



## Center for Work and Fatigue Research

**BSC Workplace Fatigue Mini-symposium  
May 19, 2021**

Imelda Wong, PhD

Coordinator, Center for Work and Fatigue Research

*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.*

# 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's (2015)** three-factor conceptualization of fatigue:

- (1) Fatigue involves equal parts of both “extreme tiredness” and “reduced functional capacity;”
- (2) Fatigue can manifest physically, mentally, and/or emotionally;
- (3) Fatigue is “temporally tied to the workday”

**MedLinePlus:** a feeling of weariness, tiredness or lack of energy

**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:** extreme tiredness resulting from mental or physical exertion or illness

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Frone and Tidv

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

MedLinePlus: a

DOT Operation

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

*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.*

- Symptoms: Fatigue is a state of reduced performance, often accompanied by drowsiness.
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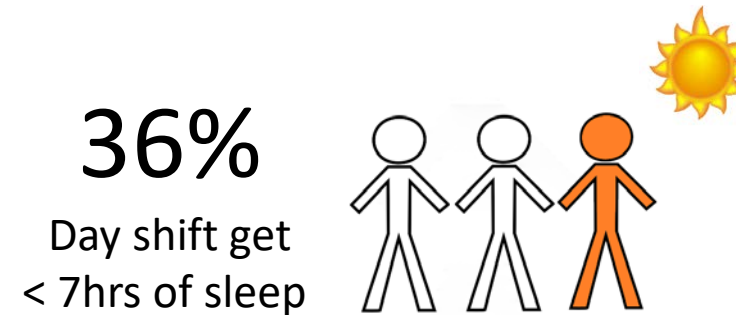
# Workplace fatigue in the US

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

– National Safety Council

20% (~21 million) Americans work nonstandard hours

37% of workers get < 7 hrs of sleep/day



90% of employers have been negatively impacted by tired employees

- 50% will adjust employee's schedule or task
- 70% will issue a warning or disciplinary action

68% of workers experience workplace fatigue that requires additional effort to perform tasks at desired level

# Effects of fatigue



## Cognitive impairment

- May accelerate cognitive aging with long term effects



## Work injuries

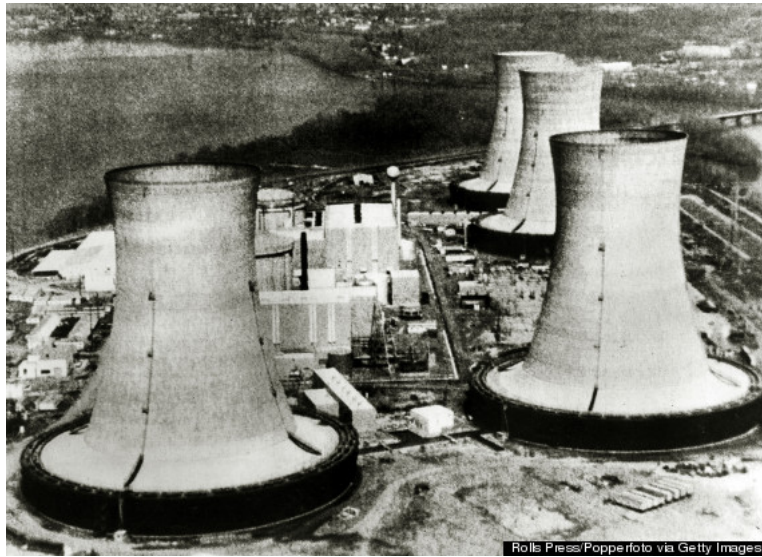
- Increased risk related to:
  - Nonstandard shifts (2 x times compared to daytime workers)
  - Time on task
    - $\leq 20$  hours/wk: 2.03 injuries/100 workers
    - $\geq 60$  hrs/wk: 4.34 injuries/100 workers
    - Dose-response effect



## Illness

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





**Workplace fatigue can have spillover effects to coworkers, family life, and public health and safety**

# Annual cost of workplace fatigue in the US\*

## Workers compensation

*(Liberty Mutual 2019 Workplace Safety Index)*

\$ 1.2 bn

## Health related productivity

*(National Safety Council 2016)*

\$ 151.0 bn

## Drowsy driving crashes

*(National Highway Traffic Safety Admin 2017)*

\$ 72.4 bn

## Societal harm of drowsy driving

*(National Highway Traffic Safety Admin 2017)*

\$ 157.0 bn

## Shortened mortality rates, absenteeism, presenteeism, future losses on skill development among adolescents

*(RAND 2016)*

\$ 434.0 bn

**“Total”**

**\$ 815.6 bn**

*\* Estimates converted to 2021 equivalent \$*



# Fatigue: A unique workplace hazard

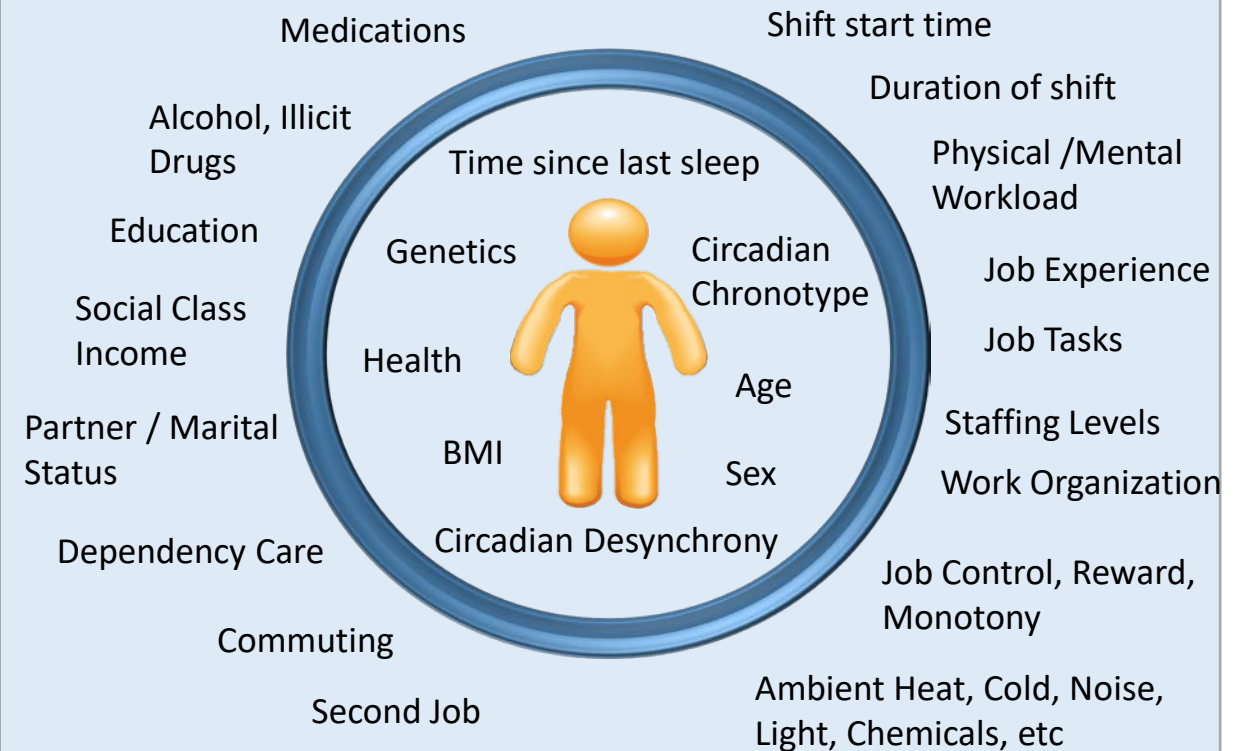
Anticipate and Recognize Hazards → Evaluate Exposure → Control and Confirm Protection from Risks

aiha.org

Constant communication, continuous improvement

- No standard definition of workplace fatigue
- No standard measure
- No threshold / exposure limit

## Endogenous and Exogenous Factors



Adapted from Di Milia (2011)



# Fatigue: A unique workplace hazard



aiha.org  
 Constant communication

- No standards
- No standards
- No thresholds

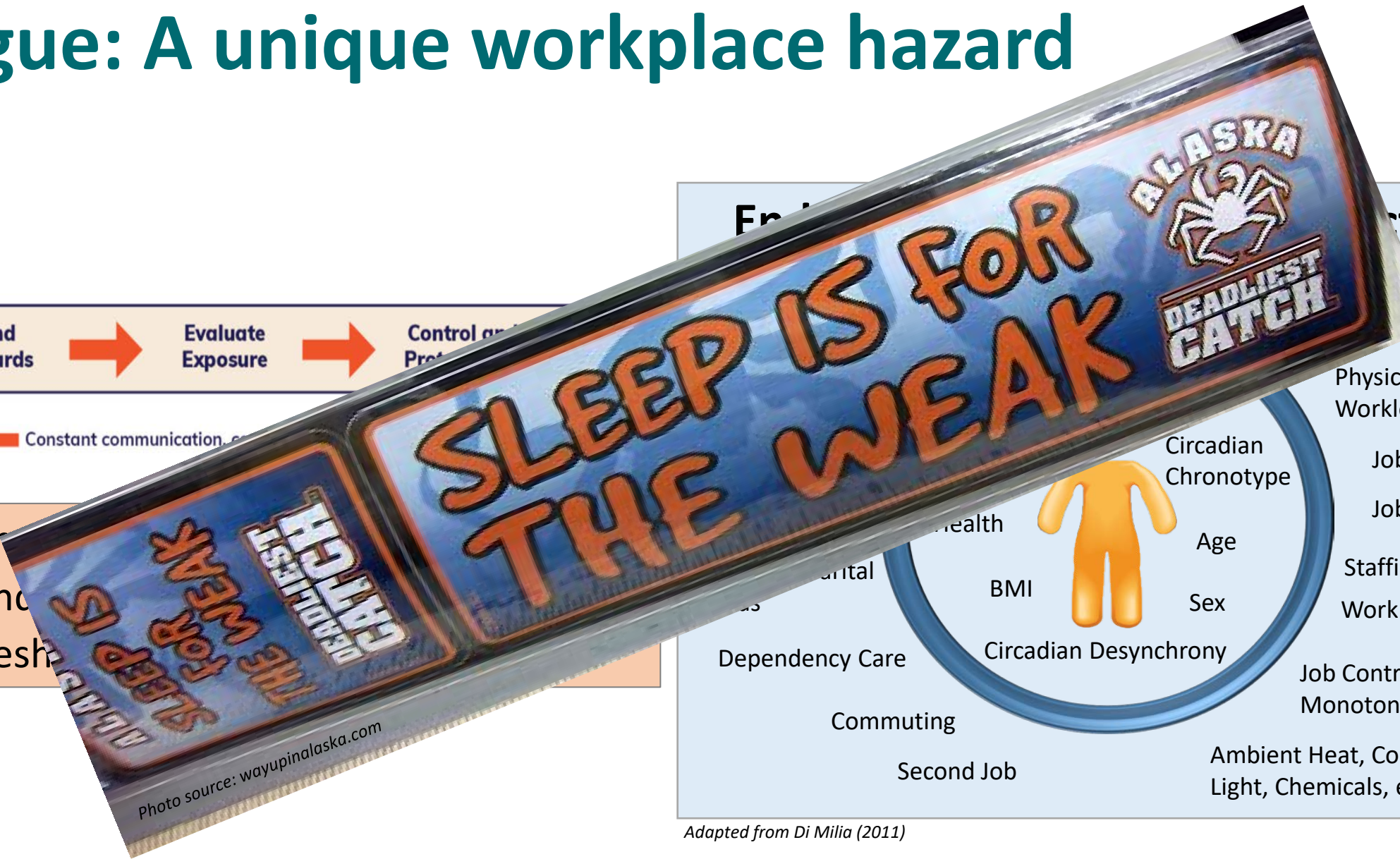
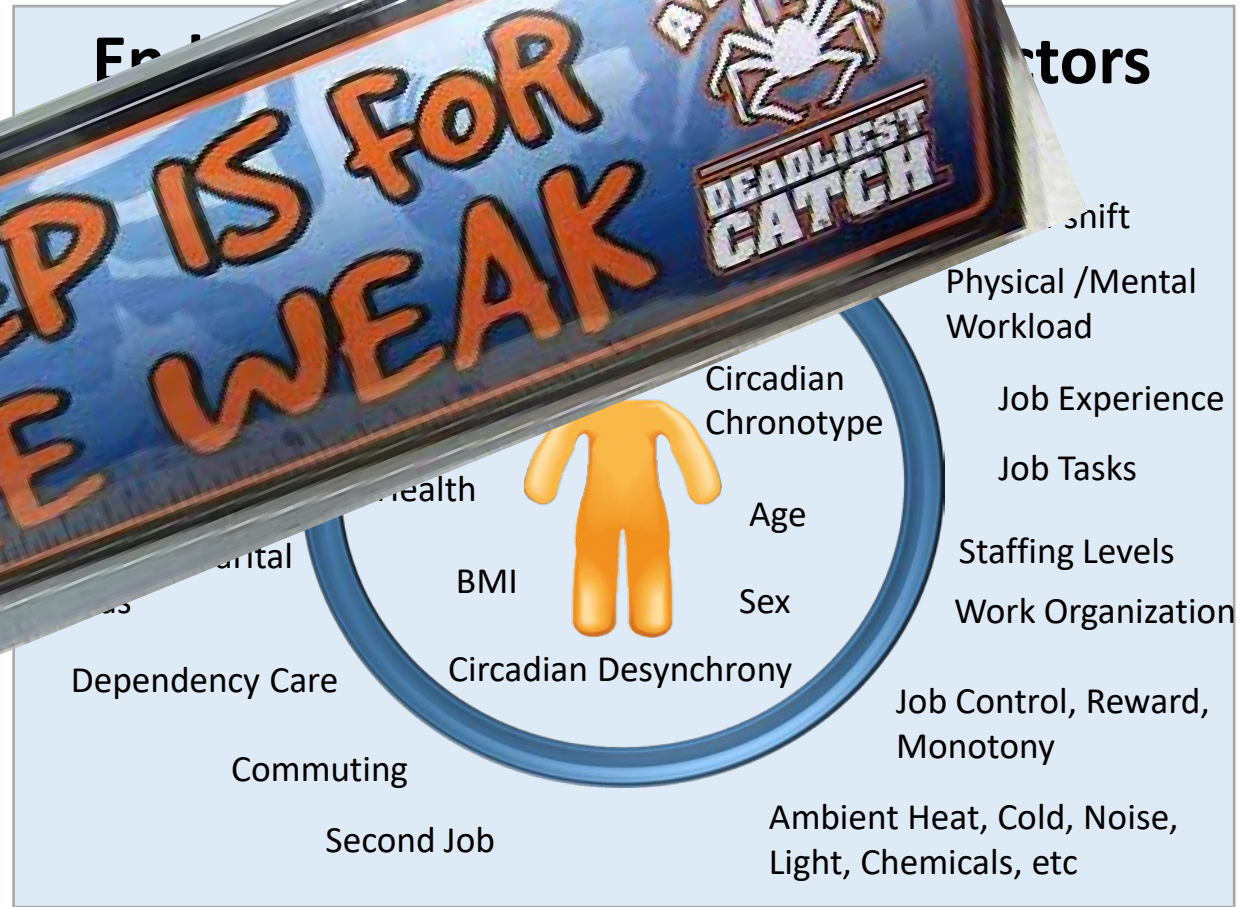


Photo source: wayupinalaska.com



Adapted from Di Milia (2011)

# Center for Work and Fatigue Research

## Launched May 2020

- Over 50 NIOSH members from different Divisions, Sectors and Cross-sectors



## Vision

- *Safe and healthy workplaces, free from the effects and consequences of fatigue*

## Mission

- Raising awareness of different sources of worker fatigue
- Identifying effective methods of assessing fatigue-risk in workplaces
- Developing and communicating strategies to reduce health and safety risks associated with workplace fatigue

## Values

- Service, Collaboration, Practicality, Integrity

# Center for Work and Fatigue Research Activities

## Fatigue Biomonitoring (FaB)

### Partners:

- Health Effects Laboratory Division

### Activities:

- Literature review
- Method development



## Innovations in Fatigue Detection (IFaD)

### Partners:

- Center Motor Vehicle Safety
- Center for Direct Reading and Sensor Technologies

### Activities:

- Literature review
- Survey and Focus Group Studies
- Outreach



## Knowledge Translation

- NIOSH Director's Seminar Series: Work and Fatigue
- Special issue of AJIM: Work and Fatigue
- Toolbox kits
- Online course and modules / podcasts
- Article series: Synergist



## Automation and Situation Awareness (ASAP)

### Partners:


























- Center Motor Vehicle Safety
- Center for Occupational Robotics Research
- US DOT Volpe Center

### Activities:

- Outreach



# Workplace fatigue activities at NIOSH

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



# Future Directions



Other fatigue factors and interactions between factors

Fatigue “thresholds”

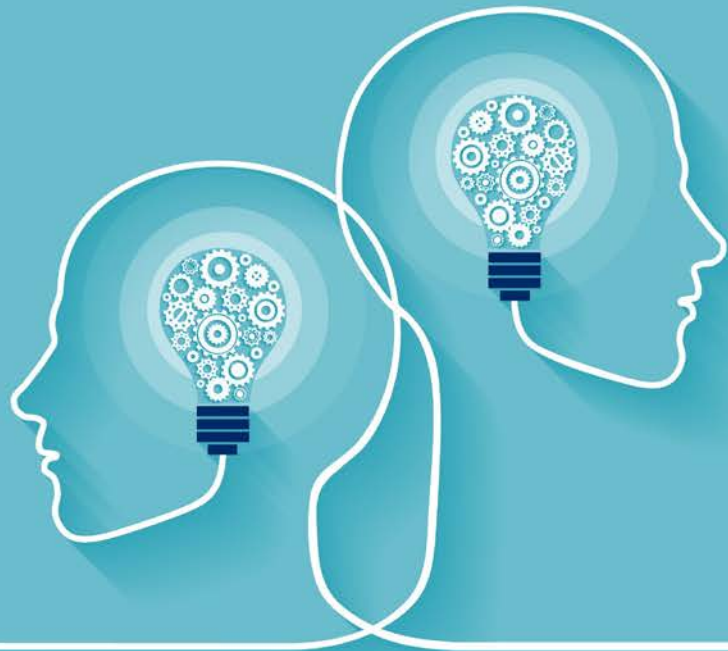
Fatigue Risk Management Systems

- Holistic approach to fatigue management
- Training for NIOSH researchers

Further partnerships

- AIHA, ACGIH, NSC

# Questions for the Board



How should we measure success of the Center?

What other gaps in the knowledge base should be addressed?

**Thank you!**

Center for Work and Fatigue Research

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

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

# Selected publications

## NIOSH numbered publications

**NIOSH Training for Nurses on Shiftwork and Long Work Hours.** Caruso CC, Geiger-Brown J, Takahashi M, Trinkoff A, Nakata A. Cincinnati, OH: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 2015-115 (Revised 04/2020)

**Using *Total Worker Health*<sup>®</sup> Concepts to Reduce Fatigue Among Retail Workers.** Afanuh S. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2019-102

**Fatigue Prevention for Pilots: A Training Program for Commercial Pilots in Alaska.** Spokane, WA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication Number 2016-162

**Overtime and Extended Work Shifts: Recent Findings on Illnesses, Injuries, and Health Behaviors.** Caruso CC, Hitchcock EM, Dick RB, Russo JM, Schmit JM. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 2004-143.

**Plain Language about Shiftwork.** Rosa RR, Colligan MJ. US Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Division of Biomedical and Behavioral Science, Education and Information Division. DHHS (NIOSH) Publication No. 1997-145.

**The Twenty-four Hour Workday: Proceedings of a Symposium on Variations in Work-sleep Schedules.** Johnson LC, Texas DI, Colquhoun WP, Colligan MJ, eds. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 1981-127.

**Shift Work Practices in the United States.** Tasto DL, Colligan MJ. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Division of Biomedical and Behavioral Science. DHEW (NIOSH) Publication No. 1977-148.



# Selected publications

## Recent Scientific Manuscripts

- Bauerle T, Dugdale Z, Poplin G. **Mineworker fatigue: A review of what we know and future decisions.** Min Eng. 2018 Mar;70(3):33. PMID: 29867256; PMCID: PMC5983045.
- Birdsey J, Sussell AL. **Prevalence of obesity, no leisure-time physical activity, and short sleep duration among occupational groups in 29 states.** Journal of occupational and environmental medicine. 2017 Dec 1;59(12):1221-8.
- Caruso CC, Baldwin CM, Berger A, Chasens ER, Landis C, Redeker NS, Scott LD, Trinkoff A. **Position statement: Reducing fatigue associated with sleep deficiency and work hours in nurses.** Nurs Outlook. 2017 Nov-Dec;65(6):766-768
- Chen GX, Fang Y, Guo F, Hanowski RJ. **The influence of daily sleep patterns of commercial truck drivers on driving performance.** Accident analysis & prevention. 2016 Jun 1;91:55-63.
- Gärtner J, Rosa RR, Roach G, Kubo T, Takahashi M. **Working Time Society consensus statements: Regulatory approaches to reduce risks associated with shift work—a global comparison.** Industrial health. 2019;57(2):245-63.
- Grajewski B, Whelan EA, Nguyen MM, Kwan L, Cole RJ. **Sleep disturbance in female flight attendants and teachers.** Aerospace medicine and human performance. 2016 Jul 1;87(7):638-45.
- Lunn RM, Blask DE, Coogan AN, Figueiro MG, Gorman MR, Hall JE, Hansen J, Nelson RJ, Panda S, Smolensky MH, Stevens RG. **Health consequences of electric lighting practices in the modern world: A report on the National Toxicology Program's workshop on shift work at night, artificial light at night, and circadian disruption.** Science of the Total Environment. 2017 Dec 31;607:1073-84.
- Ma CC, Hartley TA, Sarkisian K, Fekedulegn D, Mnatsakanova A, Owens S, Gu JK, Tinney-Zara C, Violanti JM, Andrew ME. **Influence of work characteristics on the association between police stress and sleep quality.** Safety and health at work. 2019 Mar 1;10(1):30-8.
- Shockey TM, Wheaton AG. **Short sleep duration by occupation group—29 states, 2013–2014.** MMWR. Morbidity and mortality weekly report. 2017 Mar 3;66(8):207.
- Sieber WK, Robinson CF, Birdsey J, Chen GX, Hitchcock EM, Lincoln JE, Nakata A, Sweeney MH. **Obesity and other risk factors: the national survey of US long-haul truck driver health and injury.** American journal of industrial medicine. 2014 Jun;57(6):615-26.
- Wong IS, Dawson D, Van Dongen HP. **International consensus statements on non-standard working time arrangements and occupational health and safety.** Industrial health. 2019;57(2):135-8.
- Wong IS, Popkin S, Folkard S. **Working Time Society consensus statements: A multi-level approach to managing occupational sleep-related fatigue.** Industrial health. 2019;57(2):228-44.

# Selected publications



**Working Hours,  
Sleep & Fatigue**

Meeting the Needs  
of American Workers  
& Employers

**Abstracts from NIOSH Working Hours, Sleep and Fatigue Forum: Meeting the Needs of American Workers and Employers.  
September 13-14, 2019. Coeur d'Alene**

**Working hours, sleep, and fatigue in the Agriculture, Forestry, and Fishing Sector.** Lincoln JM; Elliott KC; Syron LN; Flynn M; Levin JL; Smidt M; Dzugan J

**Work hours and fatigue in the Healthcare and Social Assistance Sector.** Caruso CC; Arbour MW; Barger L; Berger AM; Chasens ER; Dawson J; Edmonson JC; Hittle B; Landrigan C; Patrician PA; Redeker NS; Rogers AE; Trinkoff A; Tucker S

**The human factors of mineworker fatigue: unique properties of fatigue in the mining environment.** Martell MJ; Bauerle TJ; Willmer DR; Sammarco JJ

**U.S. oil and gas extraction workers: fatigue, sleep, and working hours.** Retzer KD; Lerman SE; Pratt SG

**Working hours and fatigue in the public safety sector.** Allison P; Tiesman HM; Bernzweig D; Butler CR; James L; James S; Kumagai J; Patterson PD

**Research gaps and needs for work hours and fatigue in the transportation, warehousing, and utilities sector.** Sieber WK; Iker K; Lincoln JE; Menendez CC; O'Connor MB; Krueger GP

**Work-related fatigue: a hazard for vulnerable workers.** Cunningham TR; Guerin RJ

# Selected publications

## Infographics / Fact Sheets

**Oil and Gas Workers: How to Prevent Fatigued Driving at Work.** Retzer K., Olsavsky R., and Dalsey E. Morgantown, WV: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication 2018–126

**Oil and Gas Employers: How to Prevent Fatigued Driving at Work.** Retzer K., Olsavsky R., and Dalsey E. Morgantown, WV: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication 2018–125

**Quick sleep tips for truck drivers.** Hitchcock EM, Caruso CC, Dalsey EJ. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2014-150.

**10 Sleep tips for miners.** Dugdale Z, Baurele T. Spokane, WA: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, 2019. NIOSHTIC2 Number 20057029

**Do your workers show signs of fatigue?** Dugdale Z, Baurele T. Spokane, WA: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, 2019. NIOSHTIC2 Number 20057031