Shiftwork and Sleep

Optimizing Health, Safety and Performance

Sponsored by: UNIVERSITY OF CINCINNATI

Educational partner: Rockpointe

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The American College of Occupational and Environmental Medicine

and the

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National Heart, Lung and Blood Institute
National Institutes of Health
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Program Faculty

NATALIE P. HARTENBAURM, MD, MPH, FACOEM (Chair)
President and Chief Medical Officer
OccuMedix, Inc.
Dresher, PA

EVE VAN CAUTER, PhD
Frederick H. Rawson Professor
Department of Medicine
Section of Endocrinology, Diabetes, and Metabolism
The University of Chicago
Chicago, IL

PHYLLIS C. ZEE, MD, PD
Professor of Neurology, Neurobiology, and Physiology
Director, Sleep Disorders Program
Northwestern University
Chicago, IL
Faculty Disclosures

• Natalie P. Hartenbaum, MD, MPH, FACOEM: Spouse works for Merck

• Eve Van Cauter, PhD: Co-investigator: The ResMed Foundation

• Phyllis C. Zee, MD, PhD: Advisory Board: Takeda, Sanofi-Aventis, Merck, Zeo, Philips-Respironics; Stock Option: Zeo
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- Carole Drexel, PhD; Brad Pine; Blair St. Amand; Jay Katz; Robert Schneider; Kay Weigand: Nothing to Disclose
Educational Objectives

Upon completion of the activities in this initiative, the participants should be better able to:

- Recognize the impact of sleep restriction on overall health, occupational performance and safety
- Understand the complex pathophysiology of sleep and the circadian system
- Assess and implement available management strategies in order to relieve and prevent the acute consequences and long-term health sequelae of sleep disorders associated with shift work
Healthy People 2020

Sleep Health

- Increase the proportion of adolescents obtaining adequate sleep
  
  **Baseline 31% (YRBS, 2007)**

- Increase the proportion of adults obtaining adequate sleep
  
  **Baseline 63% (NHANES, 2005-2008)**

- Decrease the number of motor vehicle incidents attributed to drowsy driving
  
  **Baseline 2.667 vehicular crashes/100 million miles**
  
  (FARS/GES/NHTSA, 2008)

- Increase the proportion of adults with apnea symptoms seeking medical treatment
  
  **Baseline 10% (NHANES, 2005-2008)**


CDC/BRFSS Maps 2009, General Health “Good”

http://apps.nccd.cdc.gov/gisbrfss/map.aspx
Typical Personnel Policy
Employer Expectation

- All employees should report for duty in manner able to perform their duties safely without risk of impairment

- Employees should be awake and alert throughout their work shifts.
Causes of Fatigue

- Extended work hours
- Shift work
- International travel
- Sleep disorders
- Medications
- Medical conditions
- Drugs and alcohol
- Insufficient sleep
Extended/Unusual Shift

Occupational Safety and Health Administration

- Normal work shift (no OSHA standard):
  - Daytime
  - Work period ≤8 consecutive hours
  - 5 days per week
  - At least an 8-hour rest between shifts

- Anything else - extended or unusual
- Work shifts
  - Day, evening, night
  - Regular or rotating
    - Predictable or unpredictable
  - Split Shifts
  - Extended Shifts
    - Planned or unplanned
    - Voluntary or mandatory
  - Consecutive unusual shifts
Who are Shift Workers

- 20% of wage and salary workers work a shift other than a regular daytime shift
- 7% work evening shift
- 4% employer arranged irregular shifts
- 4% night shift
- 3% Rotating shift

- Almost 15 million Americans work full time on evening shift, night shift, rotating shifts, or other employer arranged irregular schedules.

Monthly Labor Review • December 2007 • Data from 2004
Shift work and sleep

- Night shift and rotating shift workers get less sleep per night
- Rapid rotating shift worker get less sleep than those on slower (>3 weeks) rotations
- 25% reported that current work schedule does not permit sufficient sleep*
- 1/3 reported they obtain less sleep on workdays and weekends needed to function at their best*
- Cost to US employers in lost productivity due to sleep loss $18 billion annually

*2010 Sleep in America Poll
Fatigue in Transportation

- National Highway Traffic Administration estimates ≥100,000 police-reported crashes annually due to driver fatigue
  - 1,550 deaths
  - 71,000 injuries
  - $12.5 billion in monetary losses
- Human error contributes to >90% of transportation accidents
- Fatigue one of NTSB Top 10 Most Wanted Safety Improvements since 1989
- Congress passed Hours of Service (HOS) Act for Locomotive Engineers in 1907
  - HOS for commercial drivers passed in 1937, modified repeatedly
Macdonal, TX  June 28, 2004
Fatigue Indicators
- Circadian low point
- Schedule inversion
- Acute sleep loss
- Alcohol
- Numerous lapses in performance
- Conductor Behavior

Evidence Sources
- Work Schedules
- Engineer interview
- Housemate interview
- Toxicological tests
- Event recorder
- Records
Crossed median and ran over state trooper vehicle
Driver stated he may have fallen asleep
Involved in similar accident in Utah 3 years prior
Prior diagnoses of obstructive sleep apnea and hypothyroidism
OSA not adequately treated
BP Texas City Explosion

Incident summary

- March 23, 2005
- Explosion and fire
- 15 deaths
- 180 injuries
- Refinery process damaged and trailers destroyed
- Offsite property damage
BP Refinery Explosion

- Operators likely fatigued
- Worked 12 hour shifts, 7 days per week, 29+ days
- Acute sleep loss and cumulative sleep debt
- BP had no corporate or site specific fatigue prevention policy or maximum shift work guidelines
- No fatigue prevention standards in petroleum industry
Health Care Worker - Sleep and Safety

- Physicians in training - >24 h increases risk of:
  - Occupational sharps injury
  - Motor vehicle crash on way home
  - Making serious medical error
  - >16 hours
    - Twice as many attentional failures
    - 36% more serious medical errors

- Nurses - > 12.5 h shifts increases risk of:
  - Decreased vigilance on job
  - Suffering an occupational injury
  - Making a medical error

Fatigue and Alertness

- Related to time-of-day more than time-on-task
- Sleep duration in shift workers less than ideal
- **Schedule factors that impact worker safety and performance**
  - Number of hours on duty
  - Time of day when work is performed
  - Time off from work
  - Number of consecutive night shifts
  - Variability in work start time
    (e.g., direction of start time, speed of rotations)
- Employees poor at assessing levels of alertness
  - Subjective reports did not correlate with objective measures
Sleep Disorders – Lost Productivity

- Insomnia and Insufficient Sleep Syndrome groups had significantly worse productivity, performance, and safety

- Workers on irregular schedules
  - Greater reported on job productivity
  - Greater productivity loss

- Fatigue-related productivity losses estimated at $1967/employee annually

Addressing Sleep Issues in the Workplace

- Federal/State Regulation - Hours of Service /Mandatory Overtime
  - Transportation
  - Healthcare
- Industry Standards/Best Practices
  - ACGME
  - International Petroleum Industry Environmental Conservation Association (IPIECA) and International Association of Oil and Gas Producers (OGIP)
- Criminal Laws
  - Maggie’s Law: A sleep deprived driver who causes an accident, after being awake for more than 24 hours, can be convicted of vehicular homicide
- Medical Standards
## HOS Regulations in the Department of Transportation

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>US Interstate Truck and Bus Drivers</td>
<td>&lt;11 driving hrs within a 14-hr interval</td>
</tr>
<tr>
<td></td>
<td>&lt;14 consecutive hrs from start to end of work</td>
</tr>
<tr>
<td></td>
<td>&gt;8 consecutive rest hours</td>
</tr>
<tr>
<td></td>
<td>&lt;60 work hours per 7 days; &lt;70 work hours per 8 days</td>
</tr>
<tr>
<td></td>
<td>&gt;34 consecutive hours off between work weeks</td>
</tr>
<tr>
<td>US Airplane Pilots</td>
<td>&lt;8 daily flight hours</td>
</tr>
<tr>
<td></td>
<td>&lt;16 daily work hours</td>
</tr>
<tr>
<td></td>
<td>&gt;8-12 hours rest required</td>
</tr>
<tr>
<td></td>
<td>&lt;34 hours flight time per week</td>
</tr>
<tr>
<td>US Railroad Operators</td>
<td>&lt;12 work hours per day</td>
</tr>
<tr>
<td></td>
<td>&gt;8-10 hours rest required per day</td>
</tr>
</tbody>
</table>
## Table 1—Hours of Service Guidelines for 8-, 10-, and 12-hour Shifts

<table>
<thead>
<tr>
<th>Operational Situation</th>
<th>12-Hour Shift</th>
<th>10-Hour Shift</th>
<th>8-Hour Shift</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maximum Consecutive Shifts (Day or Night)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Normal Operations</td>
<td>7 shifts</td>
<td>9 shifts</td>
<td>10 shifts</td>
</tr>
<tr>
<td>b) Outages</td>
<td>14 shifts</td>
<td>14 shifts</td>
<td>19 shifts</td>
</tr>
<tr>
<td><strong>Minimum time off after a work set</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Normal Operations</td>
<td>36 hours</td>
<td>36 hours</td>
<td>36 hours</td>
</tr>
<tr>
<td>• Work set of 4 or more night shifts</td>
<td>48 hours</td>
<td>48 hours</td>
<td>48 hours</td>
</tr>
<tr>
<td>• After 84 hours or more regardless of day or night</td>
<td>48 hours</td>
<td>48 hours</td>
<td>48 hours</td>
</tr>
<tr>
<td>b) Outages</td>
<td>36 hours</td>
<td>36 hours</td>
<td>36 hours</td>
</tr>
<tr>
<td><strong>Extended Shifts</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Unscheduled maximum shift</td>
<td>16 hours</td>
<td>16 hours</td>
<td>16 hours</td>
</tr>
<tr>
<td>b) Time off after shift</td>
<td>N/A</td>
<td>N/A</td>
<td>8 hours</td>
</tr>
<tr>
<td>• 10 to 16 hour shift</td>
<td>N/A</td>
<td>N/A</td>
<td>8 hours</td>
</tr>
<tr>
<td>• 12 to 16 hour shift</td>
<td>N/A</td>
<td>8 hours</td>
<td>N/A</td>
</tr>
<tr>
<td>• 14 to 16 hour shift</td>
<td>8 hours</td>
<td>8 hours</td>
<td>N/A</td>
</tr>
<tr>
<td>• &gt;16 to 18 hour shift</td>
<td>10 hours</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Maximum Number of Extended Shifts per Work set</strong></td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>1 for 14 hour shift or 2 for 12 hour shifts or for 3 or more 12 hour shifts, follow 12 hour normal operations guidelines above</td>
<td>2 if greater than 12 hours in duration; extended shifts must be non-consecutive. If &gt;2, follow 12 hour normal operations above</td>
<td></td>
</tr>
</tbody>
</table>
Accreditation Council for Graduate Medical Education (ACGME)

- Maximum Duty Period Length
  - PGY-1 residents not exceed 16 hours in duration
  - PGY-2 residents and above up to 24 hours continuous duty in the hospital

- PGY-1 residents should have 10 hours, and must have 8 hours, free of duty between scheduled duty periods

- Intermediate-level residents should have 10 hours free of duty, and must have eight hours between scheduled duty periods
  - Must have 14 hours free of duty after 24 hours in house duty.
Fatigue Risk Trajectory

Sleep Opportunity
- HOS, Labor agreements, corporate policies, use of fatigue models

Sleep Obtained
- Commute time, personal lifestyle

Behavioral Symptom

Fatigue-related errors

Fatigue-related incidents

Key Component of Fatigue Management Systems

- Organizational Commitment
- Employee-Employer-Partnership
- Management, Supervisor and Employee Education and Training
- Fatigue risk assessment
- Staffing level analysis
- Work/rest scheduling
- Employee Health Screening
- Program Evaluation and Refinement
# Fatigue

<table>
<thead>
<tr>
<th>Managed by Employer</th>
<th>Managed by Employee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours of work</td>
<td>Second job</td>
</tr>
<tr>
<td>Shifts</td>
<td>Commuting time</td>
</tr>
<tr>
<td>Time between shifts</td>
<td>Family and social obligations</td>
</tr>
<tr>
<td>Time of day of shift start</td>
<td>General health</td>
</tr>
<tr>
<td>Timing of critical tasks</td>
<td>Sleep environment</td>
</tr>
<tr>
<td>Overtime policies</td>
<td>Medications</td>
</tr>
<tr>
<td></td>
<td>Adequate sleep</td>
</tr>
</tbody>
</table>
Ideal Work Schedule

- “No one best way to arrange work given that the value of work varies in response to economic, physiological and social factors”

- Dependent on;
  - Type of work being performed
  - Consequences of an error
  - Time of day at which work is performed
    - NIOSH

- One Size Does NOT Fit All
Neurobiology of Sleep and Circadian Rhythms

Impact Of Restricted Sleep And Circadian Misalignment On Health

EVE VAN CAUTER, PhD
Frederick H. Rawson Professor, Department of Medicine, Section of Endocrinology, Diabetes, and Metabolism
University of Chicago, Chicago, IL
Determinants of Alertness and Performance

- Consecutive Waking Hours
- Night Sleep Duration
- Biological Time of Day (circadian rhythms)
- Sleep Inertia
- Use of Stimulants or Hypnotics
- Underlying Medical Condition/Age
Neurobiological Systems that Support Wakefulness

Neurobiological Systems That Drive Sleep

Illustration Courtesy of Dr. Clif Saper
Acute Sleep Loss

>18 hours of wakefulness

- Marathon work shifts
- Regular shifts plus overtime shifts
- Two different jobs
- Recreational activities
- Internet 24/7 culture
- Family demands
- Travel logistics
## Comparative Impairment of Alcohol vs. Sleep Loss

<table>
<thead>
<tr>
<th>Sleep Loss (Time-in-Bed)</th>
<th>Equivalent Alcohol Dose</th>
<th>Equivalent Alcohol Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>US beers $^1$</td>
<td>BrEC% $^2$</td>
</tr>
<tr>
<td>8 hrs (0 hrs of sleep)</td>
<td>10-11</td>
<td>0.190%</td>
</tr>
<tr>
<td>6 hrs (2 hrs of sleep)</td>
<td>7-8</td>
<td>0.102%</td>
</tr>
<tr>
<td>4 hrs (4 hrs of sleep)</td>
<td>5-6</td>
<td>0.095%</td>
</tr>
<tr>
<td>2 hrs (6 hrs of sleep)</td>
<td>2-3</td>
<td>0.045%</td>
</tr>
</tbody>
</table>

$^1$ Given 14.22 g ethanol in a 12 oz beer  
$^2$ Approximate breath ethanol concentration (BrEC) at peak

Chronic Sleep Loss

4-6 hours of sleep per night

- Long work shifts (>12 hours)
- Work hours plus family demands
- School, extracurricular activities, homework
- Sleep interruptions
- Parents of newborns
Cumulative Adverse Effects of Chronic Sleep Restriction Were Greater For Objective Performance Than For Subjective Awareness

Objective performance

PVT performance lapses

4h TIB

6h TIB

8h TIB

Days of sleep restriction

Subjective awareness

KSS subjective sleepiness

deficits

Days of sleep restriction

Adverse Circadian Phase

3am-8am: circadian nadir of alertness

- Night work
- Long distance driving
- Early morning trips
- Just in time deliveries
- Truck driving
Circadian Clock in Human Brain

Intrinsic Circadian Period in Young Adults

Ages 20 – 41
n = 3 women, 42 men
Average = $24.2 \pm 0.2$ h
Range = 23.8 to 24.5 h

Courtesy of David Weaver, Ph.D.
Our circadian clock emits a “waking” signal that increases in strength throughout the usual daytime period and then abruptly turns off when nocturnal melatonin secretion is initiated (around 9 - 10 pm in most adults).

The timing of maximum of the circadian alerting signal is paradoxically in the evening.

The abrupt termination of the alerting signal from the central clock is often referred to as “the opening of the sleep gates”.

Temporal Distribution of Fatigue-related Single Vehicle Truck Accidents

Number of Accidents

National Transportation Safety Board Safety Study (SS-1995/01)
Starting Times for Full-Time Workers

26% of the U.S. Labor Force at Risk for SWD


Start time unknown: 1.5%

Elevated risk for SWD: 25.9%

Day and evening workers: 72.6%

Unknown risk: 1.5%
Increase in Reaction Time On Psychomotor Performance Task Resulting from 8 Hours of Sleep Loss

Rate of Accumulation of 8 hours of Sleep Loss

D PVT (ms)

Control  Slow  Inter  Rapid
## Epworth Sleepiness Scale

<table>
<thead>
<tr>
<th>Situation</th>
<th>Chance of dozing (0-3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitting and reading</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>Watching television</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>Sitting inactive in a public place—for example, a theater or meeting</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>As a passenger in a car for an hour without a break</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>Lying down to rest in the afternoon</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>Sitting and talking to someone</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>Sitting quietly after lunch (when you’ve had no alcohol)</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>In a car, while stopped in traffic</td>
<td>0 1 2 3</td>
</tr>
</tbody>
</table>

**Total Score**

0 = would never doze  
1 = slight chance of dozing  
2 = moderate chance of dozing  
3 = high chance of dozing

Daytime Sleepiness in a Population-Based Sample

N = 3283
mean = 8.0 ± 4.6

20%

Moderate OSA = 11.5
Severe OSA = 16.0
Narcolepsy = 17.3
Daytime Sleepiness in the Population

- **Moderate OSA**: 11.5
- **Severe OSA**: 16.0
- **Narcolepsy**: 17.3

**Epworth Sleepiness Scale Score (0-24)**

- **Residents**
  - N = 3283
  - Mean = 8.0 ± 4.6
- **Residents**
  - N = 149
  - Mean = 14.6 ± 4.4

84%
Sleep-Alcohol Interaction

![Graph showing off-road deviations in driving simulator—A.M.](image)
Correlation Between score on the MSLT and Epworth Sleepiness Scale

Short Sleepers (TST < 6)

- Correlation coefficient: $r = 0.02$
- Significance: $P = 0.89$
- Sample size: $n = 15$

Long Sleepers (TST > 9)

- Correlation coefficient: $r = -0.62$
- Significance: $P = 0.02$
- Sample size: $n = 14$

2000 Omnibus Sleep in America Poll

Number of Hours Slept
(past two weeks)

Average Hours

Total Adults 18-29 30-64 65+ Reg. Days Shift

Weekends

Weekdays

Recommended

7.5 7.8 7.5 7.3 7.6 7.5 6.9 6.5

6.9 6.8 6.9 7.2 6.9 6.9 6.9 6.5
Melatonin

Sleep-Wake homeostasis

Circadian Rhythm - SCN

Hypothalamic pulse generators

ANS

Pituitary

PRL  GH  TSH  ACTH  LH  FSH

All endocrine axes
Short duration of sleep (≤7h) is associated with a 12% greater risk of death after controlling for multiple confounders. When short duration of sleep was ≤6 h, the increase in risk is 18%.

Short duration of sleep (≤6h) is associated with a 28% increase in the risk of diabetes. Difficulty in maintaining sleep is associated with a 84% increase in the risk.

How Sleep Loss Affects The Risk Of Type 2 Diabetes: Findings From Laboratory Studies Of Healthy Young Subjects

- Peripheral tissues that need insulin to utilize glucose (muscle, fat) become less sensitive to insulin, i.e. “insulin resistant”.

- The beta cells of the pancreas should produce more insulin to maintain normal glucose levels but fail to do so.

- When the beta cells fail to compensate for the increased insulin resistance, diabetes risk is elevated.
Ratings of Hunger and Appetite

<table>
<thead>
<tr>
<th></th>
<th>Clock Time</th>
<th>9</th>
<th>11</th>
<th>13</th>
<th>15</th>
<th>17</th>
<th>19</th>
<th>21</th>
</tr>
</thead>
<tbody>
<tr>
<td>HUNGER</td>
<td>3.5</td>
<td>22</td>
<td>42</td>
<td>52</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GLOBAL APPETITE</td>
<td>22</td>
<td>32</td>
<td>42</td>
<td>52</td>
<td>7.5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **AFTER 2 DAYS OF 4-H BEDTIME**
  - HUNGER (cms): <0.01, +19%
  - GLOBAL APPETITE (cms): 0.010, +20%

# Sleep Duration And Obesity

*Epidemiologic Studies*

<table>
<thead>
<tr>
<th></th>
<th>TOTAL # OF STUDIES</th>
<th># OF STUDIES IN CHILDREN</th>
<th># OF STUDIES IN ADULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Positive Findings</td>
<td>Total # Of Studies</td>
<td>Positive Findings</td>
</tr>
<tr>
<td>Cross-sectional Studies</td>
<td>45</td>
<td>49</td>
<td>20</td>
</tr>
<tr>
<td>Prospective Studies</td>
<td>12</td>
<td>13</td>
<td>7</td>
</tr>
<tr>
<td>All Studies</td>
<td>57</td>
<td>63</td>
<td>27</td>
</tr>
</tbody>
</table>
Impact of Sleep Loss On Diabetes and Obesity Risk: *Putative Pathways*

Reduced Sleep Duration and/or Quality

*Upregulation of orexin system*

- ↑ sympathetic nervous activity
- ↑ evening cortisol  
  ↑ nighttime GH
- ↓ leptin  
  ↑ ghrelin
- ↑ time to eat
- Lower energy expenditure?

- ↑ insulin resistance  
  ↓ glucose tolerance
- ↑ appetite  
  ↑ food intake

Diabetes  
Obesity  
Diabesity
Circadian clock

Feeding rhythm

Sleep/Wake cycle

Decrease in sleep duration

Circadian Misalignment

Insulin resistance

Decreased glucose tolerance
Shift Work and the Risk for Coronary Heart Disease in 79,109 Nurses

Relative Risk (95% CI)

<table>
<thead>
<tr>
<th></th>
<th>No Shift Work</th>
<th>Any Shift Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal CHD</td>
<td>1.00</td>
<td>1.23</td>
</tr>
<tr>
<td>Nonfatal MI</td>
<td>1.00</td>
<td>1.41</td>
</tr>
<tr>
<td>Total CHD</td>
<td>1.00</td>
<td>1.38</td>
</tr>
</tbody>
</table>

Gastrointestinal Disorders in Night-Shift Workers

Prevalence of Ulcers

<table>
<thead>
<tr>
<th>Shift</th>
<th>No Insomnia or ES</th>
<th>Insomnia and/or ES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day Shift</td>
<td>6.0</td>
<td>1.4</td>
</tr>
<tr>
<td>Rotating Shift</td>
<td>3.2</td>
<td>*</td>
</tr>
<tr>
<td>Night Shift</td>
<td>4.5</td>
<td>*</td>
</tr>
</tbody>
</table>

*P < 0.05 vs no insomnia or ES.

Functional Bowel Disorders

<table>
<thead>
<tr>
<th>Shift</th>
<th>% of Nurses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day Shift</td>
<td>20</td>
</tr>
<tr>
<td>Rotating Shift</td>
<td>38†</td>
</tr>
</tbody>
</table>

†P = 0.04 vs day shift.
Zhen LW, et al.

ES = excessive sleepiness.

# Odds Ratio for Cancer Among Shift Workers

<table>
<thead>
<tr>
<th>Type of Cancer</th>
<th>Odds Ratio</th>
<th>95% CI</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Breast Cancer</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Night shift ≥ 0.5 year</td>
<td>1.5</td>
<td>1.3 – 1.7</td>
<td>1</td>
</tr>
<tr>
<td>Night shift &gt; 6 years</td>
<td>1.7</td>
<td>1.3 – 1.7</td>
<td></td>
</tr>
<tr>
<td>“Graveyard shift” (any)</td>
<td>1.6</td>
<td>1.0 – 2.5</td>
<td>2</td>
</tr>
<tr>
<td>Shift work ≥ 5.7 hours/week</td>
<td>2.3</td>
<td>1.0 – 5.3</td>
<td></td>
</tr>
<tr>
<td>Rotating nights; 1-14 years</td>
<td>1.08</td>
<td>0.99 – 1.18</td>
<td>3</td>
</tr>
<tr>
<td>Rotating nights; 15-29 years</td>
<td>1.08</td>
<td>0.90 – 1.30</td>
<td></td>
</tr>
<tr>
<td>Rotating nights; ≥ 30 years</td>
<td>1.36</td>
<td>1.04 – 1.78</td>
<td></td>
</tr>
<tr>
<td>Overall shift work</td>
<td>1.04</td>
<td>0.79 – 1.38</td>
<td>4</td>
</tr>
<tr>
<td>Evening shift</td>
<td>1.08</td>
<td>0.81 – 1.44</td>
<td></td>
</tr>
<tr>
<td>Overnight shift</td>
<td>0.55</td>
<td>0.32 – 0.94</td>
<td></td>
</tr>
<tr>
<td>Rotating shift work: &gt; 20 years</td>
<td>1.79</td>
<td>1.06 – 3.01</td>
<td>5</td>
</tr>
<tr>
<td><strong>Prostate Cancer</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rotating shift work</td>
<td>3.0</td>
<td>1.2 – 7.7</td>
<td>6</td>
</tr>
</tbody>
</table>

Diagnosis And Treatment Of Shift Work Sleep Disorder

PHYLLIS C. ZEE, MD, PhD
Professor of Neurology and Neurobiology and Physiology
Director, Sleep and Wake Disorders Center
Northwestern University
Chicago, IL

Let there be wake and sleep on time!

Cardinali, Lancet, 2009
Shift Work Sleep Disorder: ICSD-2 Criteria

• Insomnia and/or ES that is temporally associated with a recurring work schedule that overlaps the usual time for sleep

• Sleep/wake disturbance causes clinically significant distress or functional impairment

• Symptoms are associated with the shift work schedule over the course of $\geq1$ month

• Evidence of disturbed circadian and sleep-/wake-time misalignment, documented usually by sleep diary/log for 7-14 days

NOT ALL SHIFT WORKERS HAVE SHIFT WORK SLEEP DISORDER!

ES = excessive sleepiness

## Shift Work Types/Schedules

<table>
<thead>
<tr>
<th>Shift Type</th>
<th>Work Time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Evening</strong></td>
<td>Between 2 PM and midnight</td>
</tr>
<tr>
<td><strong>Day</strong></td>
<td>Wake 5 AM for morning work</td>
</tr>
<tr>
<td><strong>Night</strong></td>
<td>Between 9 PM and 8 AM</td>
</tr>
<tr>
<td><strong>Rotating</strong></td>
<td>Periodic time changes among days, evenings, nights</td>
</tr>
<tr>
<td><strong>Split</strong></td>
<td>Two distinct work periods/day</td>
</tr>
<tr>
<td><strong>Irregular</strong></td>
<td>Varying times by employer</td>
</tr>
</tbody>
</table>

## Circadian Rhythm Sleep Disorder (CRSD)

*Diagnostic Code for Shift Work Disorder and Other Commonly Associated CRSD*

<table>
<thead>
<tr>
<th>ICSD-2</th>
<th>ICD-9</th>
<th>ICD-10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shift work type (Shift work sleep disorder)</td>
<td>327.36</td>
<td>F51.22</td>
</tr>
<tr>
<td>Other circadian rhythm sleep disorder due to drug or substance</td>
<td>292.85/291.82</td>
<td>G47.25</td>
</tr>
<tr>
<td>Circadian rhythm sleep disorders due to medical condition</td>
<td>327.37</td>
<td>G47.26</td>
</tr>
</tbody>
</table>

Evaluation of Suspected Shift Work Sleep Disorder and Other Associated Sleep Disturbances

- Screening/diagnostic tools
- Sleep/Wake history
- Sleep-specific exam (neck size, airway, sleepiness, sleep)
- Determine patients’ sleep/wake patterns
- Identify comorbid conditions
- Sleep/Wake diary/log Actigraphy
- Other Sleep studies
When to Suspect and Screen for SWSD in Primary Care?

- During visit for
  - Specific complaints of insomnia or sleepiness
  - Work-related complaints
  - Possible co-morbidities
  - Routine annual exam
During Visit With Specific Sleep or Work-related Complaints

- Fatigue
- Sleepiness during work and social activities
- Insomnia symptoms
- Irritability, depression, anxiety

ASK:

- Related to work schedule?
- Bedtime and wake times on work days and weekends?
- Accidents (motor vehicle, falls, injury)?
- Drowsy driving?
- Impaired work performance?
Shift Work Sleep Disorder Comorbidities

- Night shift workers
  - Gastrointestinal disorders more common
  - Cardiovascular disease more common
  - Neoplastic disease more common
  - Diabetes and metabolic syndrome may be more common
  - Substance abuse
  - Other sleep disorders (sleep apnea, restless legs)

- Persons with shift work sleep disorder appear more vulnerable than other shift workers to
  - Depression
  - Cancer
  - Stroke

Medications Associated with Sleep/Wake Disturbances

- Anticholinergics
- Antihypertensives
- Antihistamines*
- Bronchodilators
- β-blockers
- Decongestants
- Diuretics
- Dopamine agonists*
- TCA
- Hypnotics*
- MAO inhibitors
- Phenytoin
- Quinidine
- Selegiline
- SSRIs
- Thyroid hormone
- Xanthines

*Causes excessive sleepiness; other listed agents are associated with insomnia; hydrophilic, lipophilic. MAO = monoamine oxidase; SSRI = selective serotonin reuptake inhibitor.
Differential Diagnosis of SWSD

- Exclude other potentially causative conditions of ES and insomnia, including
  - Obstructive sleep apnea
  - Narcolepsy
  - Hypersomnia
  - Insufficient sleep
  - Insomnia
  - Other CRSDs
  - Restless legs syndrome
  - Drug- and alcohol-dependency

ES = excessive sleepiness; CRSDs = circadian rhythm sleep disorders

Recognizing OSA

• Consider the diagnosis of OSA when snoring is reported and any of the following are present:
  - Depression
  - Hypertension
  - GERD
  - Diabetes
  - Congestive heart failure

• Diagnosis: polysomnography

How RLS Patients Present*

Sensory-related Symptoms
- 97% of patients report at least 1 sensory-related leg symptom, including:
  - Urge to move the legs
  - Uncomfortable sensation in the legs

Sleep-related Symptoms
- 88% of patients report at least 1 sleep-related symptom, including:
  - Inability to fall asleep
  - Inability to stay asleep
  - Disturbed sleep

* Based on results from matched patient and physician questionnaires involving 551 patients with at least twice-weekly RLS symptoms and some or high negative impact on their quality of life.

Disorders of Sleep and Wakefulness

- Hypersomnias (narcolepsy)
- Insomnia
- Disorders of Sleep/Wake Regulation
- Disorders of Sleep Disruption
- Disorders of Circadian Alignment
- Parasomnias
  - SWD
  - RLS
- Obstructive Sleep Apnea/Hypopnea Syndrome

Increased Sleep Drive

Sleep Disruption
Evaluation: *Physical Exam and Laboratory Studies*

- **HEENT**
  - Crowded oropharynx?
  - Retrognathic?
  - Chronic sinus congestion, deviated septum?
- **Cardiovascular**
  - Resistant hypertension?
  - Any sign of heart failure?
- **Neurologic/Psychiatric**
  - CNS disease present?
- **Laboratory Tests**
  - Lab screen for co-morbid medical conditions (diabetes)
  - TSH; CBC, Fe/TIBC/Ferritin: <50 restless leg syndrome

# Epworth Sleepiness Scale (ESS)

<table>
<thead>
<tr>
<th>SITUATION</th>
<th>CHANCE OF DOZING (0-3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitting and reading</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>Watching television</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>Sitting inactive in a public place – for example, a theater or meeting</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>As a passenger in a car for an hour without a break</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>Lying down to rest in the afternoon</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>Sitting and talking to someone</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>Sitting quietly after lunch (when you’ve had no alcohol)</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>In a car, while stopped in traffic</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td><strong>Total Score</strong></td>
<td></td>
</tr>
</tbody>
</table>

0 = would never doze  
1 = slight chance of dozing  
2 = moderate chance of dozing  
3 = high chance of dozing

ESS total score ≥10 indicates excessive daytime sleepiness or sleep disorder

Johns MW. Sleep. 1991;14:540-545.
Diagnostic Tools for Measuring Sleep and Circadian Rhythms in SWSD

- **Sleep diary (at least 7 days)**
- **Actigraphy (at least 7 days)**
  - Actigraphy: CPT code: 95803
    - 72 hours to 14 days continuous
    - Carrier priced ($250-$300)

- **Melatonin** (24 hour or onset-DLMO)
# SWSD Assessment

*Sleep Log*

| Date  | AM | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|-------|----|----|---|---|---|---|---|---|---|---|---|----|----|----|---|---|---|---|---|---|---|---|---|---|---|---|
| 12/9  | M  |    |   |   |   |   |   |   |   |   |   |    |    |    |   |   |   |   |   |   |   |   |   |   |   |   |
| 12/10 | M  |    |   |   |   |   |   |   |   |   |   |    |    |    |   |   |   |   |   |   |   |   |   |   |   |   |
| 12/11 | M  |    |   |   |   |   |   |   |   |   |   |    |    |    |   |   |   |   |   |   |   |   |   |   |   |   |
| 12/12 |    | M  |    |   |   |   |   |   |   |   |   |    |    |    |   |   |   |   |   |   |   |   |   |   |   |   |
| 12/13 |    |    | M |   |   |   |   |   |   |   |   |    |    |    |   |   |   |   |   |   |   |   |   |   |   |   |
| 12/14 |    |    |   | M |   |   |   |   |   |   |   |    |    |    |   |   |   |   |   |   |   |   |   |   |   |   |
| 12/15 |    |    |   |   | M |   |   |   |   |   |   |    |    |    |   |   |   |   |   |   |   |   |   |   |   |   |

NHLBI, ASSM. Available at: [www.aasmnet.org](http://www.aasmnet.org).
Multiple Dimensions of Shift Work Sleep Disorder

- Sleep loss & Fatigue
  - Poor Performance
  - Irritability
  - Increased Risks
- Family/Social Disruption
- Organizational Difficulties

Further disruption & difficulties
General Management Approach for SWSD

- Educate the patient regarding strategies to minimize the risks of shift work
- Assess for, and manage, comorbid disorders
  - Depression
  - OSAS
  - Substance use disorders
  - Gastrointestinal disorders
- Healthy habits
  - Diet
  - Sleep hygiene
  - Exercise
Treatment Goals

• Promote good sleep habits and sleep/work environment
• Alertness management
• Re-align circadian rhythm with sleep/wake and work schedule

Courtesy of G. Brainard
# Therapies for Shift Work Sleep Disorder

<table>
<thead>
<tr>
<th>Therapy</th>
<th>AASM Level of Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planned sleep schedules</td>
<td>Standard</td>
</tr>
<tr>
<td>Timed light exposure</td>
<td>Guideline</td>
</tr>
<tr>
<td>Timed melatonin administration</td>
<td>Guideline</td>
</tr>
<tr>
<td>Hypnotics</td>
<td>Guideline</td>
</tr>
<tr>
<td>Stimulants</td>
<td>Option</td>
</tr>
<tr>
<td>Alerting agents</td>
<td>Guideline</td>
</tr>
</tbody>
</table>

*Standard: High degree of clinical certainty, level 1 or 2 evidence*

*Guideline: Moderate degree of clinical certainty, level 2 or consensus of level 3 evidence*

*Option: Uncertain clinical use, inconclusive or conflicting evidence*

Sleep Hygiene Measures

- Quiet bedroom
  - Turn off TV, radio, telephone
  - Ear plugs
- Comfortable bedroom temperature
- Regular exercise
- Avoid …
  - Alcohol
  - Caffeine, nicotine, and other stimulants prior to bedtime
  - Large meals or excessive fluids prior to bedtime
  - Exercise within 3 hours of bedtime

Planned Napping

- 20 minutes to one hour
- Prior to or during night shift
- Demonstrated improvements
  - Improved reaction times
  - Increased alertness
  - Fewer accidents
  - Improved performance
- Generally does not adversely affect daytime sleep

Timed Light Exposure

- Bright lights during work shifts
- Sunglasses during commute home in the morning
- Minimize light exposure prior to bedtime
- Darken bedroom at home
  - Curtains
  - Black-out blinds
  - Dim lights
Timed Light Exposure

- Intensities (illuminances) of 2,350 to 12,000 lux
- Usually full spectrum, no UV
- Schedules
  - 20- to 30-min discontinuous periods during night shift
  - Continuously during the first half to the entire night shift
- Often combined with morning light restriction with goggles
- Demonstrated improvements
  - Performance
  - Alertness
  - Mood
  - Daytime sleep
  - Beneficial shifts in circadian phase markers (e.g. salivary melatonin)

**Timed Melatonin Administration**

- Administered following night shift, prior to daytime sleep period
- Doses have ranged between 0.5 and 10 mg, mostly lower doses (1-3 mg)
- Results mixed; improvements noted in some studies in
  - Daytime sleep quality and duration
  - Shift in circadian phase (DLMO)
- Has not been shown to enhance alertness during night shift
- Melatonin is not FDA-approved
- Adverse effects
  - Have not been well investigated
  - No serious side effects reported in low doses (1-5 mg)

Caffeine for Excessive Sleepiness

• Numerous experimental sleep deprivation studies demonstrating mitigation of sleepiness and enhancement of performance
• One field trial with shift workers
  - Caffeine 4 mg/kg 30 min prior to night shift
  - Combined with napping
  - Diminished sleepiness alone, better in combination

Not FDA indicated for this use

Hypnotics for Insomnia

- Studies with shift workers have utilized
  - Triazolam 0.25 and 0.5 mg
  - Temazepam 20 mg
  - Zopiclone 7.5 mg
- Demonstrated improvements in quality and duration of daytime sleep
- Inconsistent effects on alertness during night shift

Not FDA indicated for circadian rhythm disorders

Modafinil for Excessive Sleepiness

- Simulated night shift study
  - Modafinil 200 mg 1 hour prior to simulated night shift
  - Four consecutive night shifts
  - Improvements noted in
    • Excessive sleepiness (MWT)
    • Vigilence and reaction time (PVT)
    • Executive function tests
- Field study
  - Modafinil 200 mg 30-60 min prior to each shift
  - Following three or more nights of work, on 3 occasions 1 month apart (12 weeks)
  - Improvements noted in
    • Excessive sleepiness (MSLT)
    • Overall condition (CGI-C)
    • Reduction in lapses in attention
    • Fewer accidents or near misses during commute home

Armodafinil for Excessive Sleepiness

- Field study
  - Armodafinil 150 mg 30-60 min prior to each shift
  - Following three or more nights of work, on 3 occasions 1 month apart (12 weeks)
  - Improvements noted in
    - Excessive sleepiness (MSLT)
    - Overall condition (CGI-C)
    - Performance on memory and attention tests

Modafinil and Armodafinil Adverse Effects

- Most common: headache, nausea, dizziness, anxiety, and insomnia
- DEA schedule IV
- Potential for serious rash and hypersensitivity reactions
- May diminish effectiveness of oral contraceptives

**Summary:** Addressing Circadian Misalignment and Sleep Deprivation in Shift Work Sleep Disorder

- **Increase sleep duration**
  - Sleep hygiene education
  - Hypnotic medication
  - Melatonin bedtime

- **Increase alertness**
  - Naps
  - Caffeine
  - Modafinil

- **Circadian Alignment**
  - Bright light during work
  - Melatonin (bedtime during the day)
  - Avoid morning bright light
When to Seek a Sleep Medicine Consultation

- Symptoms do not improve sufficiently following management
- Discovery of comorbid sleep disorders
  - OSAS
  - Narcolepsy
  - Restless legs/Periodic limb movement disorder

Primary Care Professionals are KEY to diagnosis and treatment!