AN EPIDEMIC OF SLEEPINESS: SLEEP DEPRIVATION, HEALTH AND SOCIETY

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The main facts in human life are five:

- Birth
- Food
- Love
- Sleep
- Death
“I do not want to discuss the nature of sleep and dreams—only to point out that they occupy much time and that what is called "History" only busies itself with about two-thirds of the human cycle...” (Forster)
Objectives

- Background
- Function of sleep
- Excessive sleepiness
  - Measurement
  - Recognition
  - Causes
- Sleep deprivation
  - Sleep requirement
  - Consequences of sleep deprivation
    - Physiological
    - Cognitive performance and emotional regulation
      - Occupational issues
      - Driving
- Role of shift work in health and disease
- Management strategies
Control of Sleep-Wake

Sleep Drive

Wake Propensity

Circadian Drive for Wakefulness

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Why Do We Sleep

- Organisms from yeast to man show basic rest-activity cycles
- A fundamental, common sense theory would suggest that sleep/rest is for restoration…. 
- But restoration of what? And how?
What happens when we sleep?

- Muscle relaxation / atonia
- Growth hormone / anabolic steroid release
- Decreased energy consumption
- Reduced autonomic activity
  - HR/Resp/BP – NREM
- Reduced / absent CNS catecholamine activity
  - Locus coeruleus
- Internal cortical activation (REM)
Why Do We Sleep?

• Is sleep for the whole body?
  ▫ Restoration/repair of muscles/skeleton
    • Growth hormone/anabolic steroid secretion
  ▫ Energy conservation

• Or for the brain?
  ▫ Development
  ▫ Vigilance
  ▫ Memory

Or both?
Why Do We Sleep?

- Do we sleep to conserve energy?

- Data showing longer sleep periods for small animals with high metabolic rates suggests this might be the case.

- But the energy savings with sleep are limited.
Play It Again, Sam
Do we sleep to remember (or forget)?
Neuronal playback of waking experience during sleep
Sleep and Memory Consolidation

![Graph showing the effect of wake and sleep on motor skill memory.](image)
Why do we sleep?

- Sleep may fulfill multiple needs for both brain (brain development, vigilance, learning/memory) and body (physical growth and development, energy conservation, restoration of musculo-skeletal system).
- Certain functions (e.g. energy conservation) may be most strongly connected to NREM while others (e.g. memory consolidation) may function across all stages of sleep.
- Much more research is needed to understand this.
Nature of Sleepiness

- Sleepiness is a basic physiological state - like hunger or thirst
  - It is not to be denied
- The presence and intensity can be inferred by
  - how readily sleep onset occurs
  - how easily sleep is disrupted
  - how long sleep endures
- But... defining and measuring sleepiness is difficult
  - Differing approaches to measurement (e.g. ESS and MSLT) do not correlate well with one another
    - What are we really measuring?
  - Inter-individual variability to manifest sleepiness, or at least subjective awareness, seems high
HABITUAL SLEEP TIME IN US

NSF/Gallop Poll 2005:

Ave. adult = 6.8 hours on weekdays
(7.4 hours on weekends)
How much sleep do we need?

![Graph showing actual sleep length for men and women](image)
Total Sleep Requirement

[Bar chart showing the percentage of all people's sleep requirements in hours. The chart indicates that the majority of people require 8 hours of sleep.]
How much sleep do we need?

Roth et al., 1994
Sleep Loss is Cumulative

![Graph](image)

- **Sleep latency (min)**
  - 0
  - 2
  - 4
  - 6
  - 8
  - 10
  - 12
  - 14
  - 16
  - 18
  - 20

- **Days Deprived**

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For myself I never found need of more than four or five hours' sleep in the twenty-four. I never dream. It's real sleep. When by chance I have taken more I wake dull and indolent. We are always hearing people talk about "loss of sleep" as a calamity. They better call it loss of time, vitality and opportunities.
...but he was a good napper
Rampant Sleep Deprivation?

“I’m right there in the room, and no one even acknowledges me.”

_The New Yorker, 9/18/06_
Determinants of Sleepiness

- Quantity of Sleep
  - Sleep deprivation
- Quality of Sleep
  - Repetitive arousal – Obstructive sleep apnea
- Timing of Sleep
  - Circadian rhythm sleep disorder
- Substances
- Primary Sleep Disorders
  - Narcolepsy et al.
- Psychiatric ±
Sleep Deprivation
Inter-individual Variability: Putative Traits

- Sleep requirement
  - Presumed genetic basis but complex
    - Homeostat / circadian drive
- Vulnerability to sleep loss
- Sleep-ability
- Morningness/eveningness
- Rigidity to morningness/eveningness
- Sleep inertia
# Assessment - Epworth Sleepiness Scale

<table>
<thead>
<tr>
<th>Situation</th>
<th>Chance of Dozing or Sleeping (0-3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitting and reading</td>
<td></td>
</tr>
<tr>
<td>Watching TV</td>
<td></td>
</tr>
<tr>
<td>Sitting inactive in a public place</td>
<td></td>
</tr>
<tr>
<td>Passenger in a motor vehicle for an hour or more</td>
<td></td>
</tr>
<tr>
<td>Lying down in the afternoon</td>
<td></td>
</tr>
<tr>
<td>Sitting and talking to someone</td>
<td></td>
</tr>
<tr>
<td>Sitting quietly after lunch (no alcohol)</td>
<td></td>
</tr>
<tr>
<td>Stopped for a few minutes in traffic while driving</td>
<td></td>
</tr>
</tbody>
</table>

**Total score (add the scores up)**
- (This is your Epworth score)
  - (>10 is abnormal)
Assessment - Sleep Logs
Behaviorally-Induced Insufficient Sleep Syndrome - Diagnostic Criteria

- The patient has a **complaint of excessive sleepiness** or, in pre-pubertal children, a complaint of behavioral abnormalities suggesting sleepiness. The abnormal sleep pattern is present for at least 3 months;
- The patient’s habitual **sleep episode** is usually shorter than expected from age-adjusted normative data except for Long Sleepers where it may be within normal limits;
- When the habitual sleep schedule is not maintained (weekends or vacation time), patients will sleep considerably longer than usual;
Effects of sleep extension in alert and sleepy healthy adults

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INSOMNIA ≠ SLEEP DEPRIVATION

Insomnia occurs **despite adequate opportunity to sleep**

- *that is, spending enough time in bed*

  • *The consequences of insomnia differ significantly from the consequences of sleep deprivation*
Consequences of sleep deprivation

- **Physiological**
  - Obesity
  - Cardio-vascular disease
  - Diabetes

- **Cognitive**
  - Occupational hazards and safety
Sleep Restriction

- Sleep restricted to 5 hrs/night for 7 nights
  - Subjective sleepiness and fatigue increased immediately in response to restriction
  - Psychomotor performance showed declines after the second day, reached a steady state but worsened again by day 7.
- MSLT (sleepiness) scores clearly worsened
- Partial sleep deprivation is associated with cumulative waking neurobehavioral deficits.

Dinges, et al., 1997
Sleep Deprivation Decreases Attention

Van Dongen et al, Sleep, 2003

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Sleep and Academic Performance

![Bar graph showing grade point average by amount of sleep. The graph indicates that students with 7 or more hours of sleep per week have a higher mean GPA compared to those with less sleep.](image-url)
OBESITY: A Weighty Issue for Children

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Childhood Obesity and Sleep Deprivation

Cappucio et al, 2008

Ages 2-20 y
Short sleep = <10h/nt.

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Sleep deprivation reduces leptin levels

(A) Leptin (ng/mL) and Ghrelin (ng/mL) over clock time:
- After 2 days of 10 h sleep time
- After 2 days of 4 h sleep time

(B) Hunger and Global appetite over clock time:
- After 2 days of 4 h bedtime
- After 2 days of 10 h bedtime

<table>
<thead>
<tr>
<th>Parameter</th>
<th>P value</th>
<th>change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leptin</td>
<td>0.041</td>
<td>-19%</td>
</tr>
<tr>
<td>Ghrelin</td>
<td>0.038</td>
<td>+24%</td>
</tr>
</tbody>
</table>

Hunger (cm): P value <0.01, +19%
Global appetite (cm): P value 0.010, +20%
Sleep Deprivation

- Altered glucose metabolism
- Increased appetite
- Increased opportunity to eat
- Increased fatigue
- Increased caloric intake
- Reduced exercise/energy expenditure
- Increased diabetic risk

leptin

ghrelin

Obesity

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Sleep Disorders Center
Impairment in glucose metabolism following moderate sleep restriction
### Sleep duration and hypertension risk

<table>
<thead>
<tr>
<th>Usual sleep duration, h/night</th>
<th>Model 1 Unadjusted ( p &lt; .0001 )</th>
<th>Model 2 Adjusted for age, sex, race, and AHI ( p &lt; .0001 )</th>
<th>Model 3 Adjusted for all covariates in Model 2 plus BMI ( p &lt; .0001 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 6</td>
<td>1.86 (1.54 – 2.26)</td>
<td>1.67 (1.36 – 2.05)</td>
<td>1.66 (1.35 – 2.04)</td>
</tr>
<tr>
<td>6 to &lt; 7</td>
<td>1.25 (1.08 – 1.44)</td>
<td>1.20 (1.03 – 1.39)</td>
<td>1.19 (1.02 – 1.39)</td>
</tr>
<tr>
<td>7 to &lt; 8</td>
<td>1.0 (referent)</td>
<td>1.0 (referent)</td>
<td>1.0 (referent)</td>
</tr>
<tr>
<td>8 to &lt; 9</td>
<td>1.31 (1.15 – 1.49)</td>
<td>1.19 (1.04 – 1.36)</td>
<td>1.19 (1.04 – 1.37)</td>
</tr>
<tr>
<td>≥9</td>
<td>1.75 (1.42 – 2.15)</td>
<td>1.31 (1.05 – 1.63)</td>
<td>1.30 (1.04 – 1.62)</td>
</tr>
</tbody>
</table>
Coronary heart disease risk and sleep duration

### Table 2. The RRs of CHD According to Self-reported Sleep Duration at Baseline

<table>
<thead>
<tr>
<th>Variable</th>
<th>≤5</th>
<th>6</th>
<th>7</th>
<th>8*</th>
<th>≥9</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of cases</td>
<td>67</td>
<td>267</td>
<td>348</td>
<td>193</td>
<td>59</td>
</tr>
<tr>
<td>Person-years of follow-up</td>
<td>30,115</td>
<td>175,629</td>
<td>288,731</td>
<td>162,662</td>
<td>31,015</td>
</tr>
<tr>
<td>Age-adjusted RR†</td>
<td>1.82 (1.34-2.41)</td>
<td>1.30 (1.08-1.57)</td>
<td>1.06 (0.89-1.26)</td>
<td>1</td>
<td>1.57 (1.18-2.11)</td>
</tr>
<tr>
<td>Multivariate model RR‡§</td>
<td>1.45 (1.10-1.92)</td>
<td>1.18 (0.98-1.42)</td>
<td>1.09 (0.91-1.30)</td>
<td>1</td>
<td>1.38 (1.03-1.86)</td>
</tr>
<tr>
<td>Not adjusted for diabetes mellitus or hypertension</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted for diabetes mellitus and hypertension</td>
<td>1.39 (1.05-1.84)</td>
<td>1.18 (0.98-1.43)</td>
<td>1.10 (0.92-1.31)</td>
<td>1</td>
<td>1.37 (1.02-1.85)</td>
</tr>
<tr>
<td>Nonfatal MI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age-adjusted RR‡</td>
<td>1.89 (1.35-2.66)</td>
<td>1.43 (1.15-1.79)</td>
<td>1.19 (0.97-1.48)</td>
<td>1</td>
<td>1.50 (1.04-2.17)</td>
</tr>
<tr>
<td>Multivariate model RR‡§</td>
<td>1.58 (1.12-2.22)</td>
<td>1.31 (1.04-1.64)</td>
<td>1.21 (0.98-1.59)</td>
<td>1</td>
<td>1.34 (0.93-1.93)</td>
</tr>
<tr>
<td>Not adjusted for diabetes mellitus or hypertension</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted for diabetes mellitus and hypertension</td>
<td>1.52 (1.08-2.14)</td>
<td>1.32 (1.05-1.65)</td>
<td>1.23 (0.99-1.52)</td>
<td>1</td>
<td>1.35 (0.93-1.95)</td>
</tr>
<tr>
<td>Fatal CHD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age-adjusted RR‡</td>
<td>1.67 (1.02-2.74)</td>
<td>1.05 (0.75-1.46)</td>
<td>0.80 (0.58-1.09)</td>
<td>1</td>
<td>1.71 (1.05-2.77)</td>
</tr>
<tr>
<td>Multivariate model RR‡§</td>
<td>1.20 (0.73-1.97)</td>
<td>0.92 (0.65-1.28)</td>
<td>0.84 (0.61-1.16)</td>
<td>1</td>
<td>1.45 (0.89-2.25)</td>
</tr>
<tr>
<td>Not adjusted for diabetes mellitus or hypertension</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted for diabetes mellitus and hypertension</td>
<td>1.12 (0.68-1.84)</td>
<td>0.91 (0.65-1.28)</td>
<td>0.83 (0.60-1.14)</td>
<td>1</td>
<td>1.45 (0.89-2.36)</td>
</tr>
</tbody>
</table>

Abbreviations: CHD, coronary heart disease; MI, myocardial infarction; RR, relative risk.

*Reference.

†Includes nonfatal MIs and fatal CHD-related events.

‡Data in parentheses are 95% confidence intervals.

§Adjusted for shift work (from 1988), hypercholesterolemia, body mass index, smoking, snoring, exercise level, alcohol consumption, depression (from 1992), aspirin use (from 1988), postmenopausal hormone use, and family history of MI.
Repeated voluntary nocturnal sleep deprivation leads to chronic states of sleep deprivation

- Prolonged waking hours, sedentary life, high calorie food
- Increased IL-6, CRP, TNF

Daytime Fatigue, less exercise

Glucose dys-regulation, increased cortisol, hyperinsulimia
  - high ghrelin, low leptin

Insulin resistance, hormonal changes, increased sympathetic drive

Obesity, hypertension, DM, Dyslipidemia

Metabolic syndrome, increased cardiovascular mortality/morbidity
Sleeping Air Traffic Controller Suspended After Emergency Landing at Reno Airport

... the fifth lapse so far this year among controllers at the nation's airports
Air Traffic

- "Have you ever nodded off in the cockpit?" 
  - 70 percent acknowledge having done that
- (During) nine-hour transatlantic flights, we measured them during the last 90 minutes of flight 
  - (We found)… 120 microsleeps … that were five seconds or longer.
  - Twenty-two of those (microsleeps) were literally when the wheels were coming to the ground.
Military

- Three U.S. special forces troops were killed and 19 were injured in Afghanistan on Wednesday by an errant 2,000-pound "smart" bomb dropped by a U.S. B-52 bomber north of the Taliban stronghold of Kandahar, the Pentagon said.
Military

- "Pilots from the U.S. fighter squadron that mistakenly bombed Canadian troops in Afghanistan had told their commanders shortly before the fatal accident that they were exhausted and needed more rest between missions."
- "Pilots were advised to speak to a flight surgeon about so-called 'go/no pills'-amphetamines used to help stay awake on long missions, and sedatives to help sleep."
- "U.S. jet fighter pilots, responsible for at least 10 deadly 'friendly fire' accidents in the Afghanistan war, have regularly been given amphetamines to fly longer hours."
Medicine
Sleepiness in residents is equivalent to that found in patients with serious sleep disorders.

Papp et al, Academic Medicine, 2002
Mustafa et al, Sleep and Breathing, 2005
Work Hours, Medical Errors, and Workplace Conflicts by Average Daily Hours of Sleep*

*Baldwin and Daugherty, 1998-9 Survey of 3604 PGY1,2 Residents

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Figure 5. Mean (+SE) Number of Attentional Failures among the 20 Interns as a Group and Individually while Working Overnight (11 p.m. to 7 a.m.) during the Traditional Schedule and the Intervention Schedule.
Driving

NSF’s 1999 “Sleep in America” Poll found:
- 62% reported driving drowsy in past year
- 27% actually dozed off at the wheel
- 23% knew someone who had a fall-asleep crash sometime in their life
It’s the same as being drunk

- 24 hours of sustained wakefulness produced a decline in general psychomotor performance equal to that observed at a BAC of roughly .1%, or four beers. 

(Powell et al, 2001)

- Three groups, one sleep-deprived completely for one night, one limited to five hours of sleep for 7 days, and one challenged with alcohol
  - Sleep-deprived groups showed a greater deficit as compared to prior performance than those with a BAC of .09%
  - They did not anticipate the effect lack of sleep would have, and overestimated their performance post-task
Police verified single occupant MVA versus degree of sleepiness in a 10 year follow-up period

Crash prevalence

- Excessive Sleepiness (MSLT ≤ 5)
- Moderate Sleepiness (MSLT > 5 ≤ 10)
- Alert (MSLT > 10)

Drake, 2010
It takes only a 4 second lapse in attention to have a drowsy driving crash
# Sleep health and “happiness”

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Life satisfaction</th>
<th>Net affect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Divorced (1 = Divorced; 0 = Married)</td>
<td>-.12</td>
<td>.06</td>
</tr>
<tr>
<td>Log household income</td>
<td>.20</td>
<td>.06</td>
</tr>
<tr>
<td>Education</td>
<td>.20</td>
<td>.03</td>
</tr>
<tr>
<td>Age</td>
<td>.12</td>
<td>.09</td>
</tr>
<tr>
<td>Sleep quality</td>
<td>.29</td>
<td>.30</td>
</tr>
</tbody>
</table>

Kahneman et al, 2006
Sleep deprivation in a nutshell

• We live in a culture in which sleep is not valued as part of a healthy lifestyle in the way that good nutrition or exercise are valued
  “I’ll sleep when I’m dead” “Who needs sleep?”
• Significant percentages of the population get less sleep than is required for optimal function
  ▫ Many are functionally impaired and unhappy as a result
• Sleep deprivation is associated with significant impairments and health risks
  ▫ Reduced vigilance and attention
  ▫ Impaired cognitive function
  ▫ Irritability
  ▫ Depression
  ▫ Impaired motor performance
  ▫ Potential medical consequences
    • Obesity
    • Lowered immune function
    • ? Increased risk for diabetes and cardio-vascular disease
• I’m just sayin’....
Shift Work

• **Nighttime work is part of our society**
  - 1 in 5 people work shifts;
  - ~15 million Americans
    - 3.8 million - night shifts
    - 3.3 million - rotating shifts
  - Over 22 million Americans have worked shifts in their life

• **Major impact on function**
  - Poorer work performance, missed days at work
  - Conflicts with social life, family obligations
  - **Sleep deprivation and circadian rhythm misalignment** contribute to chronic fatigue and performance impairment
  - Known effects on health
    - Increased HTN and CV disorders, metabolic disorders (diabetes, obesity), gastrointestinal illness, psychological disorders

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Shift Work

- Difficult to adjust to changing shifts
  - Frequent changes, ‘backward’ schedule shifts, longer shift hours (12 vs. 8 hrs), & longer work cycles
  - Chronic night shift no better
    - The majority of shift workers do not entrain to altered schedules
      -> Circadian misalignment for daytime activities
Shift Work Sleep Disorder

- Affects ~ 10 -30% of shift workers
- Sleep is curtailed on average by 1-4 hrs/day in those with SWSD
- Associated with poor performance at work, health problems (CV, GI, reproductive problems), increased accidents, illnesses and depression.
Management Strategies

- In some occupations, a certain degree of sleep deprivation is inevitable
- Sleep deprived individuals are often unaware of their impairment
  - Sleepiness clouds judgment and insight
- Therefore, workers must recognize when their sleep is insufficient and closely monitor performance
- When impairment is an issue, workers must take action to ensure safety and adequate performance
  - This is especially important in the health care field
Management Strategies - Caffeine

- **Strategic** consumption is key
- Effects within 15 – 30 minutes; half-life 3 to 7 hours
- Use for temporary relief of sleepiness
- Cons:
  - disrupts subsequent sleep (more arousals)
  - tolerance may develop
  - diuretic effects
Naps restore cognitive function

- Brife nap: Increased cognitive functioning
- Short nap: No change from pre-nap
- Long nap: Decreased cognitive functioning

Time following awakening from nap
Strategies

- Address sleeping environment & social factors that contribute to daytime sleep disruption
  - Dark, cool, quiet room with phone off
  - Protected sleep times without frequent daytime obligations

- Sleep aids
  - Have been tried, but don’t address the circadian misalignment,
  - Limited benefit, & should only be used with behavioral strategies

- Work planning
  - Avoid backwards shifting and prolonged shifts (8 vs. 12hrs)
Strategies

• Sleep Schedule
  ▫ Goal is to achieve a ‘compromised sleep phase position’
  ▫ Circadian phase **overlaps** with both regular sleep hours and hours slept between work shifts
    • Days off: 2-3 am – 10-11 am
    • Work nights: 8 am - 3pm

• Appropriately timed light
  ▫ Avoid light in the morning
  ▫ Get to bed before the sun comes up
  ▫ Sunglasses on the drive home & avoid use of computer am
  ▫ Bright lights at work to help move schedule *
    • 1200 – 10000 lux for 3-6 hrs, *earlier* in the shift
GET MORE SLEEP!

- Facebook will still be there the next day
- Turn the TV off – DVR and video on demand will save you
- Many individuals who are occupationally sleep-deprived don't get adequate make-up sleep even on days off.
Thank you!