

## Work-related fatigue: Considerations for the Construction Sector

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*The findings and conclusions in this presentation are those of the author and do not necessarily represent the official position of the National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention.*

# What is “fatigue” and why should we worry about it?

*“Fatigue is a debilitating and potentially deadly problem affecting most Americans”*

*– National Safety Council, 2018*

# Defining Fatigue

**Oliver (1914)** – Occupational Fatigue

**Lerman (2012); Akerstedt (2009)** - Sleepiness is the tendency to fall asleep; fatigue is the body's response to sleep loss or to prolonged physical or mental exertion. Fatigue may be *reduced* by sedentary activity or rest without sleeping, whereas subjective sleepiness and the propensity for sleep are often *exacerbated* by sedentary activity or rest.

**Frone and Tidwell (1990)**

- (1) Fatigue
- (2) Fatigue
- (3) Fatigue

**Fatigue is *MORE THAN* sleepiness and its effects are more than falling asleep.**

**MedLinePlus:**

*Phillips RO. A review of definitions of fatigue—And a step towards a whole definition. Transportation research part F: traffic psychology and behaviour. 2015 Feb 1;29:48-56.*

**DOT Operational definition (1999)**

- Symptoms: Fatigue is a complex state characterized by a lack of alertness and reduced mental and physical performance, often accompanied by drowsiness.
- Causes: Fatigue may be caused or exacerbated by any or all of the following: lack of sleep, disruptive work/rest cycles, neurological conditions, excess mental or physical workload, exposure to extreme physical conditions, emotional stress, the use of drugs or alcohol, illness, and/or monotony.

**Oxford Dictionary (2022):** Extreme tiredness resulting from mental or physical exertion or illness

# Effects of fatigue



## Cognitive degradation

- Slows down reaction times
- Shortens attention and concentration
- Impairs judgement
- Increases propensity for risky behaviors

*(Alhoa 2007, Dawson 2012, Lowe 2017, Kilgore 2010, Marquié 2015)*



## Work Injuries

- 2 x the work injury risk for nonstandard shifts (compared to regular dayshifts)
- Increases with time on task

≤ 20 hrs/wk: 2.03 injuries/100 workers

≥ 60 hrs/wk: 4.34 injuries/100 workers

*(Folkard 2006, Lombardi 2010, Wagstaff 2011, Wong 2011)*



## Health and Well-being

- Gastrointestinal, reproductive, metabolic health effects
- Cardiovascular disease, cancer
- Mental health

*(Brown 2020, Harris 2024, Harma 2024, Kecklund 2016, Itani 2016, IARC 2020, Moreno 2019, Smith 2019, Smith 2012, Torquati 2018)*



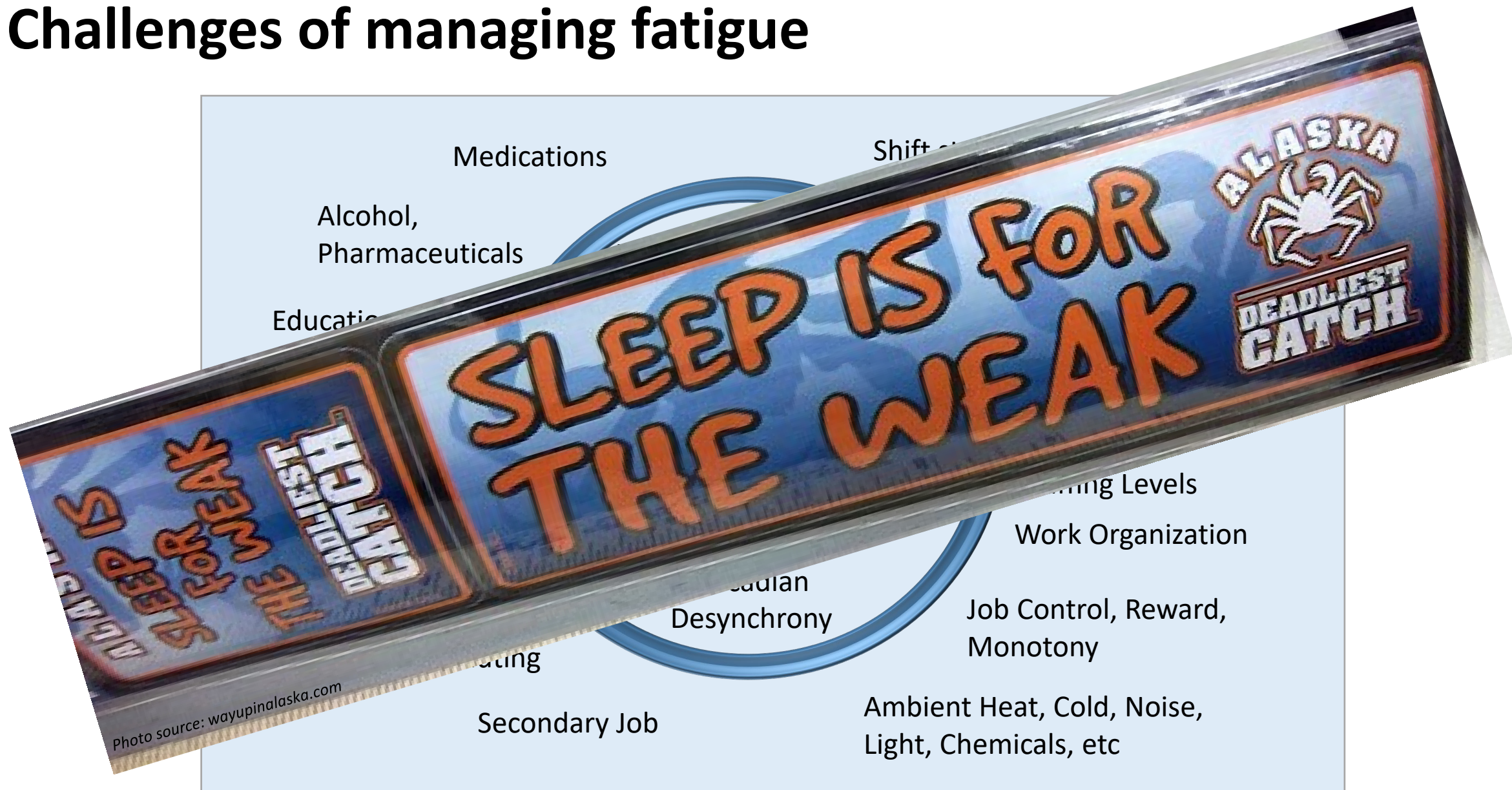
## Spillover Effects

- Family life
- Environmental impact
- Drowsy driving

*(Arlinghaus 2019, Bohle 1989, Demerouti 2005, NTSB 1989, NTSA 2020, Wong 2020, USNRC 1979)*



# Challenges of managing fatigue

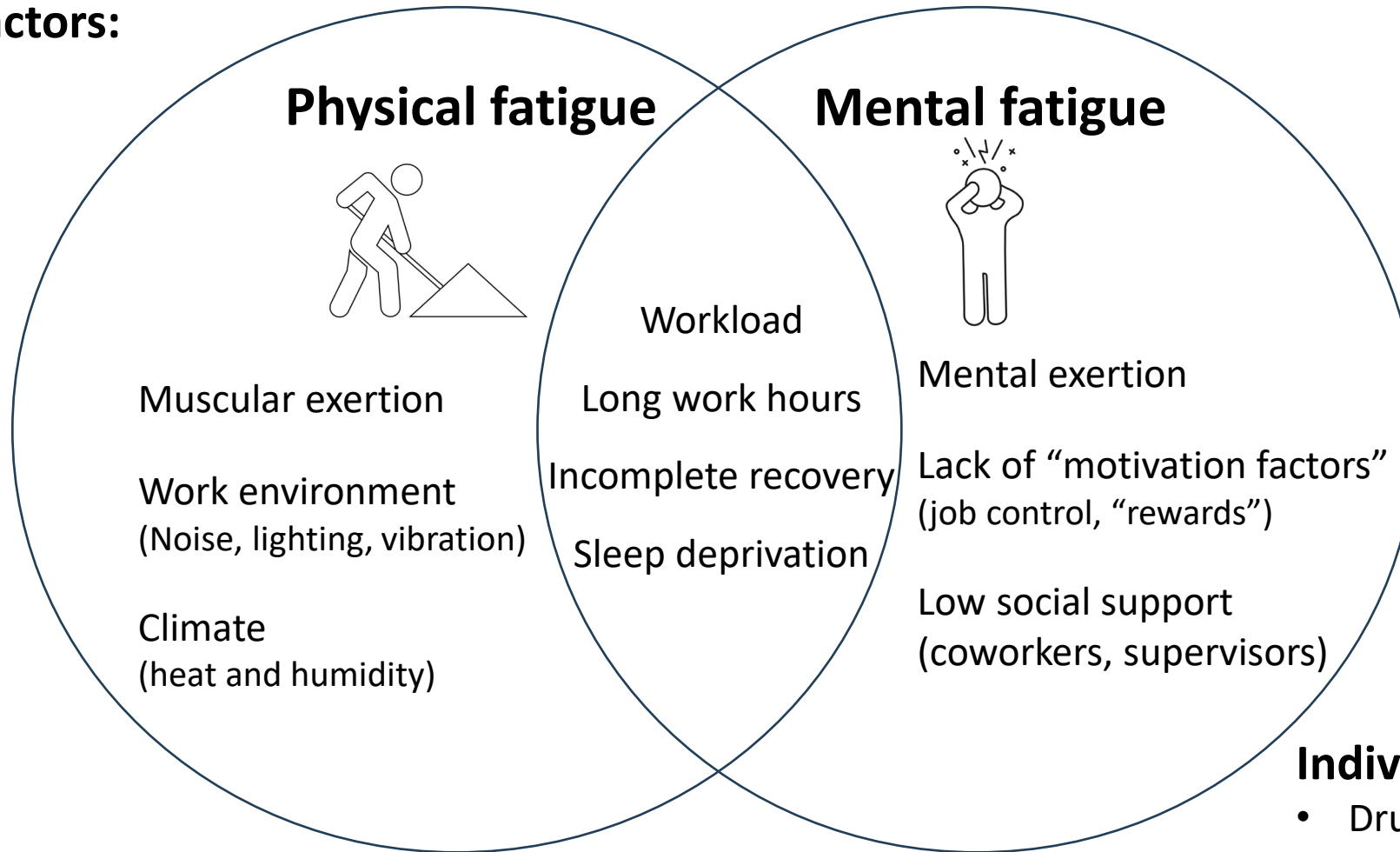


# Fatigue in the Construction Sector

2010 – 2011 National Health Interview Survey: 59% of US construction workers reported experiencing fatigue every day or on some days *(Zhang et al. 2015)*

# Factors for fatigue in Construction

## Work-related factors:



## Individual level factors:

- Drug/alcohol use
- Nutrition
- Fitness

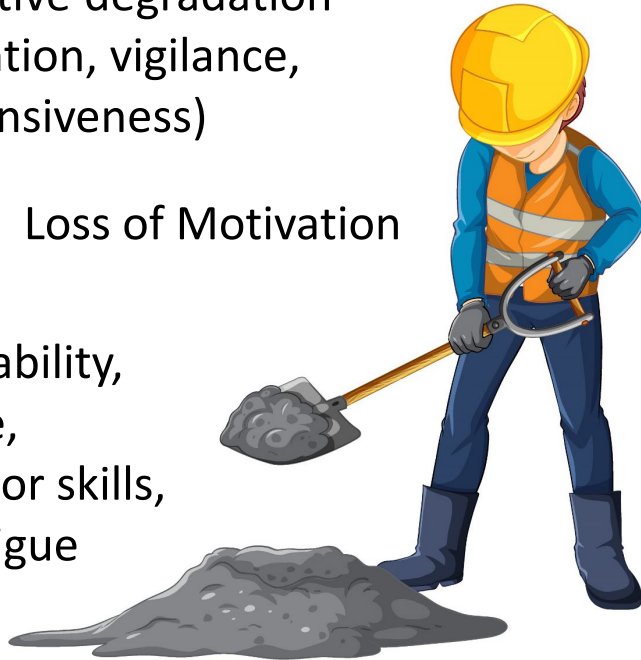
# Consequences of fatigue in Construction

Musculoskeletal Disorders

Cognitive degradation  
(attention, vigilance,  
responsiveness)

Loss of Motivation

Postural instability,  
poor balance,  
reduced motor skills,  
muscular fatigue



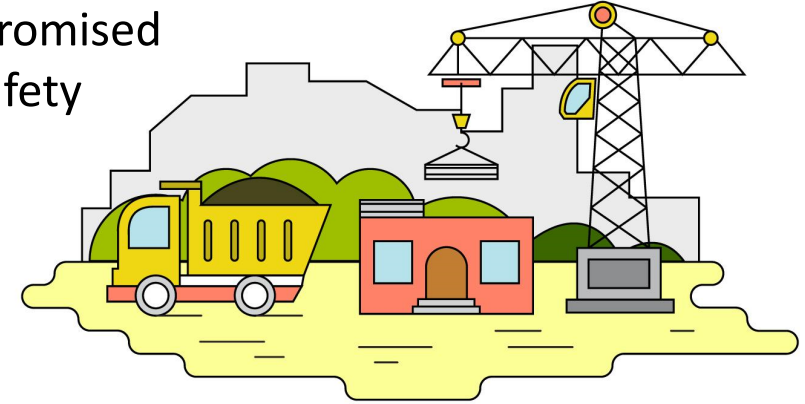
Low morale

Work errors

Injuries

Increased  
absenteesim

Compromised  
site safety



Reduced productivity  
and poor performance



# Assessment and evaluation of fatigue in Construction

## Subjective Measures



### Surveys / Self-reporting

#### Examples:

- Borg scale
- Fatigue Assessment Scale for Construction Workers

## Objective Measures



### Physiological and Physical Performance Measures

#### Examples:

- Blood pressure
- Heart rate
- Electroencephalography
- Skin thermoregulation
  
- Stability / Balance
- Grip strength
- Flexibility



### Cognitive Performance

#### Examples:

- Psychomotor Vigilance Test (PVT)



### Proposed: Predictive Measures

#### Examples:

- Biomathematical Models
- Fitness for Duty Tests

**Not yet examined in published scientific studies**

# Mitigation of fatigue in Construction

- Taking breaks
- Water, Coffee
- Napping, where allowed; providing a place to rest
- Exchange in working shifts
- Raising awareness of fatigue
- Use of motorized equipment to reduce manual labor (physical fatigue)

## Caveats:

- Only 2 studies
  - Emuze 2021 (N = 20 South African workers, General construction)
  - Techera 2019 (N = 150 US workers/ field supervisors, Electrical-transmission and distribution line construction)
- Small study size and not be representative of all US Construction workers



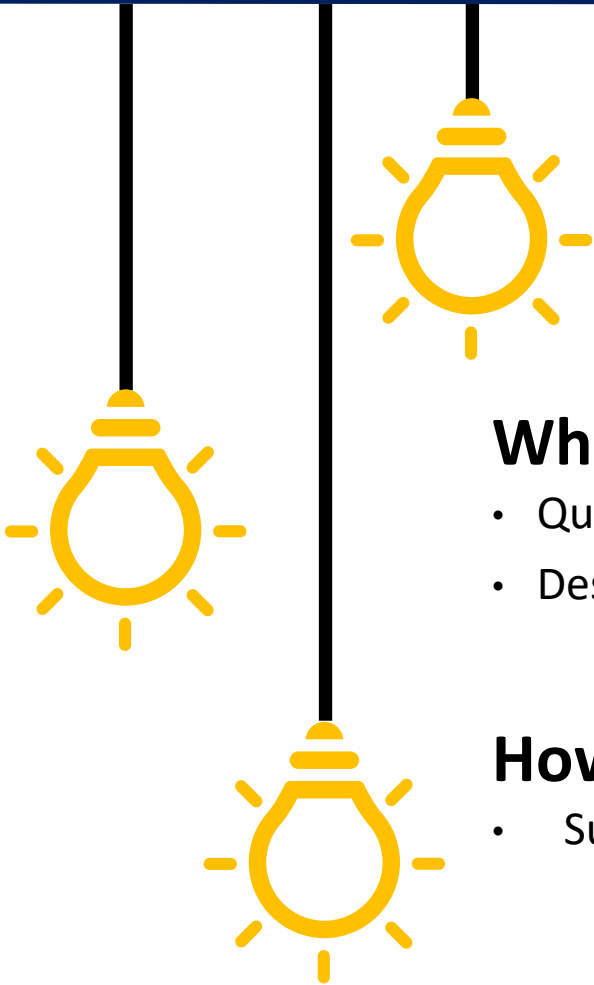
# Gaps in managing Construction Fatigue

1. Fragmented and various definitions of fatigue
2. Accurate and reliable method for measuring and predicting construction worker fatigue
3. Objective quantification of the impact of fatigue's causes and effects
4. Clear comparison of the causes and effects of fatigue in the workplace
5. Empirical studies on the various construction trades



# **NIOSH Work-related Fatigue Activities that could be applied to Construction**

# Factors for Injury Risk among Electrical Utility Workers (FIREWorks)



## Why:

- Electrical utility (EU) work is among the 10 most hazardous jobs in the US
- EU occupational injury fatality rates  $\geq 3$  times greater compared to all US workers

*(Techera 2019, Census of Fatal Occupational Injuries, 1992-2019)*

## What:

- Quantify work-injury risk associated Electrical Utility occupations
- Describe work injury prevalence (e.g., worker characteristics, overtime, storm events, temperature)

## How:

- Survival analyses, descriptive statistics
  - Data: 24 yrs work history, injury records, compensation claims from 20 companies
  - Outcomes: work-injury requiring medical leave or attention
  - Main Exposure: Occupation
  - Other interesting exposures: 2005 Energy Policy Act



# Fatigue Risk and Management in OGE

A silhouette of an oil pumpjack is shown against a sunset sky. The sun is a bright orange circle near the horizon, casting a warm glow. The pumpjack's long arm and counterweight are visible against the sky.

## Why:

- 2003-2013: OGE Worker fatality rates 7x greater than all US Workers
- Long work hours, commutes, physically demanding work, extreme temperatures
- US OGE Survey (2017-2019):
  - 35.1% of respondents had a workday + commute times > 14 hours
  - 46% of the respondents reported < 7 hours of sleep/day
  - *(Hagan-Hagan Haynes 2022, Mason 2015)*

## What:

- Determinants of high fatigue-risk among OGE service and drilling contractors, and current fatigue risk management strategies

## How:

- Field study: Survey, actigraphy, Psychomotor Vigilance Test
- Focus groups (workers and managers): perceptions of fatigue risk and current fatigue mitigation strategies
- Interviews (OGE leaders): Fatigue Risk Management Systems in OGE

Contacts:

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Imelda Wong, PhD



# Mining Program Heat Strain Research

## Why:

- Underground mines are getting deeper and hotter
- Surface mines are experiencing heat waves
- Heat exposure increases worker injury rates
  - May be related to fatigue, cognitive and psychomotor impairment (*Varghese 2018*)

## What:

- Characterize
  - physiological effects of heat exposure
  - cognitive changes associated with heat exposure
  - individual variability in physiologic and cognitive responses to heat

Contact:

Kristin Yeoman, MD, MPH

## How: Dual-arm study design

Assessing impacts  
of heat exposure

Environmental  
Chamber



Exercise Test

- Heart rate
- Internal temperature

Field data (Mines)



Work shifts

- Heart rate
- Internal temperature
- NIOSH Mobile App (includes PVT)

# Fatigue in Mining

Are Fatigue and Sleepiness the Same? A Brief Introduction to the Differences and Similarities and Their Implications for Work Safety *(Barham 2023)*

Findings from a systematic review of fatigue interventions: What's (not) being tested in mining and other industrial environments *(Dugdale 2022)*

## Stay tuned:

- Burden of fatigue risk factors in mining
- Synthesis of general and industrial work hour recommendations
- Interviews with mining safety supervisors on fatigue measurement and management



Contact: Tim Bauerle, PhD

Photo credit: Flickr Creative Commons, Helca Mining

# Toolbox Talks



## Night Shift: Road Work



- ✱ Make sure there is enough lighting so you can be seen by oncoming traffic and co-workers.
- ✱ Set arrow panels at nighttime light levels.
- ✱ Wear high-visibility safety apparel.

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## Night Shift: Road Work

Road work at night is dangerous. Both workers and motorists need enough light to move safely through work zones. Drivers on the roadway or see ground workers to ensure their safety.

### Matt's Story

Matt, a road construction worker, was finishing up his break one night around 2:00 a.m. He was walking across a poorly lit area to return to work when he was hit by a dump truck. The driver did not see Matt. Matt was taken to the hospital in serious condition.

- ✱ How could this incident have been prevented?
- ✱ Have you or someone you know ever had an injury related to night work?

### How can we stay safe tonight?

What will we do at the worksite to prevent being injured while doing road work at night?

1. \_\_\_\_\_
2. \_\_\_\_\_

OSHA Standard: 1926.56

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## Shiftwork, Long Work Hours, and Fatigue



- ✱ Pay attention to how tired you feel. If you feel tired or distracted, take a break.
- ✱ Eat healthy snacks and drink water.
- ✱ Don't drive or operate equipment if you feel sleepy.

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## Shiftwork, Long Work Hours, and Fatigue

Working evening or early morning shifts makes it hard to get enough quality sleep. Lack of sleep and long work hours can make you tired (fatigued) at work. Tired workers can have a harder time focusing, putting them at higher risk for injury.

### Henry's Story

Henry was working the night shift on a large office building construction project. One night he almost severed a finger while operating a table saw. He had been working four 10-hour night shifts for 3 weeks to wrap up work on the project.

- ✱ Have you ever felt too tired to work?
- ✱ What do you do to stay alert at work?

### Remember This

#### Signs of fatigue include

- Poor sleep
- Feeling tired or falling asleep at work
- Lack of energy or motivation; a 'do not care' attitude, moodiness, or poor judgment
- Difficulty focusing on work
- Slowed reactions
- Increased anger or irritability

### How can we stay safe today?

What will we do at the worksite to prevent problems with fatigue from shift work or long work hours?

1. \_\_\_\_\_
2. \_\_\_\_\_

Applicable OSHA Standard: 5(a)(1) of the OSHA Act, The General Duty Clause

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# Fatigue Detection Technologies

## NIOSH Science Blogs:

### Choosing the “Right” Fatigue Monitoring and Detection Technology

<https://blogs.cdc.gov/niosh-science-blog/2021/01/19/fmdt/>

### The Who, What, How and When of Implementing Fatigue Monitoring and Detection Technologies

[https://blogs.cdc.gov/niosh-science-blog/2021/05/21/fmdt\\_implementation/](https://blogs.cdc.gov/niosh-science-blog/2021/05/21/fmdt_implementation/)

### Setting Objectives for Fatigue Detection Technologies

<https://blogs.cdc.gov/niosh-science-blog/2022/09/14/fmdt3/>

### How to Choose the Right Fatigue Detection Technology for Your Workplace



Fatigue can reduce focus, slow reaction time, and impair decision-making skills. Since fatigue has many sources, it can be hard to detect on job sites. Employers can consider the factors below when selecting a fatigue detection technology as part of a comprehensive safety management approach.

	<b>PURPOSE</b> Think carefully about what new information the technology will provide compared to the data you already have.
<b>SCIENCE</b> Ask the supplier to share testing results that show the technology accurately measures fatigue or a sign of fatigue (e.g., slow reaction time, eyelid droop).	
	<b>RELIABILITY</b> Consider how reliable the technology is in different settings (e.g., wireless connectivity, extreme temperatures, humidity, lighting).
<b>FEEDBACK</b> Find out how quickly the technology provides alerts and what cues (visual, audio, vibration) it uses. Sufficient feedback time and the right cues for the work setting can prevent close calls.	
	<b>FIT</b> Determine if the technology works with your current systems (e.g., vehicle telematics). Systems that work together can make it easier to predict and detect fatigue risk.
<b>USER EXPERIENCE</b> Find out if your workers will embrace using the technology. If a device is uncomfortable or bulky, or if there is a data or privacy concern, it may not be your best option.	



Centers for Disease Control and Prevention  
National Institute for Occupational Safety and Health

For more detailed information about how to select a fatigue detection technology, visit: [go.usa.gov/xtZV](https://go.usa.gov/xtZV)

January 2022







# Working hours and fatigue: Meeting the needs of American workers and employers

## American Journal of Industrial Medicine, November 2022, Volume 65, Issue 11



Foreward (*Howard*)

Approaches to managing work-related fatigue to meet the needs of American workers and employers (*Wong, Swanson*)

Industry-specific	<p>The human factors of <b>mineworker</b> fatigue: An overview on prevalence, mitigation and what's next (<i>Bauerle, Sammarco, Dugdale, Dawson</i>)</p> <p>US research needs related to fatigue, sleep, and working hours among <b>oil and gas extraction</b> workers (<i>Hagan-Haynes, Pratt, Lerman, Wong, Baker, Flower, Riethmeister</i>)</p> <p>Research gaps and needs for preventing worker fatigue in the <b>transportation and utilities</b> industries (<i>Sieber, Chen, Krueger, Lincoln, Menéndez, O'Connor</i>)</p> <p>Research priorities to reduce risks from work hours and fatigue in the <b>healthcare and social assistance sector</b> (<i>Caruso, Arbour, Berger, Hittle, Tucker, Patrician, Trinkoff, Rogers, Barger, Edmonson, Landrigan, Redeker, Chasens</i>)</p> <p>Working hours, sleep, and fatigue in the <b>public safety sector</b>: A scoping review of the research (<i>Allison, Tiesman, Wong, Bernzweig, James, James, Navarro, Patterson</i>)</p> <p>Working hours, sleep, and fatigue in the <b>agriculture, forestry, and fishing</b> sector: A scoping review (<i>Elliott, Lincoln, Flynn, Levin, Smidt, Dzugan, Ramos</i>)</p>
All sectors	<p>Work-related fatigue: A hazard for workers experiencing disproportionate occupational risks (<i>Cunningham, Guerin, Ferguson, Cavallari</i>)</p> <p>Describing economic benefits and costs of nonstandard work hours: A scoping review (<i>Wong, Quay, Irvin, Belzer</i>)</p>

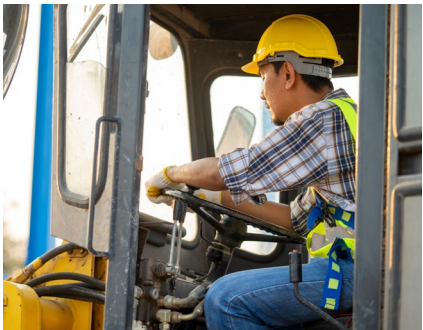


# Thank you!

## Center for Work and Fatigue Research

[cdc.gov/niosh/topics/fatigue/center.html](https://cdc.gov/niosh/topics/fatigue/center.html)

[iwong@cdc.gov](mailto:iwong@cdc.gov)



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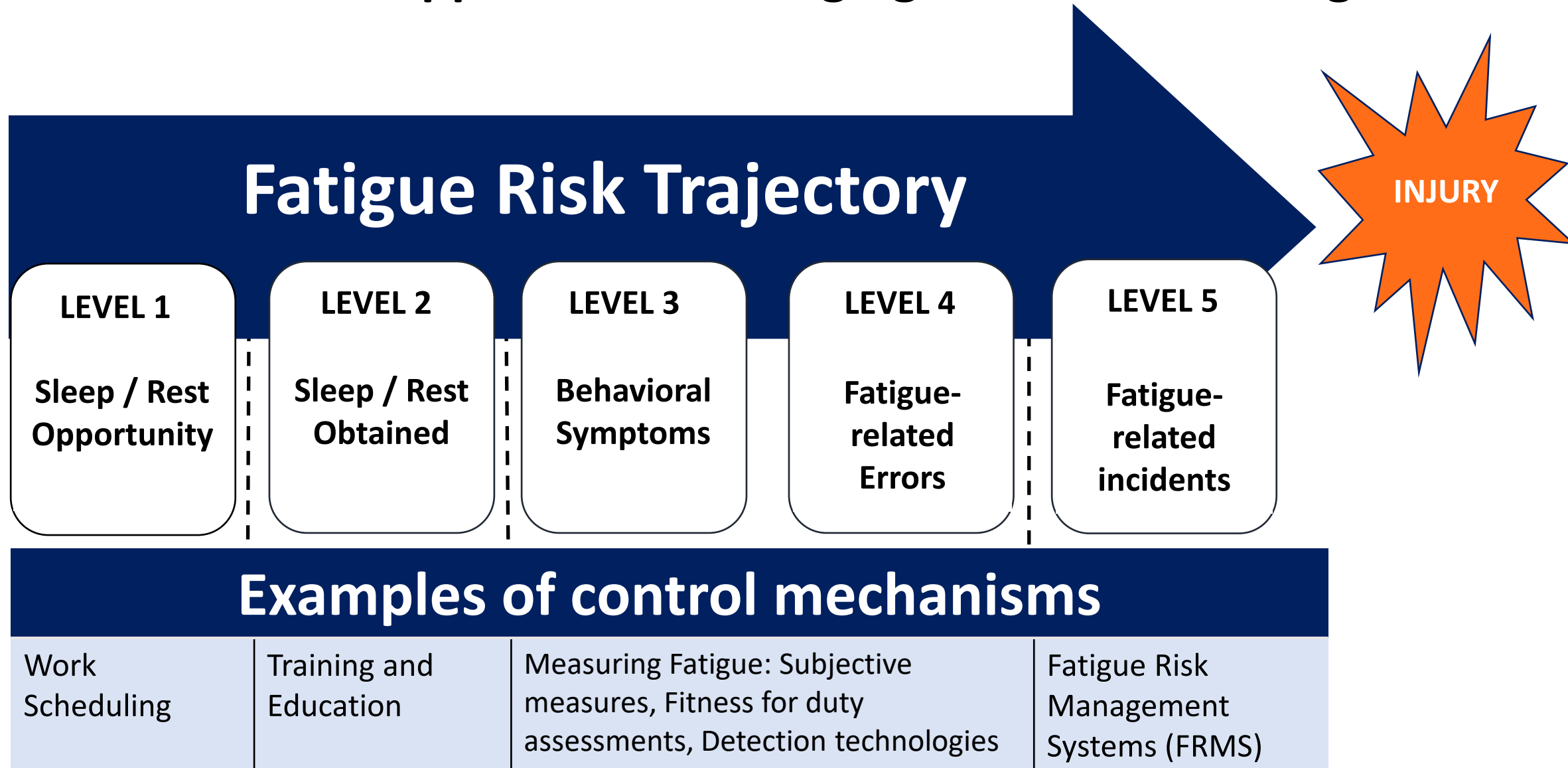


**Additional slides (reserve)**

# Work and fatigue research activities across NIOSH

	Anticipation	Recognition	Evaluation	Control / Control
All Workers in All Sectors				
Agriculture, Forestry, Fishing				
Healthcare and Social Assistance				
Mining				
Oil and Gas				
Public Safety				
Transportation, Warehousing, Utilities				
National Surveys (e.g., NHIS, QWL, WellBQ)				
Emergency Response (e.g., COVID-19, Ebola)				

# A multi-level approach to managing work-related fatigue



# What is Occupational Heat Stress?

Heat Stress is the combination of:



Metabolic  
Heat

+



Environmental  
Factors

+



Clothing /  
PPE



which results in **increased heat storage** within the body.

Individual

Environmental

# RISK FACTORS

Dehydration



Physical exertion



Clothing & PPE



Physical condition  
& health problems



Medication



Pregnancy



Lack of recent  
exposure



Advanced age



Previous heat-related illness



High temperature  
and humidity



Direct sun  
exposure



Radiant heat  
sources



Limited air  
movement

# Heat-related Illnesses and Injuries



- ▶ Sweaty palms or wet drips on floors



- ▶ Fogged-up safety glasses/goggles



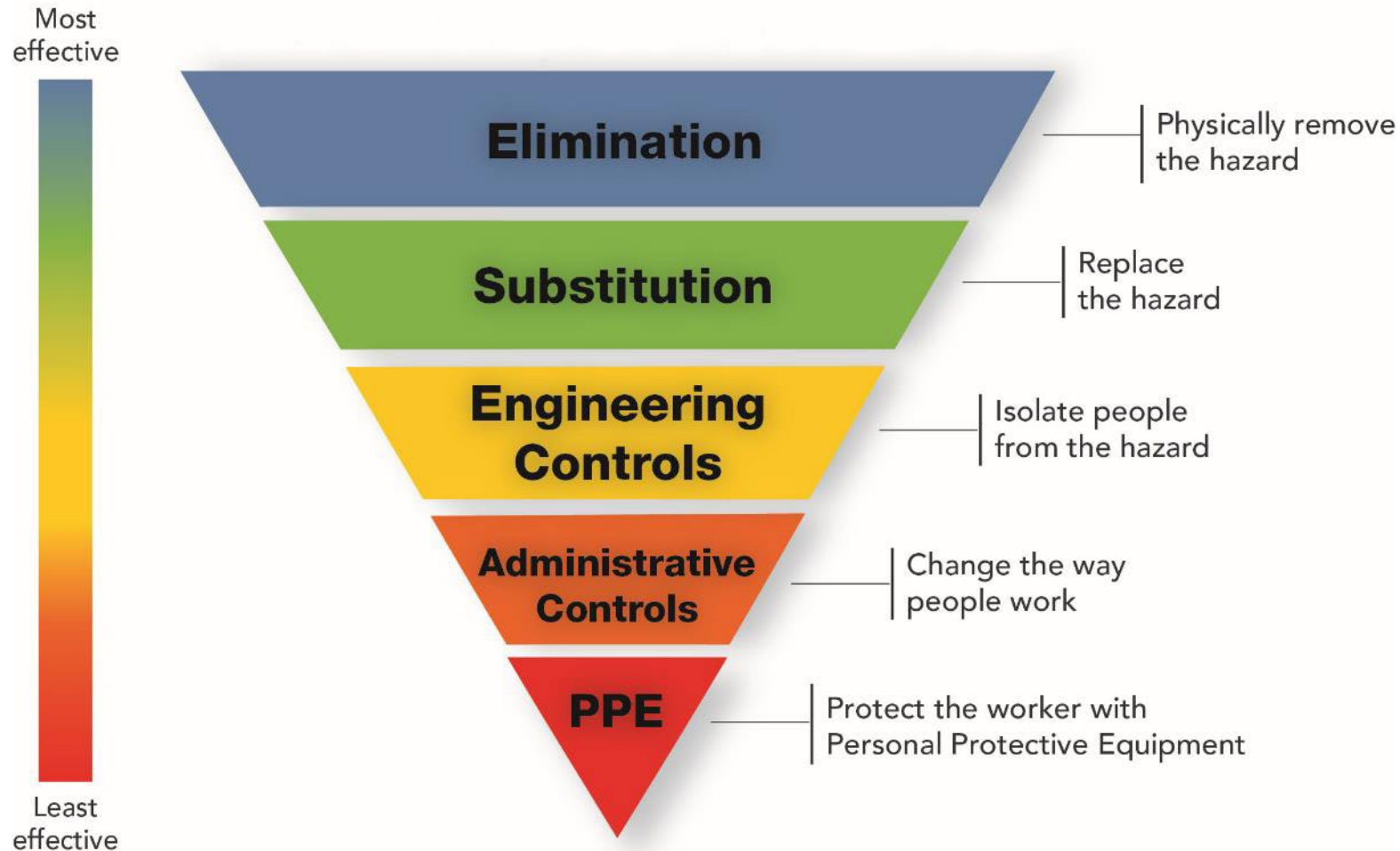
- ▶ Hot equipment could cause burns



- ▶ Dizziness and other heat illness symptoms can cause workers to forget or neglect safety protocols, resulting in injuries to self or others.



# Additional NIOSH Recommendations



## Engineering Controls

- Fans
- Reflective shielding or barriers
- Shaded area or canopy

## Administrative Controls

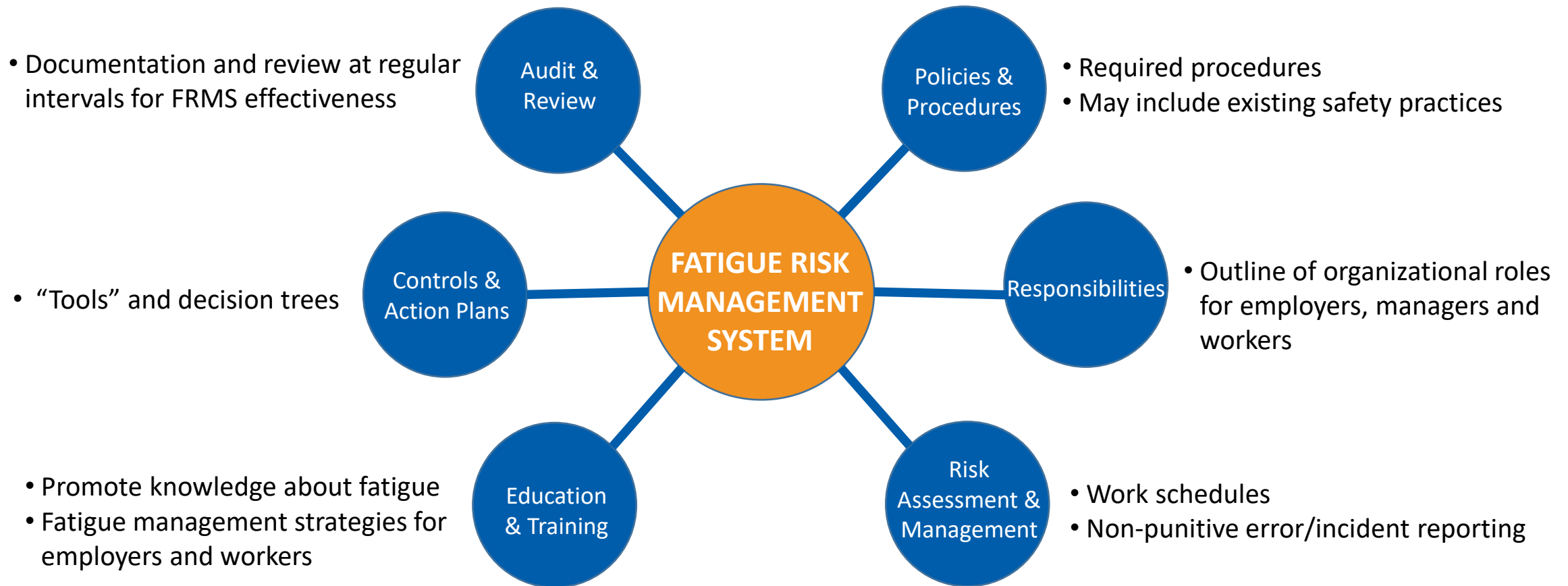
- Monitoring weather
- Buddy systems
- Training
- Heat alert plan
- Work/rest schedules
- Appropriate hydration
- Acclimatization

## Personal Protective Equipment (PPE)

- Water-cooled or air-cooled garments
- Cooling vests
- Wetted overgarments

# Fatigue Risk Management System

*“A scientifically based, data-driven addition or alternative to prescriptive hours of work limitations which manages employee fatigue in a flexible manner appropriate to the level of risk exposure and the nature of the operation”*



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