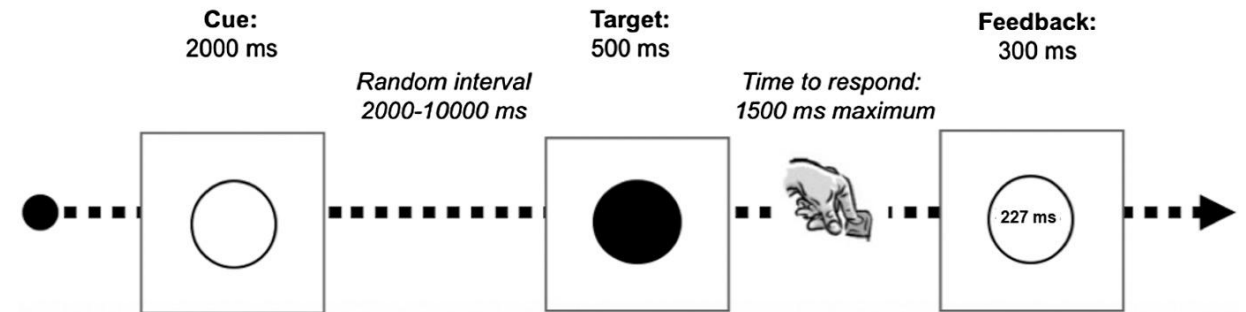
Dawson and Reid. Fatigue, alcohol and performance impairment. Nature (1997).

Fatigue vs. Alcohol Consumption



Psychomotor Vigilance Task (PVT)

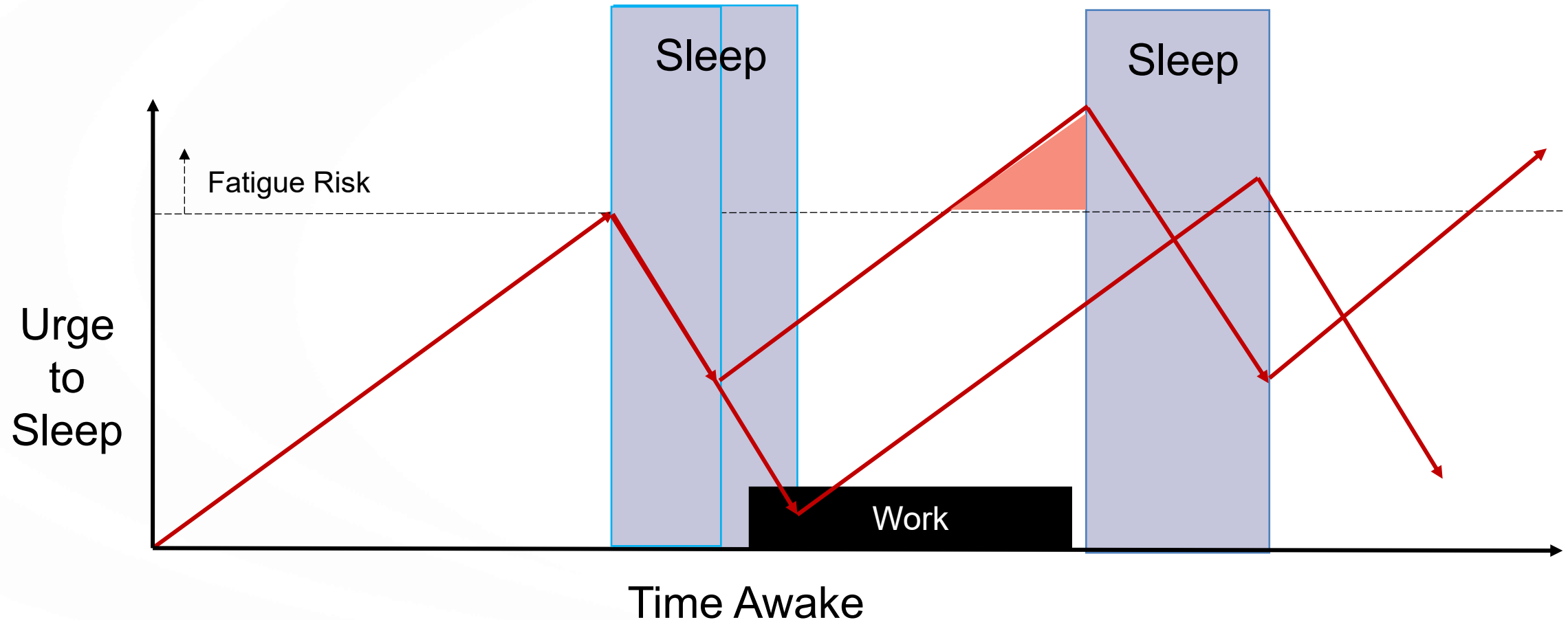
The Psychomotor Vigilance Task (PVT) procedure



The biological urge to sleep is predictable.

The longer it has been since you last slept, the more you will feel compelled to sleep.

Shorter sleep episodes will result in greater feelings of fatigue.



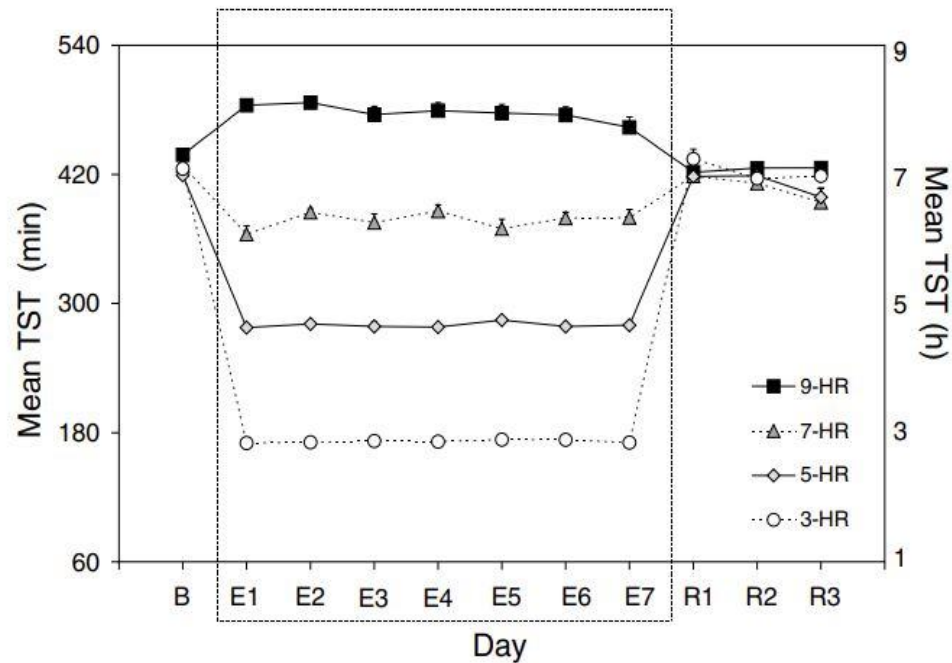
Sleep debt that builds over time impairs performance

Belenky, et al. "Patterns of performance degradation and restoration during sleep restriction and subsequent recovery: A sleep dose-response study." Journal of sleep research (2003).

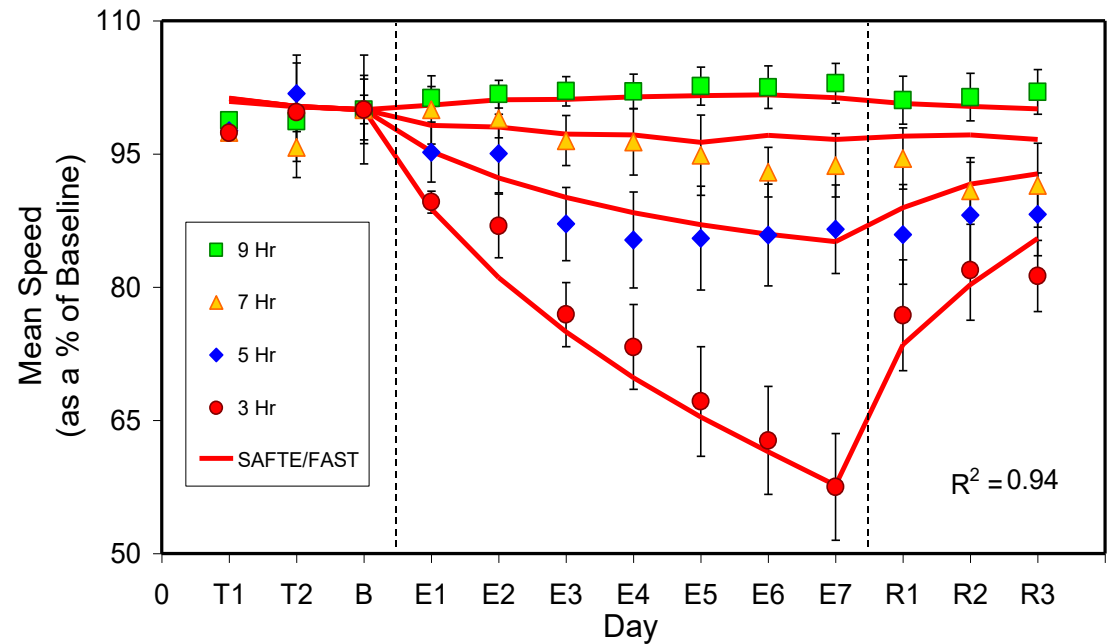
Sleep restriction over time

PVT Performance

Total Sleep Time (TST)



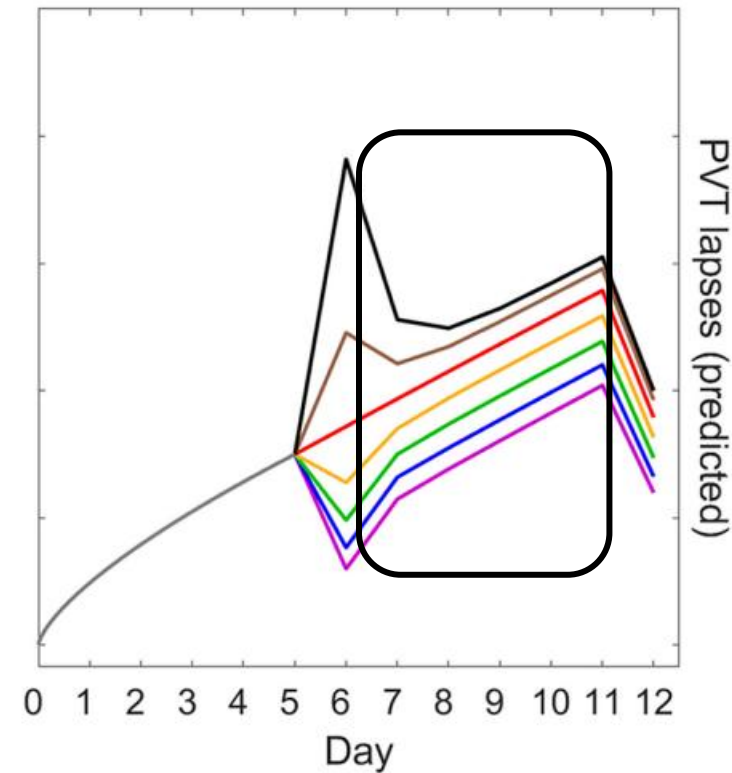
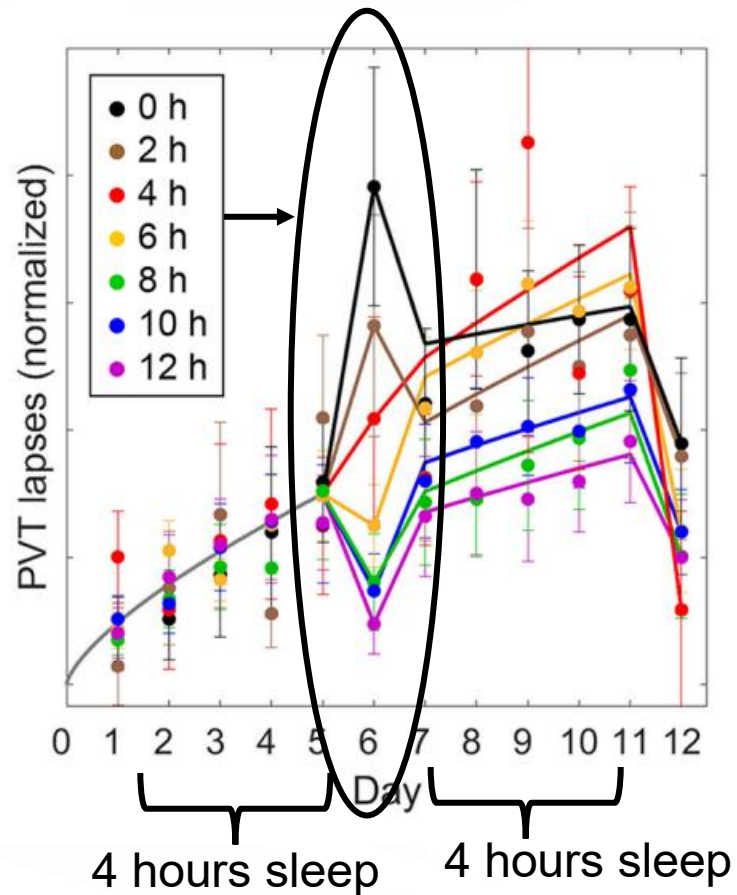
PVT Speed Chronic Restriction Adaptation



One night of bad or good sleep does not undo old habits

McCauley, et al. "The dynamics of neurobehavioral impairment and recovery sleep: improved biomathematical modeling for fatigue risk management in operational settings." *Frontiers in Environmental Health* (2024).

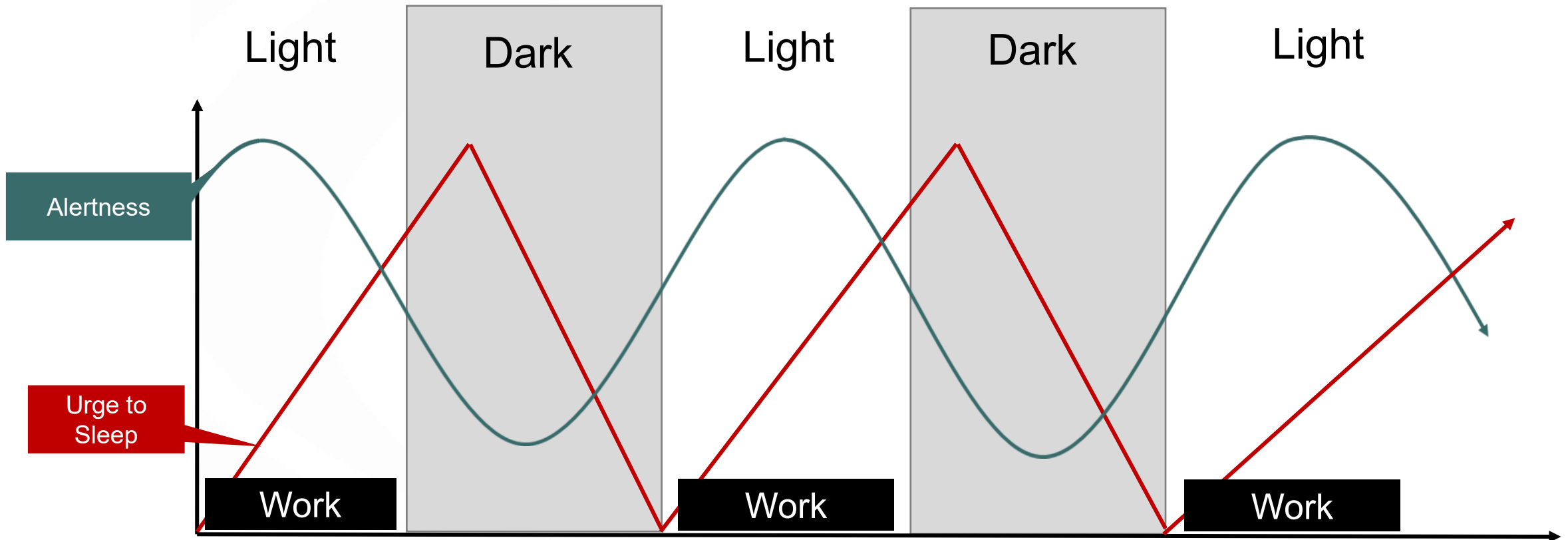
Your performance will normalize to your behavior over time.



Time of day influences fatigue as well.

Our circadian rhythm predisposes us to be active during the day and sleep at night.

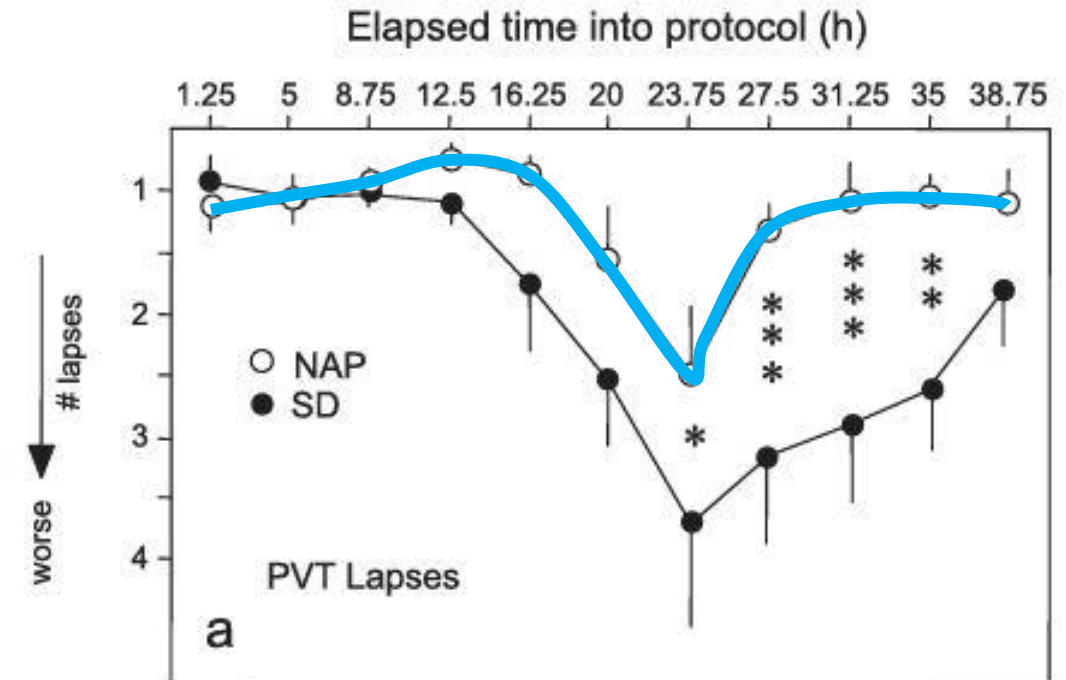
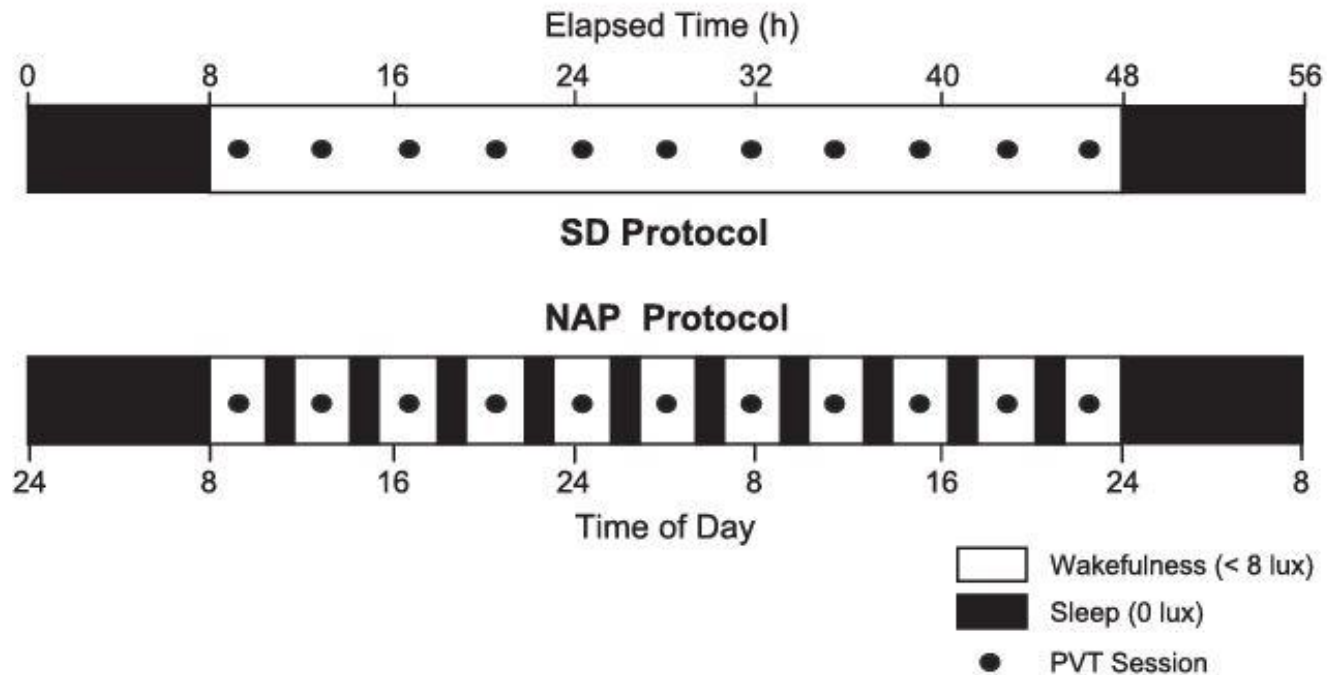
Even a well-rested person will feel less alert during night.



Cognitive performance will be worse at night even if the individual is well rested

Graw et al. "Circadian and wake-dependent modulation of fastest and slowest reaction times during the psychomotor vigilance task." Physiology & behavior (2004).

Time of day impacts PVT performance

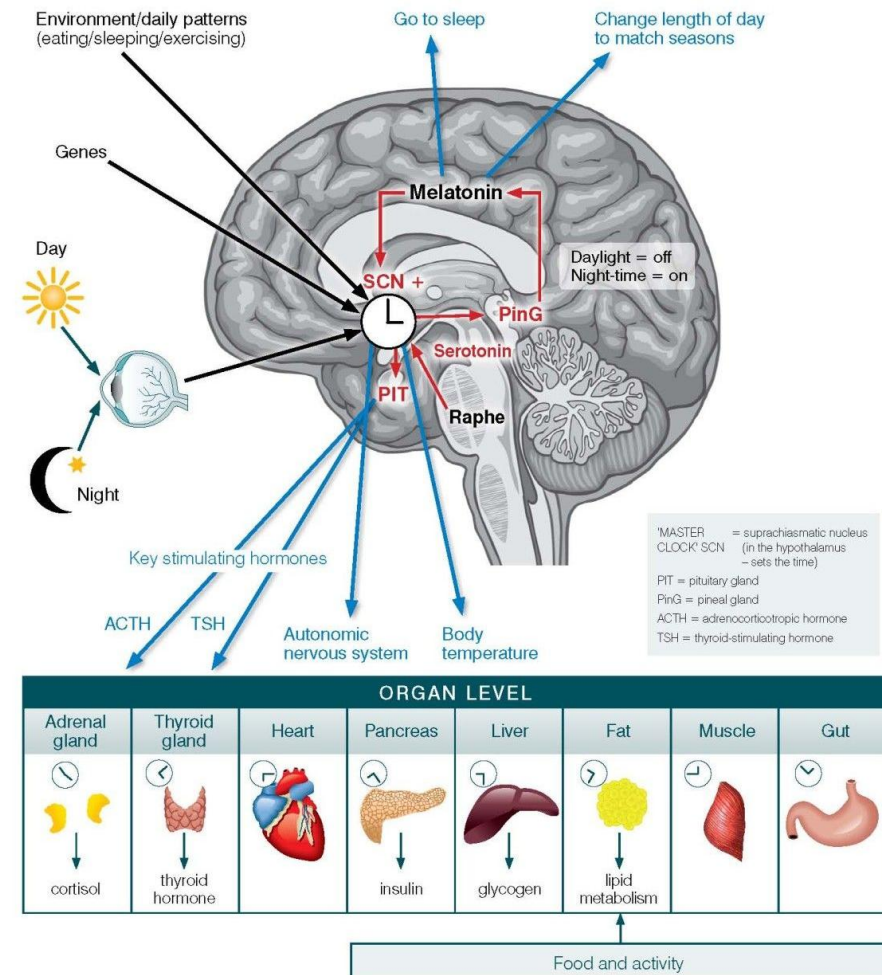


Biology of the Circadian Rhythm

Hickie, et al. "Manipulating the sleep-wake cycle and circadian rhythms to improve clinical management of major depression." BMC medicine (2013).

Humans evolved to be awake during the day and asleep at night

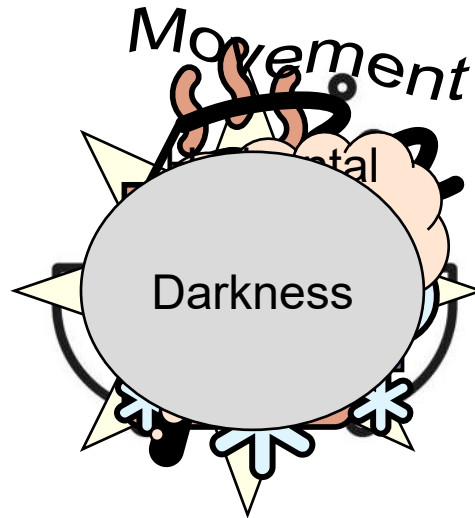
- Circadian rhythm is encoded in genes
- Brain and body organs have “clocks”
- Body clock takes cues from outside world
 - Cues are called zeitgebers:
 - Exposure to light
 - Sleep timing
 - Food intake
 - Food timing
 - Exercise



Name That Zeitgeber!

Some activities signal the brain that it is time to sleep while others signal that it is time to be awake.

Time to Sleep



Time to Be Awake

Shift Work Sleep Disorder (SWD)

Pallesen, et al. "Prevalence of shift work disorder: a systematic review and meta-analysis." Frontiers in psychology (2021).

SWD affects 26.5% of shift workers.

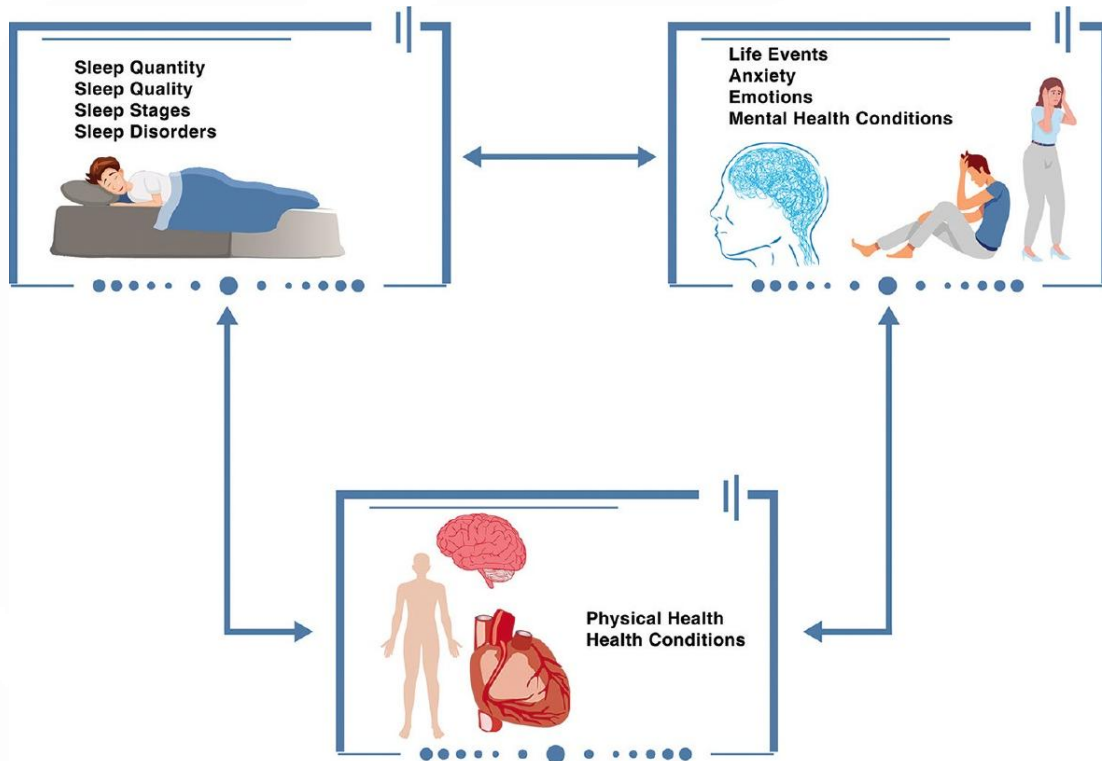


Shift Work, Sleep Disorders, and Mental Health.

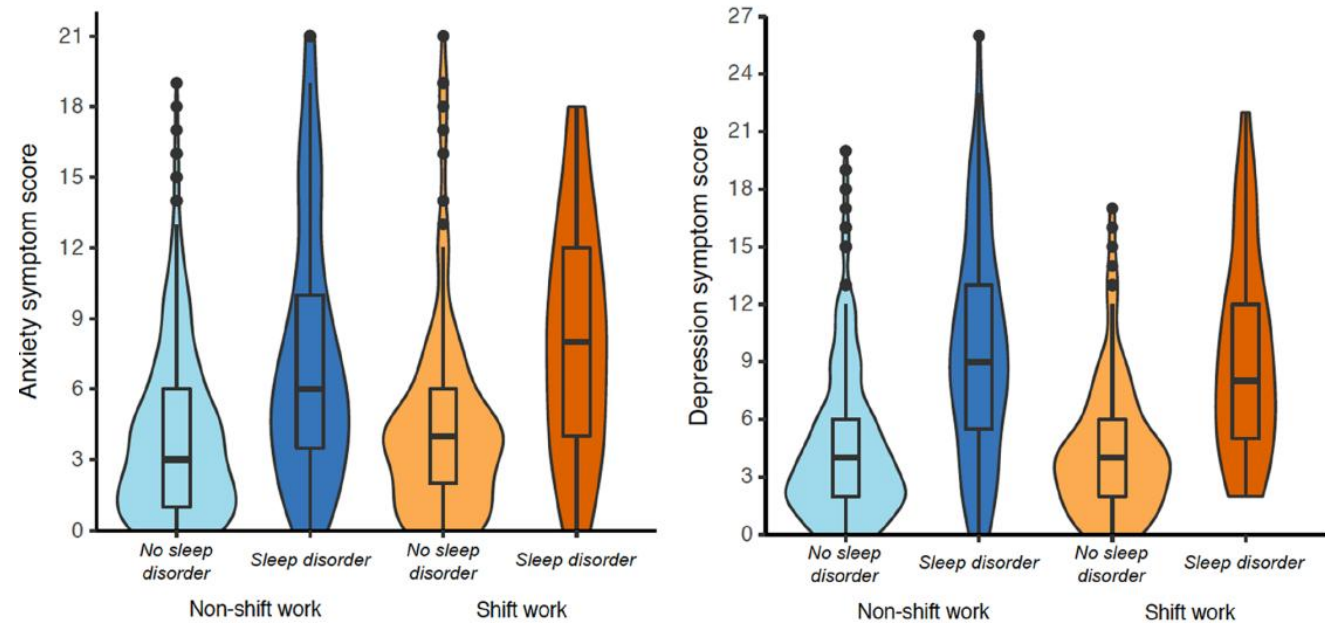
Howarth and Miller. "Sleep, sleep disorders, and mental health: a narrative review." Heart and Mind (2024).

Reynolds, et al. "Shift work, clinically significant sleep disorders and mental health in a representative, cross-sectional sample of young working adults." Scientific reports (2022).

Sleep is Related to Physical and Mental Health



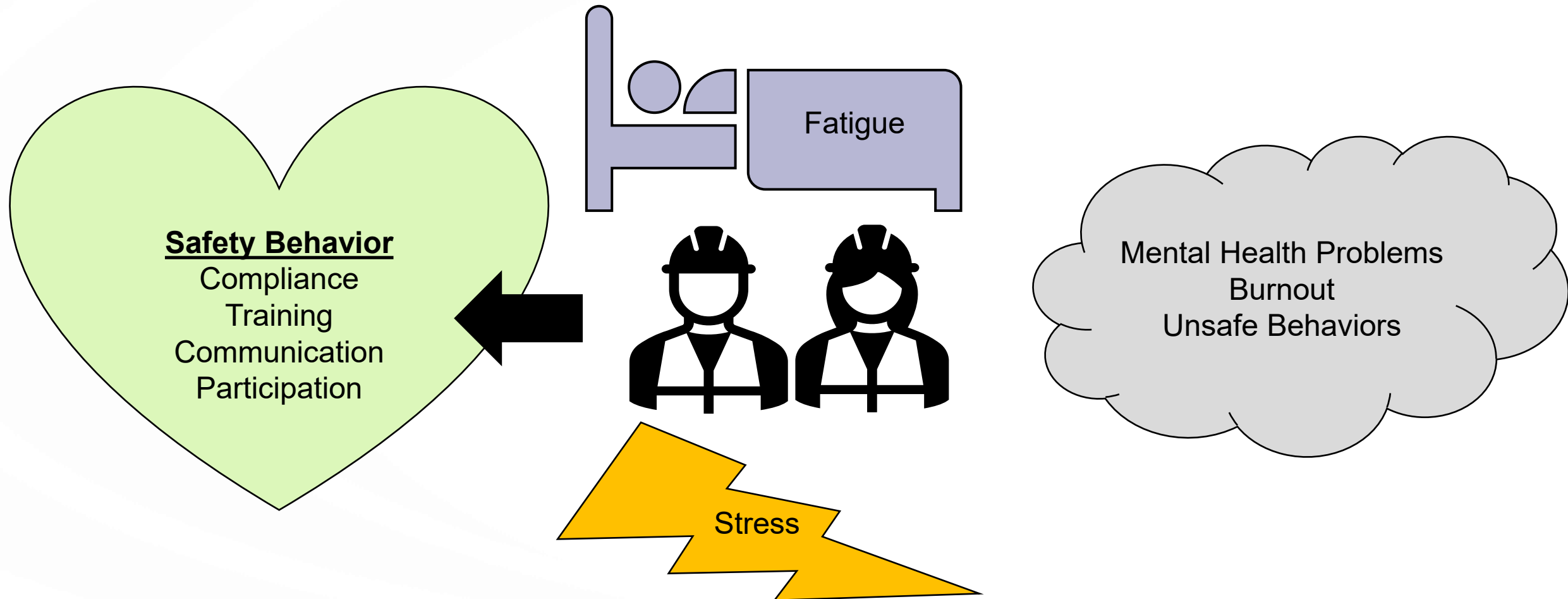
Shift Workers with Sleep Disorders Report More Anxiety/Depression



Fatigue and Mental Health are Related to Risk.

Tong, et al. "A dual perspective on work stress and its effect on unsafe behaviors: The mediating role of fatigue and the moderating role of safety climate." Process Safety and Environmental Protection (2022).

Mental health and fatigue are closely entangled with stress and safety behavior.



What can you do about it?

Optimize the bedroom environment.



What can you do about it?

Optimize the work environment.



What can you do about it?

Recommendations from the National Safety Council



NSC Fatigue Report



- **Limiting hours of service**



- **Creating a workplace safety culture**



- **Fatigue Risk Management System (FRMS)**

- Policies, practices, programs, and procedures that focus on fatigue management as part of a broader safety management system.



- **Driver alert systems**



- Technologies that alert drivers to potential fatigue, ranging from lane departure warning systems to driver-state monitoring systems.

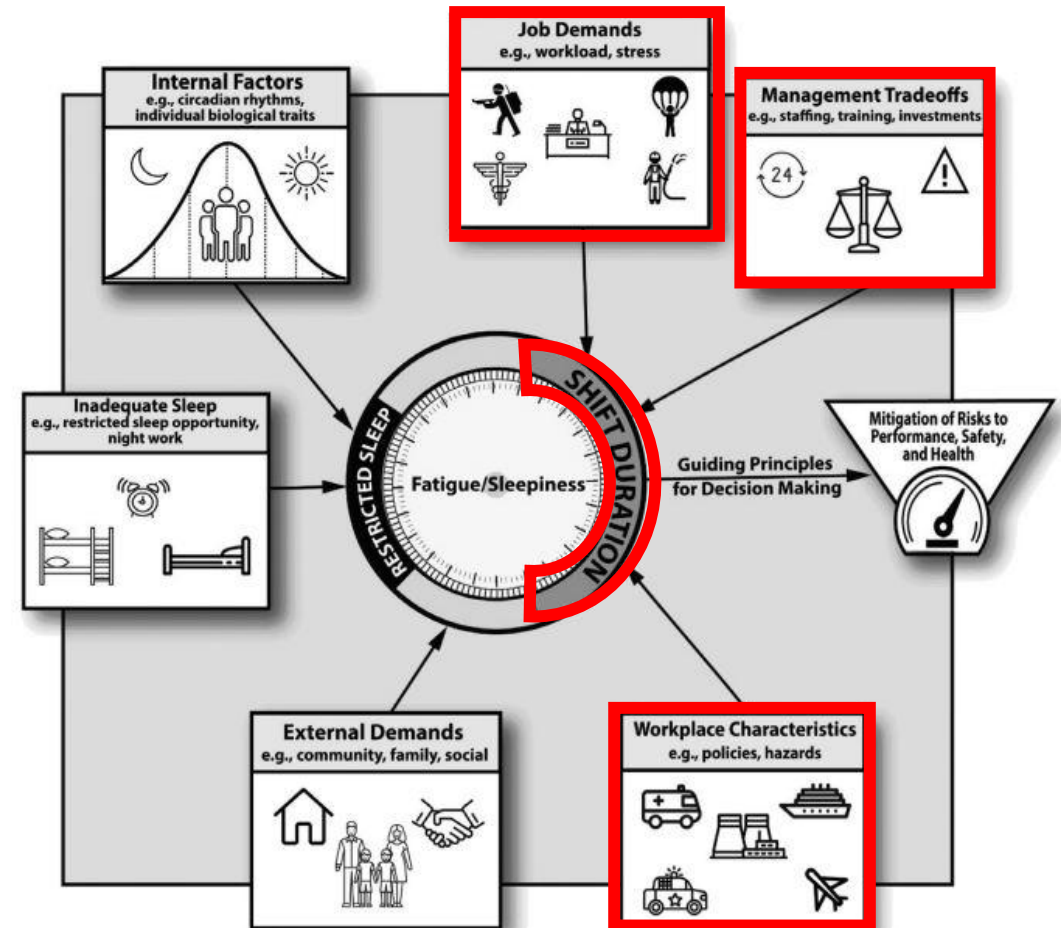
What can you do about it?

Gurubhagavatula, et al. "Guiding principles for determining work shift duration and addressing the effects of work shift duration on performance, safety, and health: guidance from the American Academy of Sleep Medicine and the Sleep Research Society (2021).

Science-based approaches need:

1. Recognition of fatigue factors
2. Evidence-based fatigue countermeasures
3. Informed approach to managing work hours in a workplace-specific way

Factors influencing fatigue risk



Fatigue Factors in Utilities



NSC Fatigue Report

Workplace Fatigue Risk Factors at a Glance

Shift work:

Night shifts, early morning shifts, rotating and irregular shifts disrupt the body clock

Quick shift returns:

Employees need at least 12 hours between shifts to recover

Long shifts:

Working 10 or more consecutive hours

Long weeks:

Working 50 or more hours a week

High-risk hours:

Working at night or in the early morning, even infrequently

Demanding jobs:

Work that requires sustained attention or is physically or cognitively demanding

No rest breaks during shift:

Short breaks allow employees to rest and re-energize

Sleep loss:

Getting less than the necessary seven to nine hours of sleep a day

Long commutes:

Driving more than 30 minutes each way to work

Employee-reported number of risk factors by industry

Industry	One risk factor	Two or more risk factors
Construction	100%	92%
Manufacturing	98%	89%
Transportation	99%	94%
Utilities	97%	79%
All industries	97%	80%

Employee-reported risk factors

Risk factor	Construction	Manufacturing	Transportation	Utilities	All industries
Shift work	8%	16%	26%	17%	17%
High-risk hours	46%	45%	64%	45%	41%
Demanding job	77%	86%	86%	83%	81%
Long shifts	27%	30%	42%	28%	21%
Long weeks	28%	28%	32%	24%	22%
Sleep loss	41%	46%	48%	34%	43%
No rest breaks	8%	8%	12%	0%	10%
Quick shift returns	18%	11%	23%	7%	14%
Long commutes	46%	34%	36%	45%	31%

SAFTE-FAST as a fatigue mitigation scheduling tool



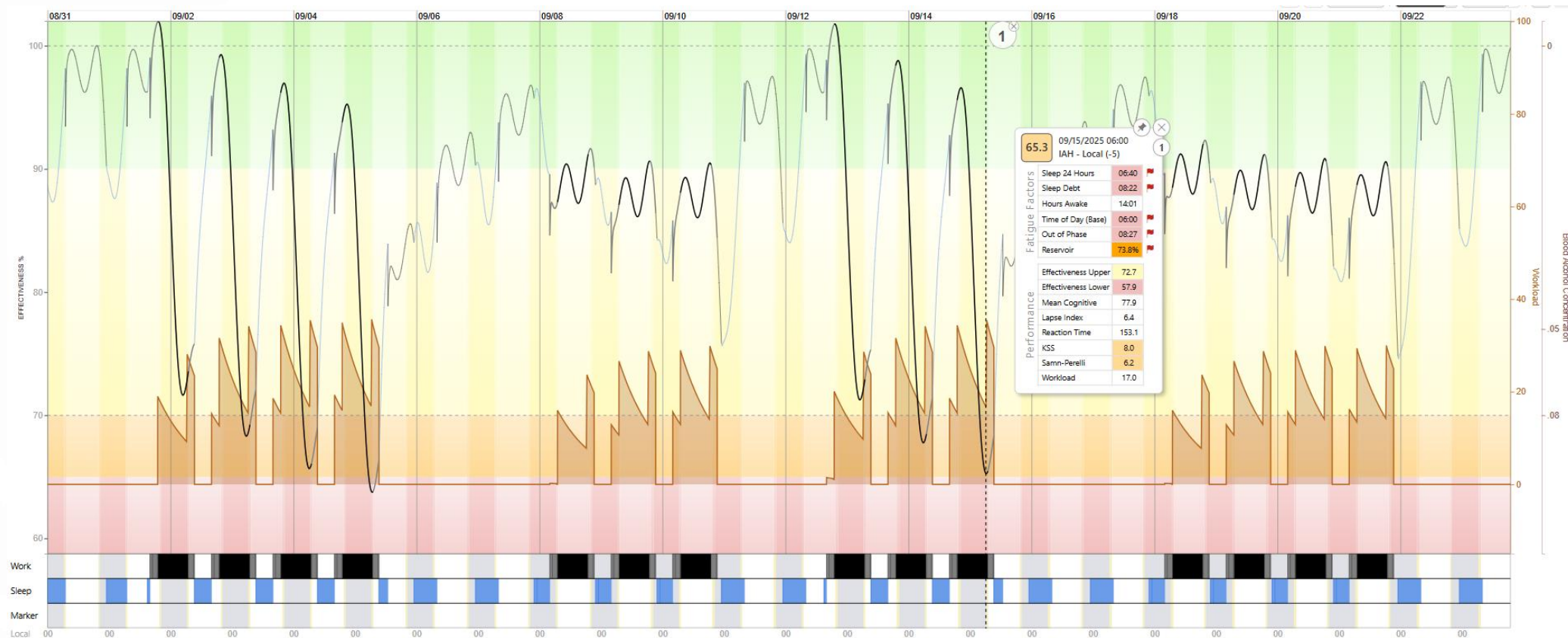
Dupont Schedule

A 12-hour rotating shift pattern in which crews work a specific shift schedule every 4 weeks.

Schedule Breakdown

- Week 1:
 - 4 night shifts
 - 3 rest days
- Week 2:
 - 3 day shifts
 - 1 rest day
 - 3 night shifts
- Week 3:
 - 3 rest days
 - 4 day shifts
- Week 4:
 - 7 rest days

SAFTE-FAST Effectiveness Prediction: DIDO, 7 PM/AM, 2-Hour Commute



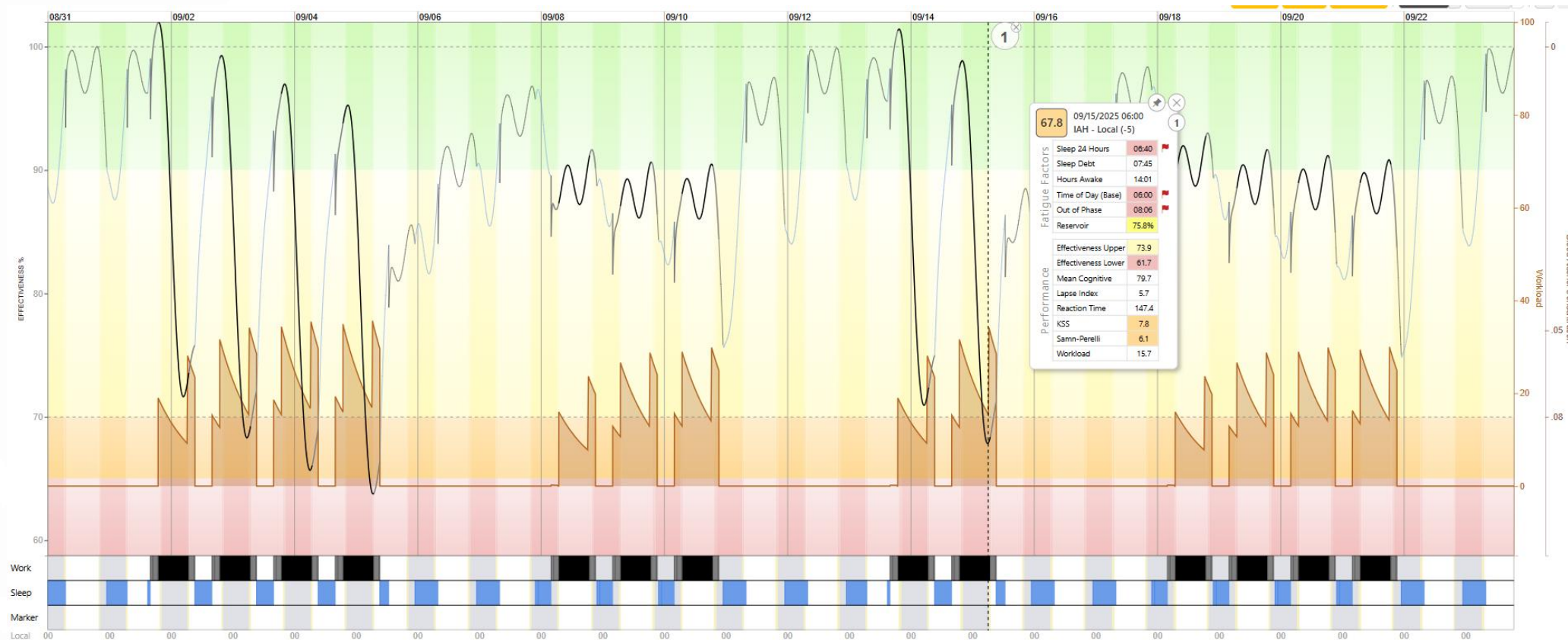
Dupont Schedule

A 12-hour rotating shift pattern in which crews work a specific shift schedule every 4 weeks.

Schedule Breakdown

- Week 1:
 - 4 night shifts
 - 3 rest days
- Week 2:
 - 3 day shifts
 - **2 rest day**
 - **2 night shifts**
- Week 3:
 - 3 rest days
 - 4 day shifts
- Week 4:
 - 7 rest days

SAFTE-FAST Effectiveness Prediction: DIDO, 7 PM/AM, 2-Hour Commute



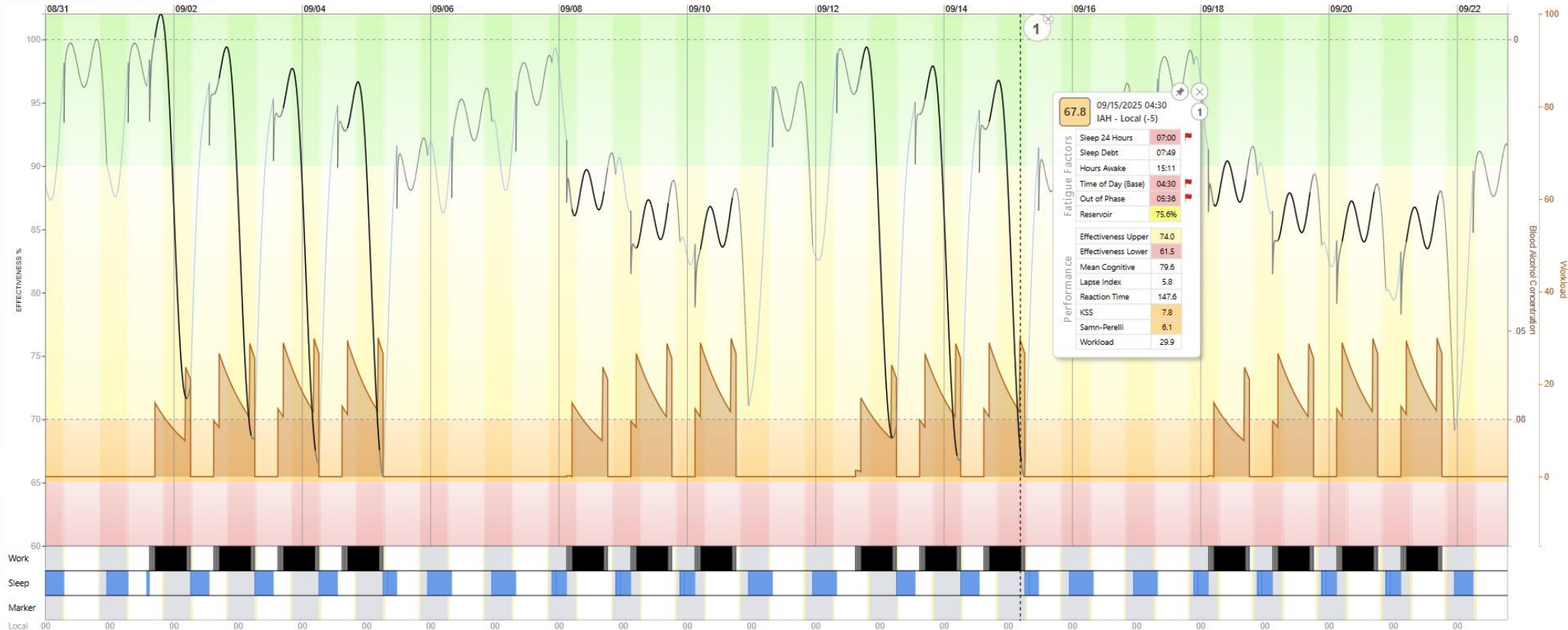
Dupont Schedule with Early Start

A 12-hour rotating shift pattern in which crews work a specific shift schedule every 4 weeks.

Schedule Breakdown

- Week 1:
 - 4 night shifts
 - 3 rest days
- Week 2:
 - 3 day shifts
 - 1 rest day
 - 3 night shifts
- Week 3:
 - 3 rest days
 - 4 day shifts
- Week 4:
 - 7 rest days

SAFTE-FAST Effectiveness Prediction: DIDO, 5 PM/AM, 1-Hour Commute



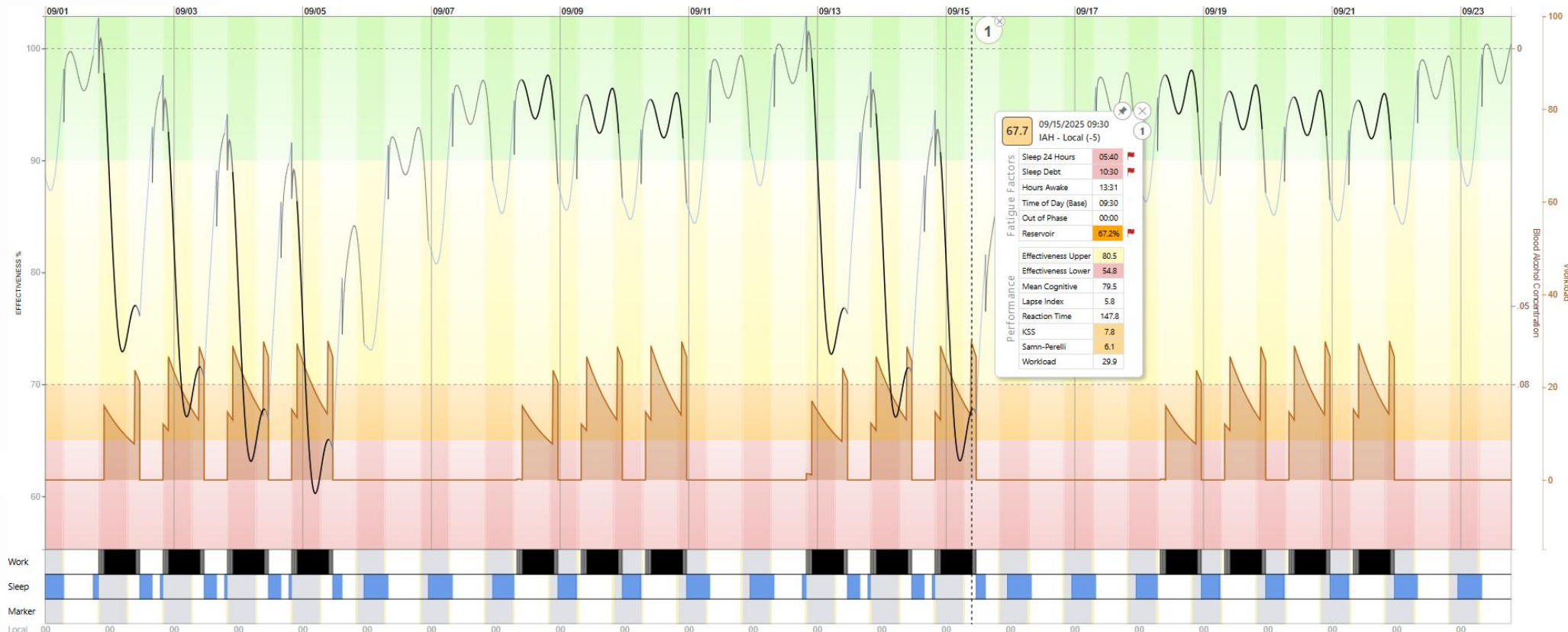
Dupont Schedule with Late Start

A 12-hour rotating shift pattern in which crews work a specific shift schedule every 4 weeks.

Schedule Breakdown

- Week 1:
 - 4 night shifts
 - 3 rest days
- Week 2:
 - 3 day shifts
 - 1 rest day
 - 3 night shifts
- Week 3:
 - 3 rest days
 - 4 day shifts
- Week 4:
 - 7 rest days

SAFTE-FAST Effectiveness Prediction: DIDO, 10 PM/AM, 1-Hour Commute



Consultancy (Professional Services)

PhD FRMS Consultancy and Outsourced Modeling and Analysis

PhD FRMS Consultancy

- Development and Support of Fatigue Risk Management Systems
- Education and Training
- Policy Development
- Research Services

Outsourced Modeling and Analysis

- Schedule Modeling and Analysis
- Results and Recommendations Report



Fatigue Reports

Alternative to full software licensing

Report Overview

- IBR provides fatigue reports on a contract basis
- Reports depend on:
 - Type of schedules
 - Number of schedules to be analyzed
 - Risk evaluation criteria
- Reports highlight schedules at risk and make recommendations for mitigation

Report Example

SAFTE-FAST Plot for DIDO Medic 01

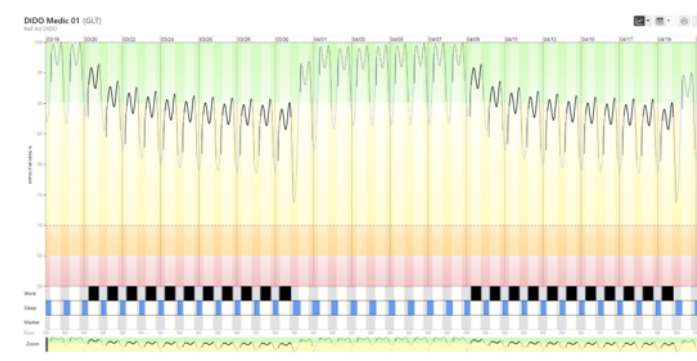


Figure 1: FAST graph for DIDO Medic 01

Figure 1 shows the work shifts and estimated sleep times for the DIDO Medic 01 schedule. This schedule has two identical periods of 11 consecutive workdays. Each of those 11-day periods begins with a crewing event from 06:00-18:30, which includes a 3.5-hour self-drive commute from 06:00-09:30, followed by a non-crewing event from 18:30 to 19:00. This is followed by nine 12-hr and 15 min day shifts from 06:00 to 18:15 with non-crewing events occurring prior to (5:15-06:00) and after (18:30-19:00) the crewing event. The final workday in this period is scheduled with a non-crewing event from 05:00-06:00 and a crewing event from 06:00-20:00. This final crewing event includes a 3.5-hour self-drive commute at the end of the work event from 16:30-20:00. This is followed by nine days off before an identical work period is repeated.

AutoSleep estimates 6 hours and 45 minutes of sleep prior to the first shift of the work period with 6 hours and 17 minutes of continuous sleep between each work event. Sleep on days off is estimated at 9 hours of continuous sleep.

It was determined that there is no fatigue risk with this proposed schedule. The minimum crewing effectiveness occurs on the final workday of the work period at approximately 13:30 with an effectiveness score of 85.7. While shorter than the recommended 8 hours of sleep per night, the estimated sleep of approximately 6 hours is enough time to adequately refill the sleep reservoir enough to provide recovery for subsequent shifts within the work period. The mitigating effects on cumulative fatigue could be due in large part to the timing of the sleep which occurs over night when sleep is most restorative.

Summary

To summarize the overall modeling results, neither of the two schedules had any duty time below the FRA criterion threshold (70%) nor had any time below the FAA criterion of 77%. Graphs and analysis of both schedules are provided. While overall total sleep time was estimated to be below the recommended 8 hours of sleep for full recovery, the approximate 6 hours of estimated total sleep time per work night was adequate enough to slow the degradation of effectiveness from reaching a level of risk below the FAA or FRA threshold criterion. It is proposed that the timing of the sleep period each night, along with working during normal day hours, had the largest mitigating effect on the cumulative fatigue over the proposed work period due to the natural circadian effect of overnight sleep and wakefulness during the day being kept largely intact.

No fatigue mitigations are needed for either of these proposed schedules at this time.

Fatigue Awareness

Raise Awareness at Work and with your Workforce

Promote Fatigue Awareness!

Free & Bespoke Documents Available



- SAFTE-FAST branded documents are free for our customers.
- Fatigue Awareness Documents Available:
 - Posters, Pamphlets and Booklets
- Each document type can be customized to include customer logo, color & font themes and personalized content.
- Place posters in bustling workplace spots such as break rooms, crew rooms, and common areas.
- Provide pamphlets and booklets during new hire training as an additional resource crew can retain for future reference beyond the training period.

Individual Risk Assessment and Mitigation

Individual assessments should not be punitive.

- Sleep Disorder Screening
- Annual Physicals
- Mental Health Resources
- Peer Support and Organizational Support
- Cover Risk Assessments and Available Resources in Education and Training

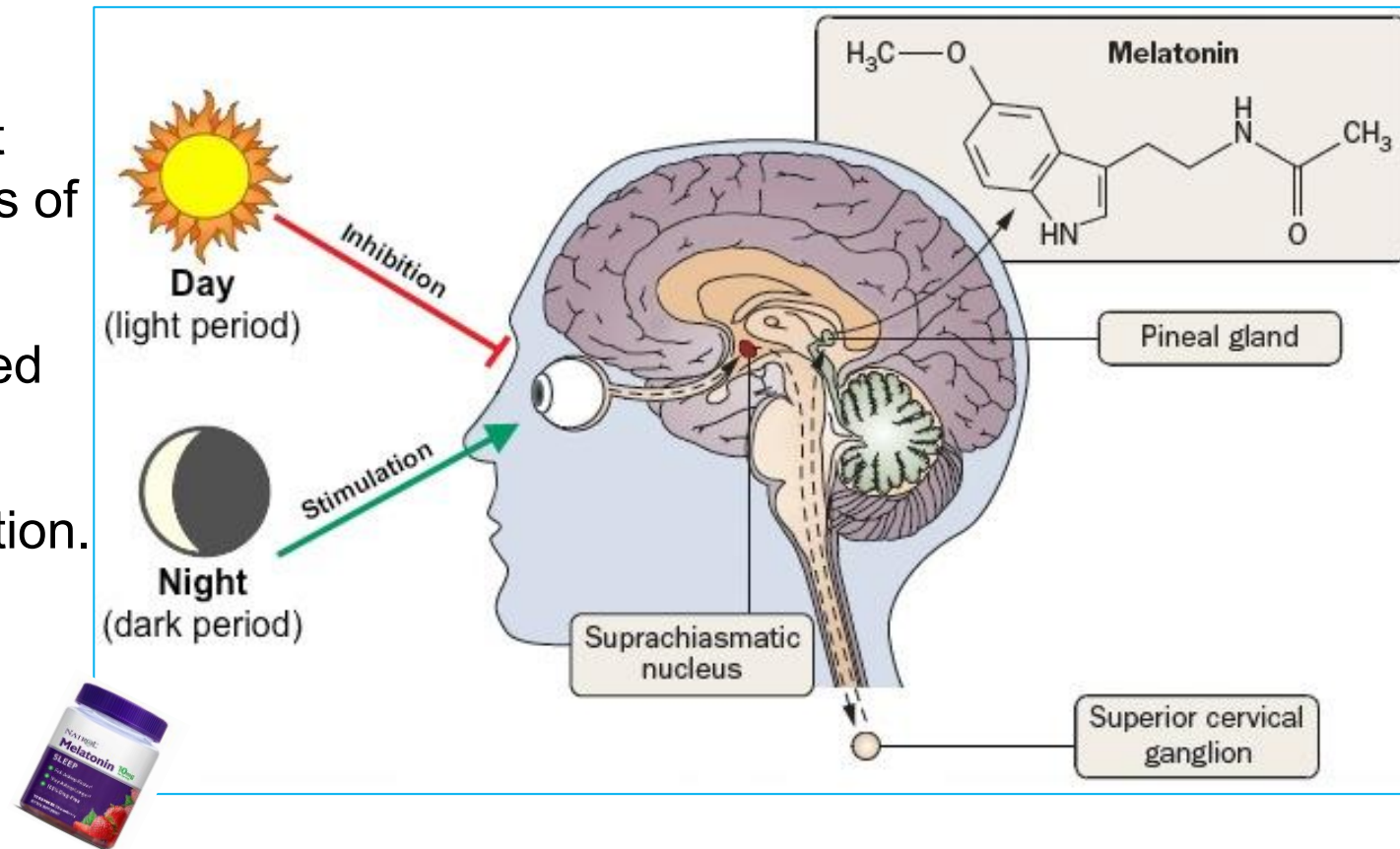


Fatigue Countermeasures: Light Exposure

Mu, et al. "Alerting effects of light in healthy individuals: a systematic review and meta-analysis." Neural regeneration research (2022).
Hardeland, et al. "Melatonin." The international journal of biochemistry & cell biology (2006)

Manipulating light exposure can facilitate sleep or alertness depending on the situation.

- Day = wake; Night = sleep
- Exposure to 30-90 minutes of bright light (natural or artificial) can increase feelings of alertness
- Limiting light for 30-90 minutes before bed may help improve sleep quality
- Darkness encourages melatonin production.
- Melatonin is not a sleeping pill.



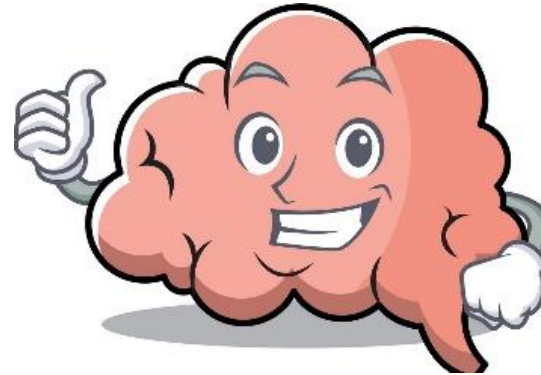
Caffeine vs. Other Stimulants

Lieberman. "The effects of ginseng, ephedrine, and caffeine on cognitive performance, mood and energy." Nutrition reviews (2001).

Mascord, et al. "Comparison of five commonly abused stimulants which are used to reduce fatigue." Proceedings International Council on Alcohol, Drugs and Traffic Safety Conference (1997).

Caffeine can stave off fatigue comparable to other stimulants with fewer health risks

- The true benefit of caffeine is not its effects on alertness, but its lack of side effects on other systems
- Caffeine is as effective as:
 - nicotine
 - ephedrine hydrochloride
 - pseudoephedrine hydrochloride
 - phentermine
 - diethylpropion hydrochloride
 - modafinil
 - dextroamphetamine
- Caffeine does not affect health as severely as the other compounds

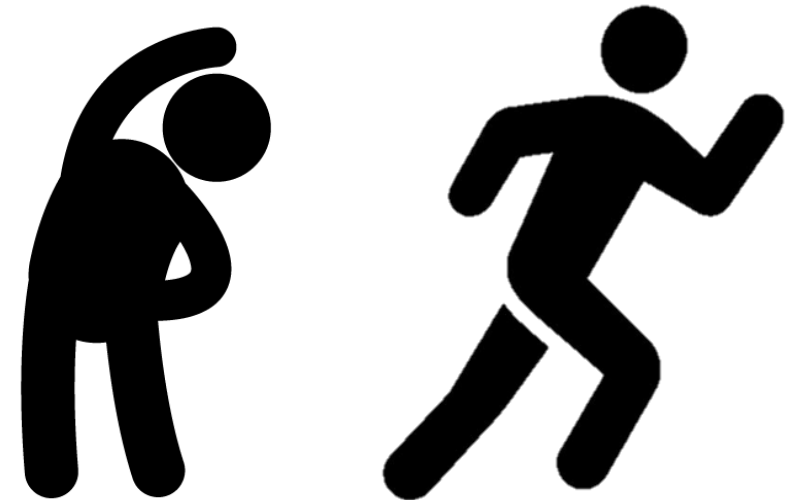


Fatigue Countermeasures: Standing and Activity

Kühnel, et al. "Take a break! Benefits of sleep and short breaks for daily work engagement." European Journal of Work and Organizational Psychology (2017).

There is a sweet spot.

- Physical activity cannot undo performance decrements due to sleep loss.
 - Short-term alerting effect
- The benefits of activity breaks or standing depends on the level of physical workload.
- Regular exercise is good for physical and mental health.
- No heavy exercise within 4 hours of bedtime.



Take Aways

In case you fell asleep...



- Fatigue is due to lack of sleep or being awake at the wrong time.
- Sleep is the only real cure for fatigue.



- Fatigue in the workplace is a safety risk.
- Duty time limitations and a comprehensive Fatigue Risk Management System (FRMS) can help organizations manage fatigue risk.



- Being fatigued makes everything worse.

Thank you!

Questions, Comments, Concerns



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