



MONASH University

Medicine, Nursing and Health Sciences

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CREPS Practical Human Factors seminar. 18 November 2011.

Sleepiness impairs performance

▶ Mental performance

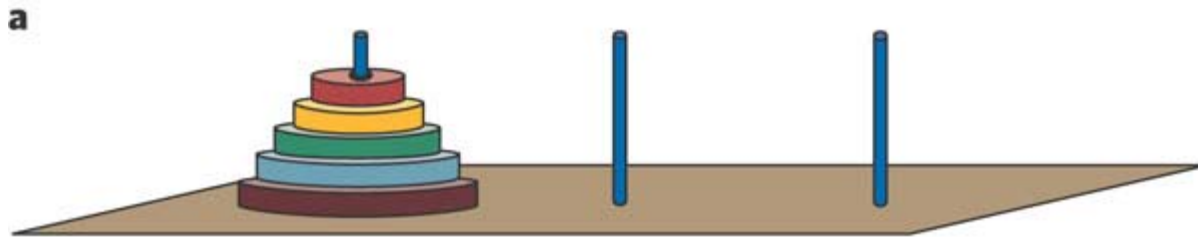
- Reduced logical reasoning
- Impaired mental processing
- Short-term memory problems
- Reduced concentration
- Frustration and irritability
- Impaired decision making



▶ Physical performance

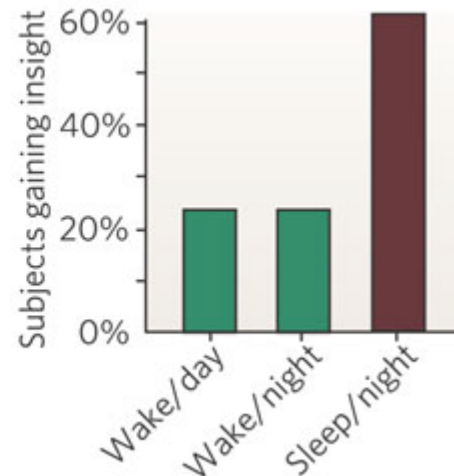
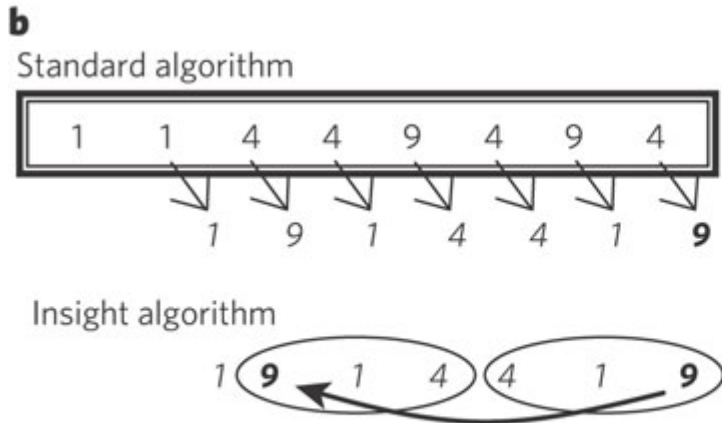
- Impaired hand-eye coordination
- Slower reaction time
- Lowered visual discrimination
- Reduced alertness
- Increased error rates

Sleep deprivation and cognitive performance



Tower of Hanoi task:

When subjects are retested a week after training, a significant 40% improvement in performance is seen. But if REM is experimentally reduced the night after training, no such improvement is seen.



Mathematical insight:

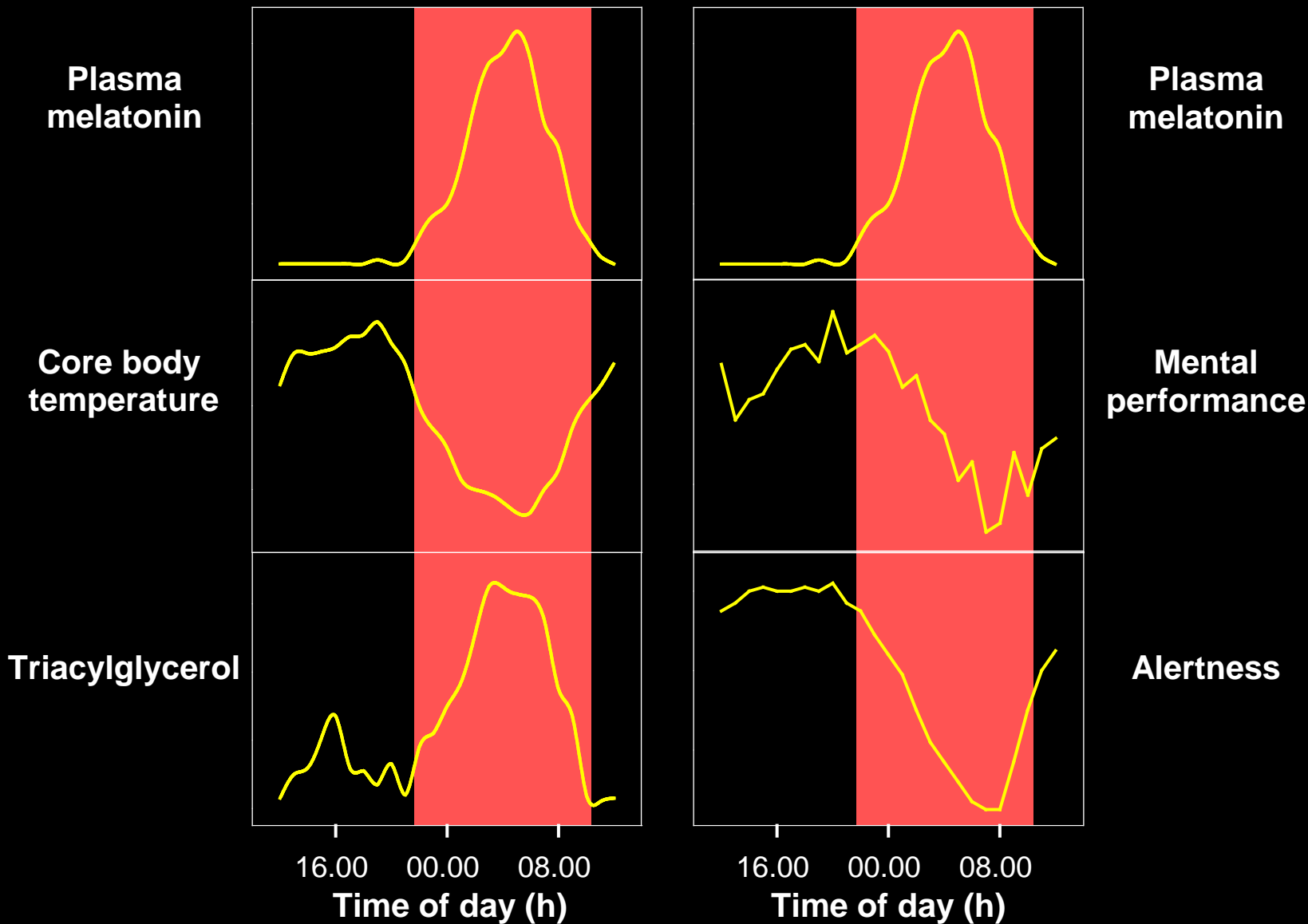
Subjects taught a complex algorithm for solving mathematical problems. Unknown to the subjects, a simpler solution also exists, which none discovered during training. But at retest (+12 hours), a subset of subjects discovered simpler method. The probability of discovering it was more than doubled after a night of sleep.

Physiological determinants of sleepiness

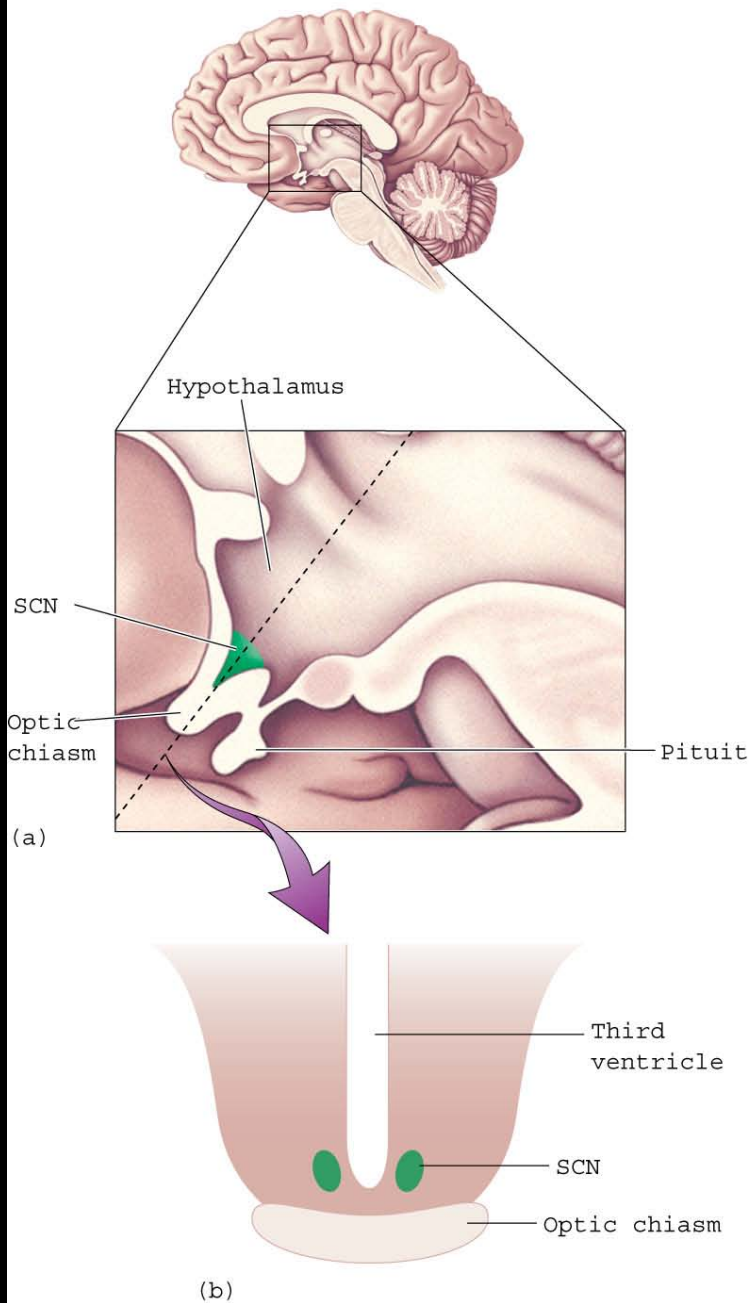


- Biological time of day (circadian rhythms)
- Consecutive waking hours
- Nightly sleep duration
- Sleep inertia
- Sleep disorders

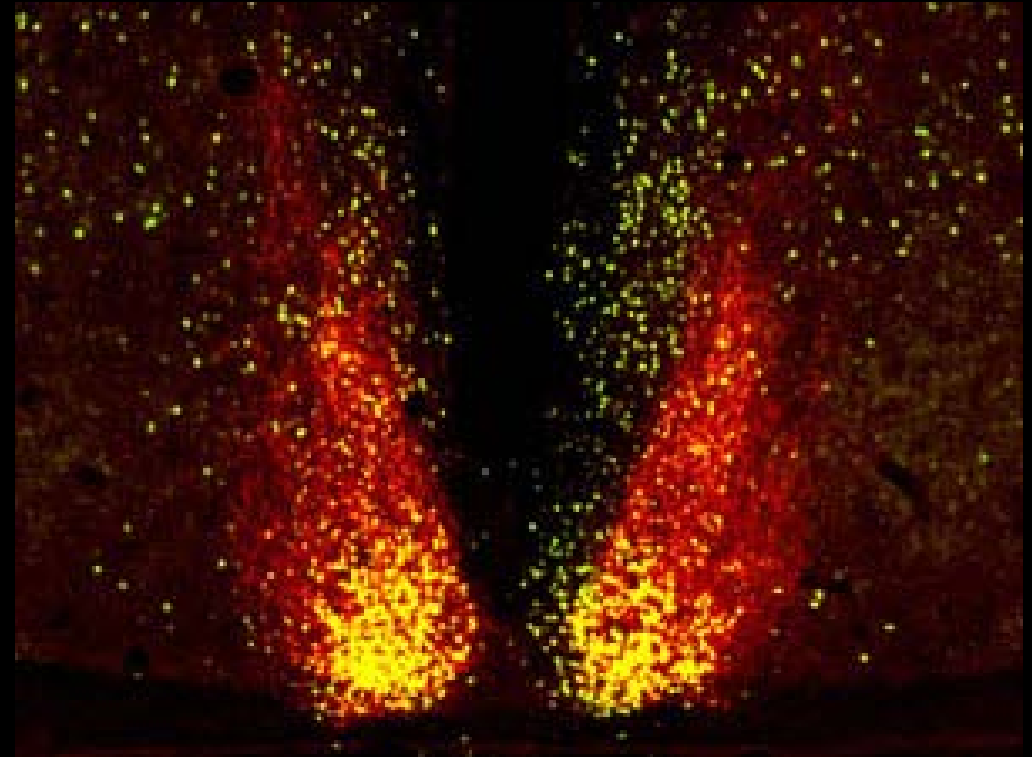
Biological time of day



Biological time of day: Human circadian pacemaker in suprachiasmatic nucleus (SCN) of hypothalamus

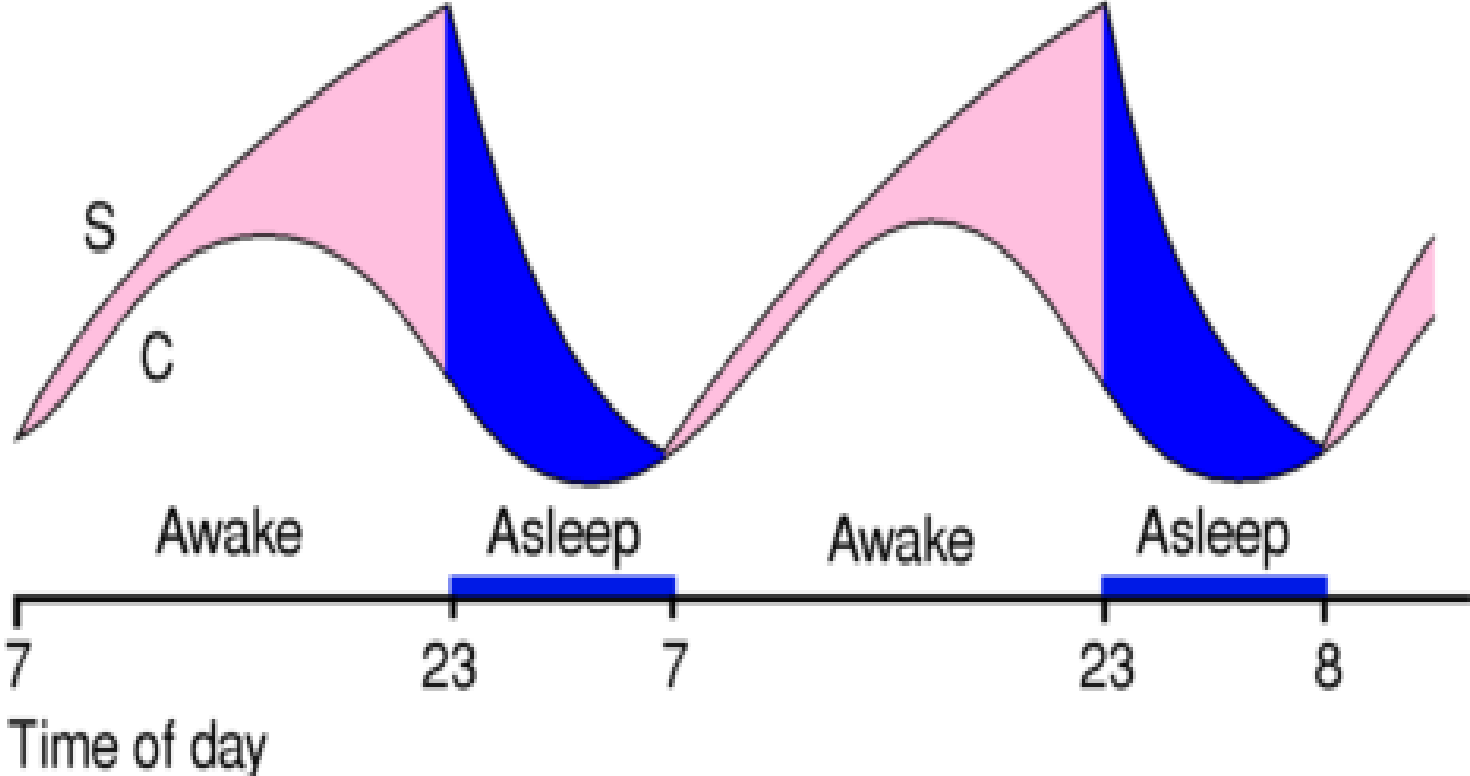


<http://www.bion.com/book/biology/whole/html/>

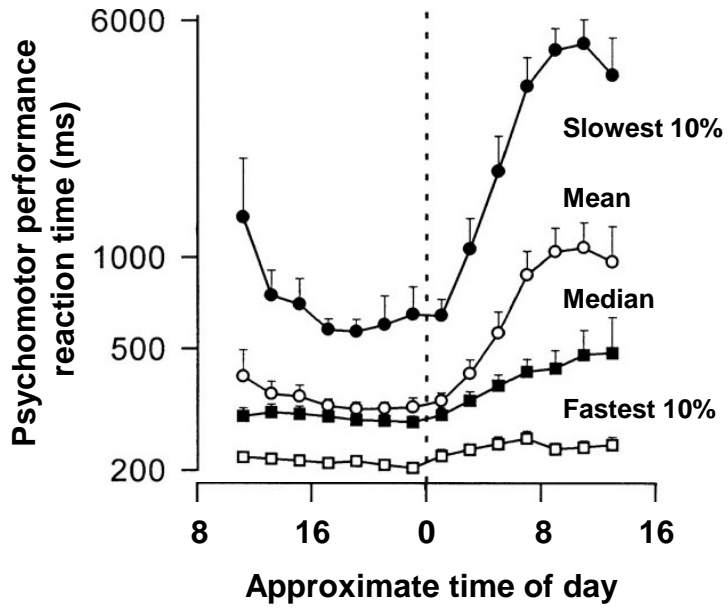


Courtesy Prof Russell G. Foster <http://www1.imperial.ac.uk>

Two Process Model of Sleep Regulation (Borbély & Daan)



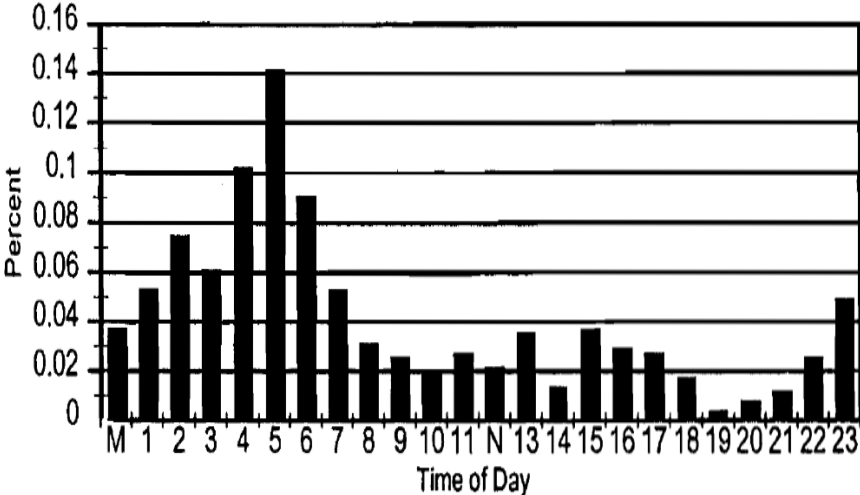
1 – Biological time of day



Cajochen et al., Am J Physiol, 1999

1 – Biological time of day

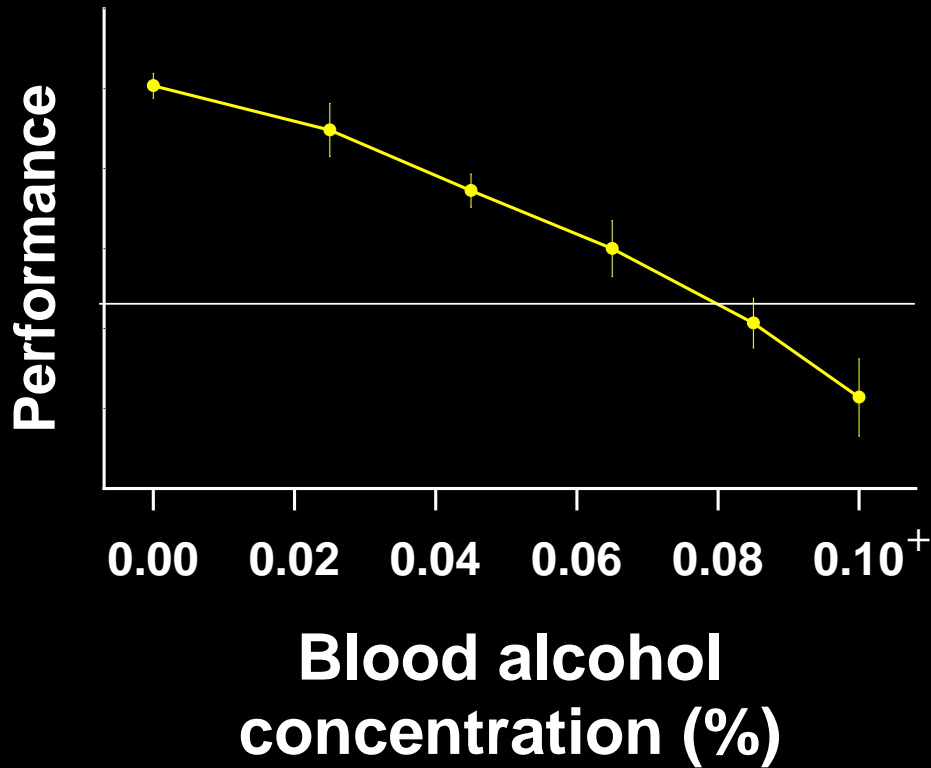
Time course of single vehicle truck accidents



After being **awake for 19 hours**, impairment on a simple reaction time test was comparable with impairment observed at a **blood alcohol concentration of 0.05%**.

After being **awake for 24 hours**, impairment on a simple reaction time test was comparable with impairment observed at a **blood alcohol concentration of roughly 0.10%**.

Effects of sleep deprivation on psychomotor performance: comparison with alcohol



Physiological Consequences of Healthcare Provider Schedules

**Biological Time of Day
(circadian phase)**

Misalignment of circadian phase

Number of Hours Awake

**Acute total sleep deprivation
scheduled frequently**

Nightly Sleep Duration

**Chronic partial sleep deprivation
resulting in cumulative sleep debt**

Sleep Inertia

**Performance often required within
minutes of awakening**

Doctors working 24 h straight:

- make 36% more serious medical errors
- make 6 times more serious diagnostic errors
- get 'needlestick' injuries twice as often overnight
- report nearly 4 times more fatigue-related errors when working 1-4 24-h shifts/month
- report 300% more fatal adverse events
- had 2.3 times more actual crashes and 6 times more 'near-crashes' when driving home after work

Risk of car crash on drive home from work

Physician work hours, sleep and patient safety

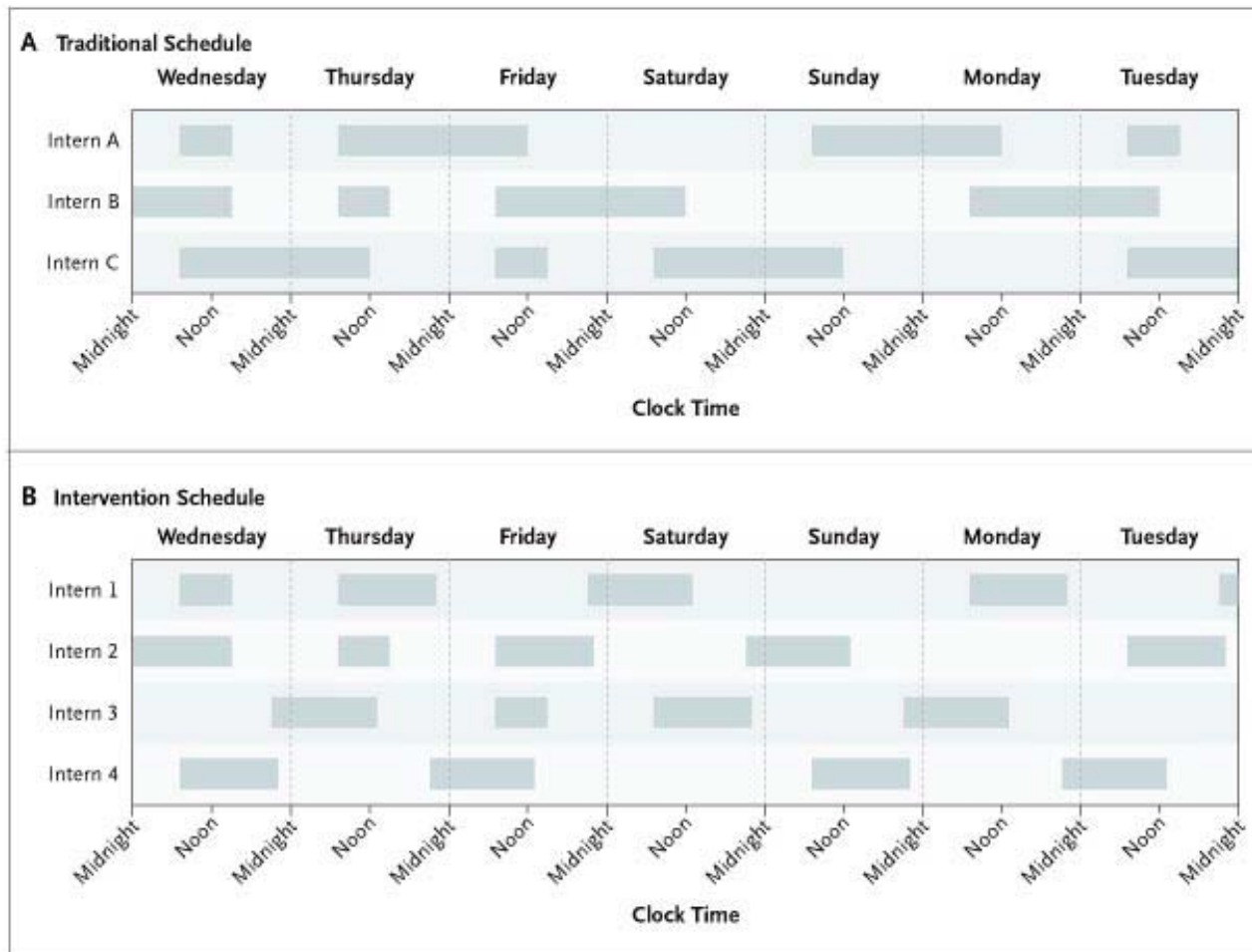
- Physicians driving home after 24 h shift have 2.3x the odds of a crash than after <24 h shift
- Each extended shift adds 16% increased risk

Table 1. Risk of Motor Vehicle Crashes and Near-Miss Incidents after Extended Shifts.*

Variable	Extended Work Shifts (≥24 hr)	Nonextended Work Shifts (<24 hr)
Crashes		
No. reported	58	73
No. of commutes	54,121	180,289
Rate (per 1000 commutes)	1.07	0.40
Odds ratio (95% CI)	2.3 (1.6–3.3)	1.0
Near-miss incidents		
No. reported	1,971	1,156
No. of commutes	54,121	180,289
Rate (per 1000 commutes)	36.42	6.41
Odds ratio (95% CI)	5.9 (5.4–6.3)	1.0



Traditional and intervention schedule of US medical interns

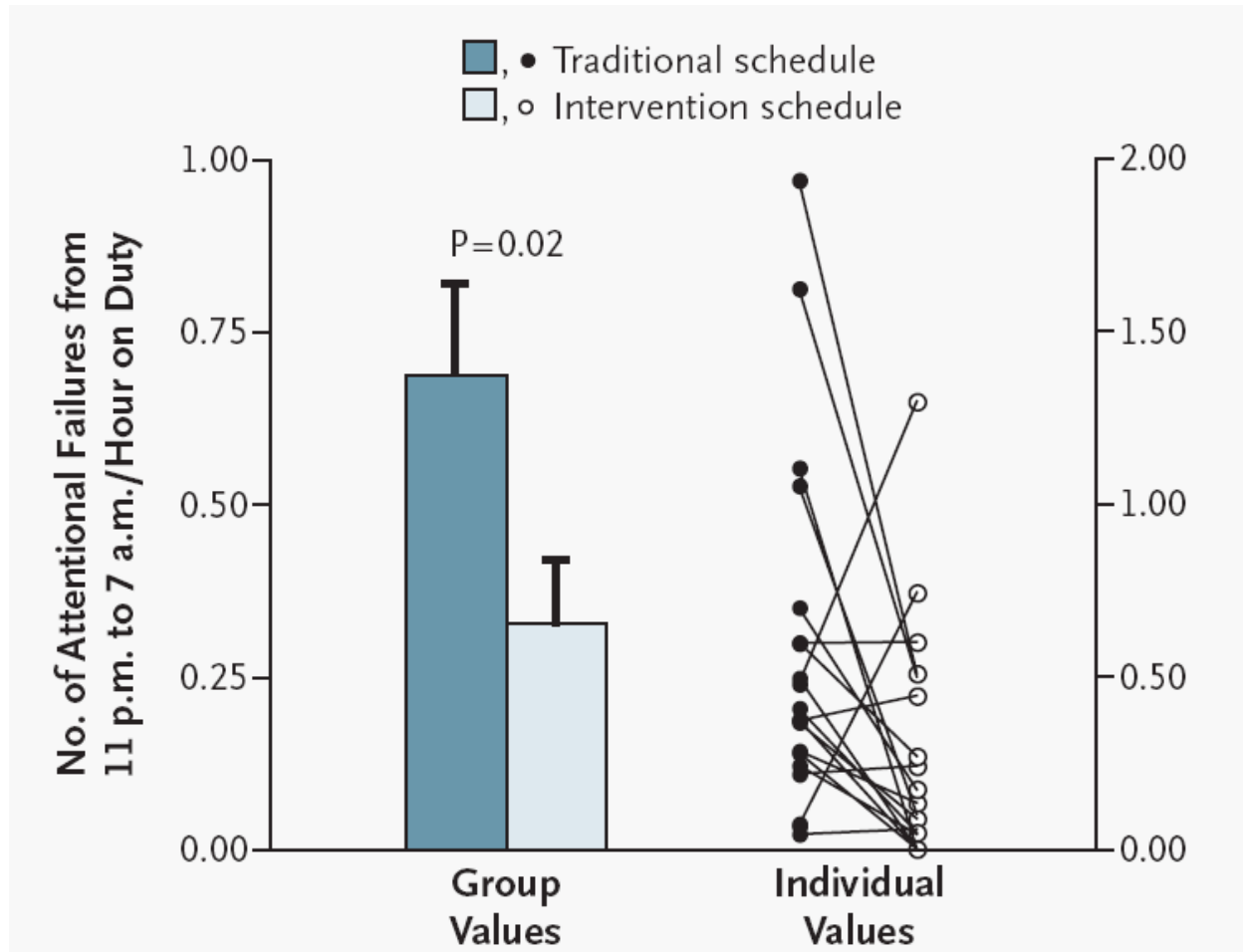


Effects of extended duration shifts on incidence of medical errors

Table 3. Incidence of Serious Medical Errors.

Variable	Traditional Schedule	Intervention Schedule	P Value
	<i>no. of errors (rate/1000 patient-days)</i>		
Serious medical errors made by interns			
Serious medical errors	176 (136.0)	91 (100.1)	<0.001
Preventable adverse events	27 (20.9)	15 (16.5)	0.21
Intercepted serious errors	91 (70.3)	50 (55.0)	0.02
Nonintercepted serious errors	58 (44.8)	26 (28.6)	<0.001
Types of serious medical errors made by interns			
Medication	129 (99.7)	75 (82.5)	0.03
Procedural	11 (8.5)	6 (6.6)	0.34
Diagnostic	24 (18.6)	3 (3.3)	<0.001
Other	12 (9.3)	7 (7.7)	0.47
All serious medical errors, unit-wide			
Serious medical errors	250 (193.2)	144 (158.4)	<0.001
Preventable adverse events	50 (38.6)	35 (38.5)	0.91
Intercepted serious errors	123 (95.1)	63 (69.3)	<0.001
Nonintercepted serious errors	77 (59.5)	46 (50.6)	0.14
Types of serious medical errors, unit-wide			
Medication	175 (135.2)	105 (115.5)	0.03
Procedural	18 (13.9)	11 (12.1)	0.48
Diagnostic	28 (21.6)	10 (11.0)	<0.001
Other	29 (22.4)	18 (19.8)	0.45

Effects of extended duration shifts on incidence of attentional failures





Thank you.

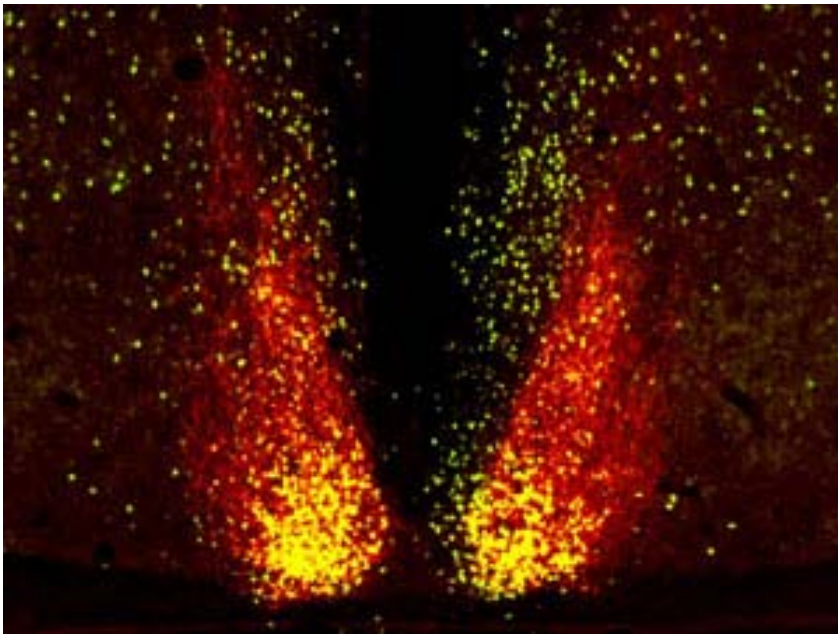
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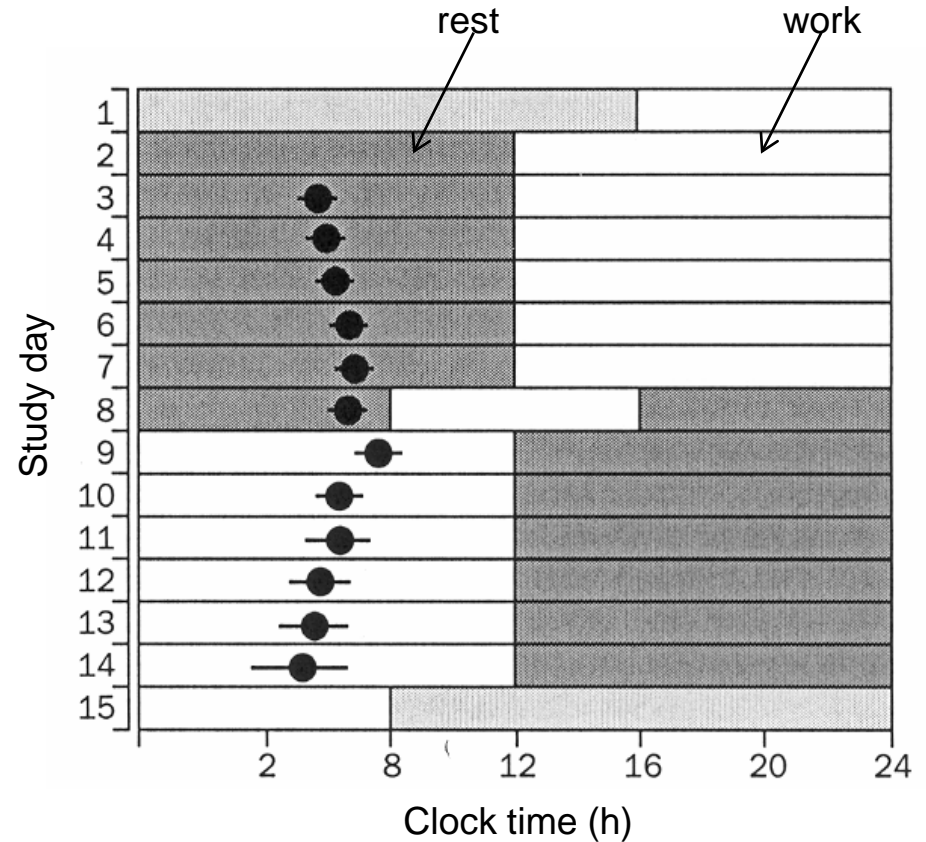
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Circadian misalignment in shift workers



Courtesy Prof Russell G. Foster <http://www1.imperial.ac.uk>

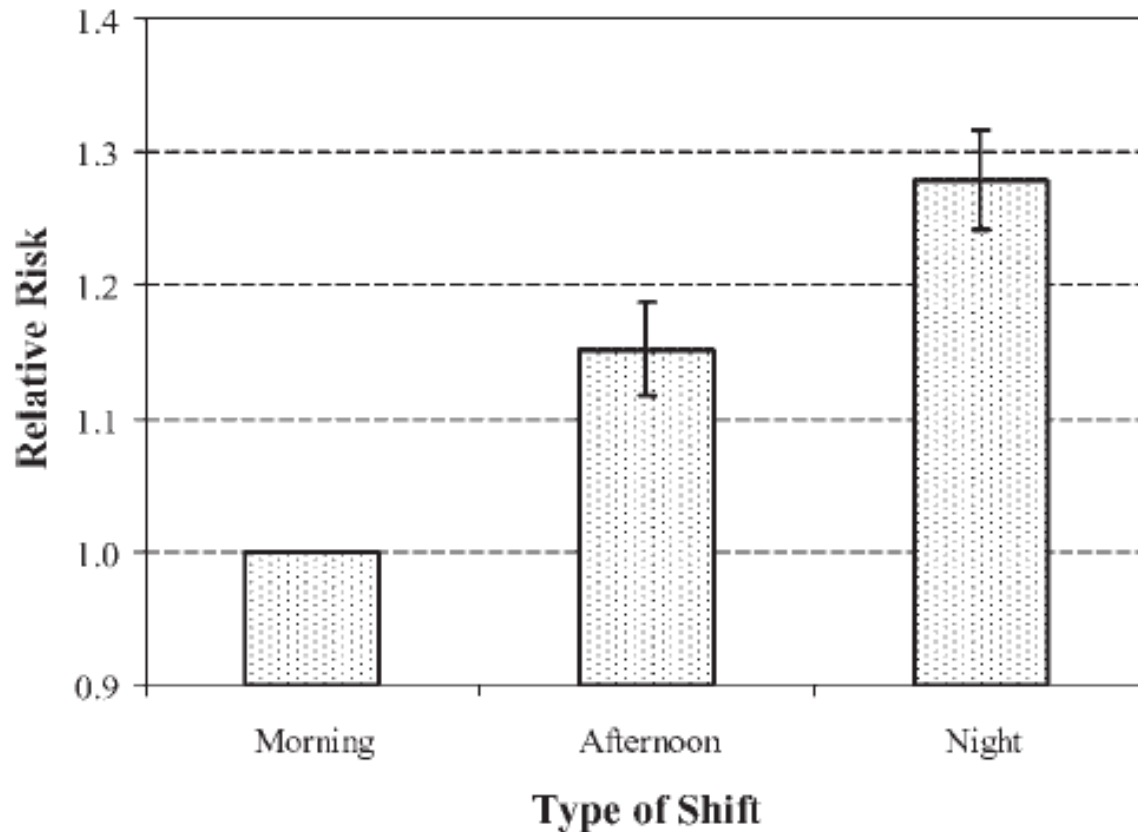


Rajaratnam & Arendt Lancet 2001

Shift-work patterns and accident risk

Risk depends on shift timing

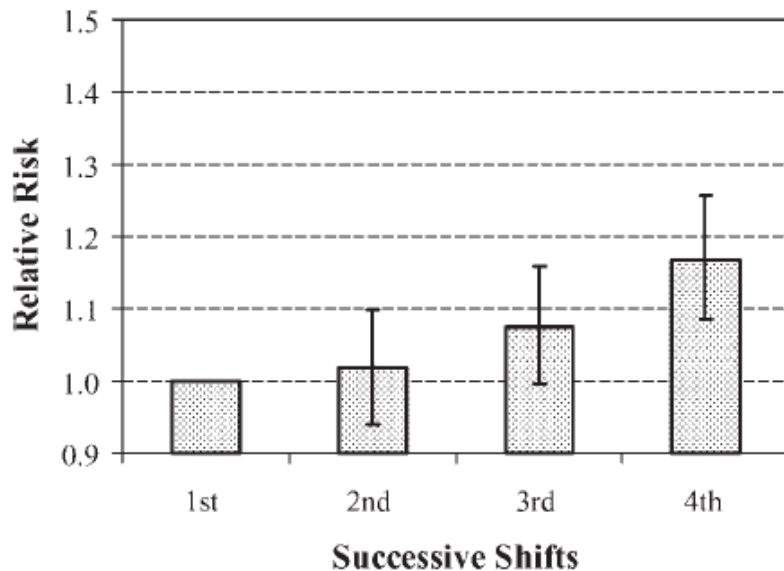
Night shift has greatest risk



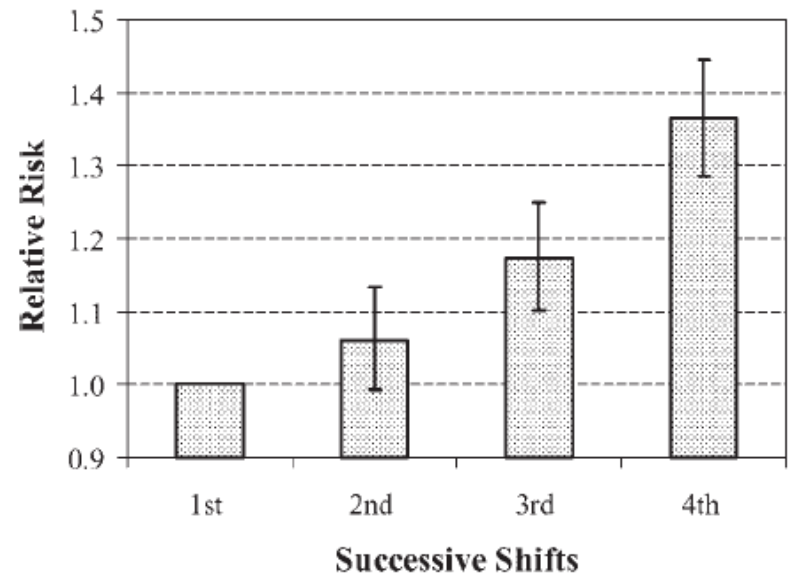
Shift-work patterns and accident risk

Risk depends on consecutive shift number

Successive day/evening shifts

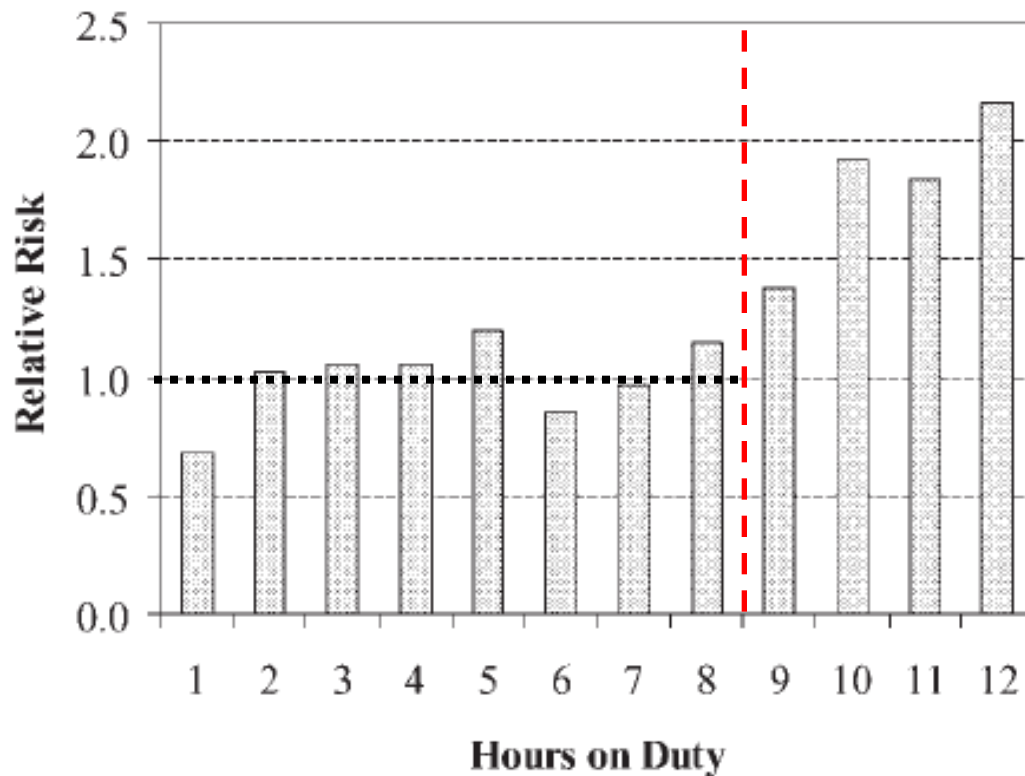


Successive night shifts



Shift-work patterns and accident risk

Risk increases with increased hours on duty



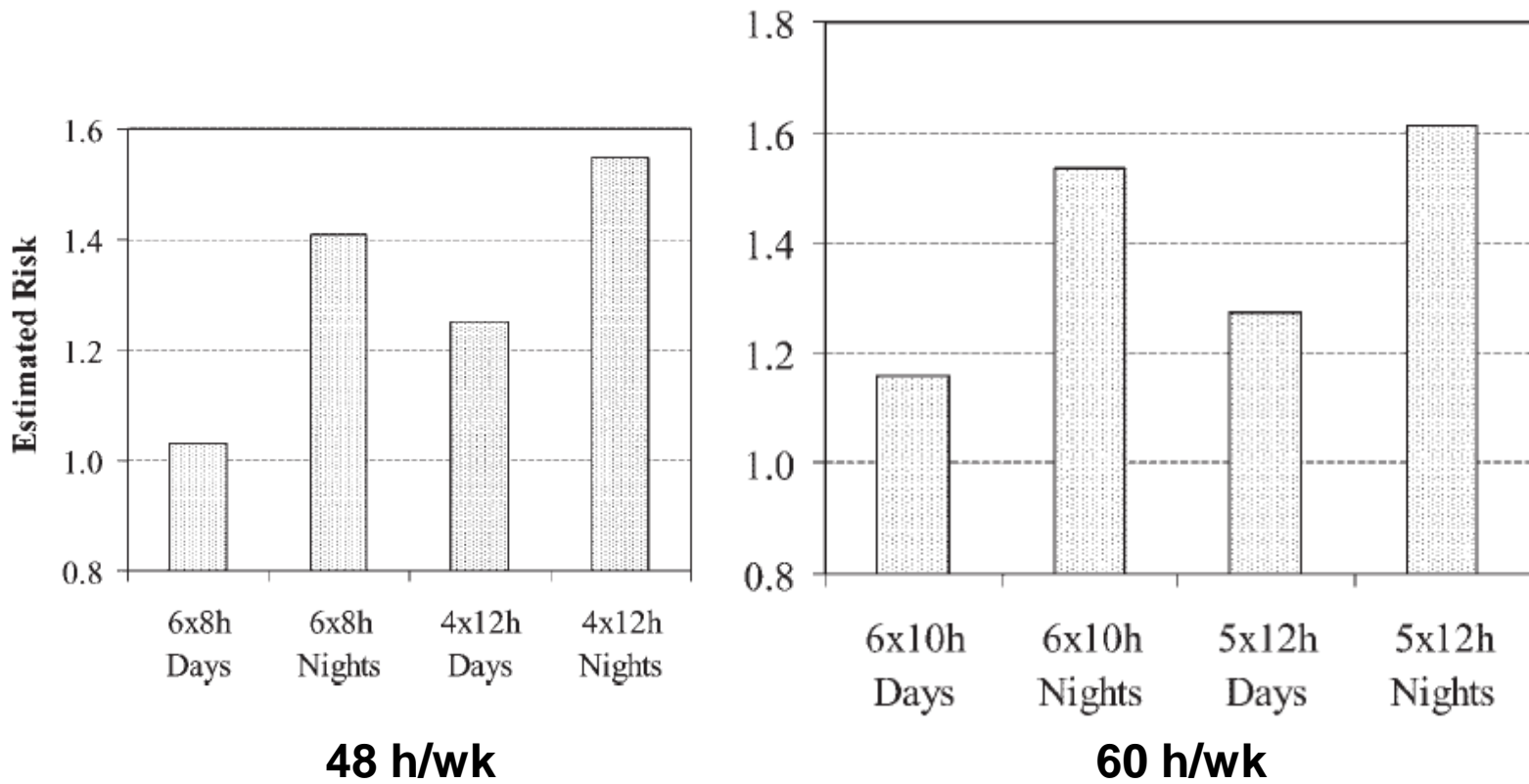
As compared to the first 8 h,

- After 10 h on duty, the relative risk increases by ~90%
- After 12 h on duty, the relative risk increases by ~110%

Mean risk for duty hours 1 - 8 = 1.0

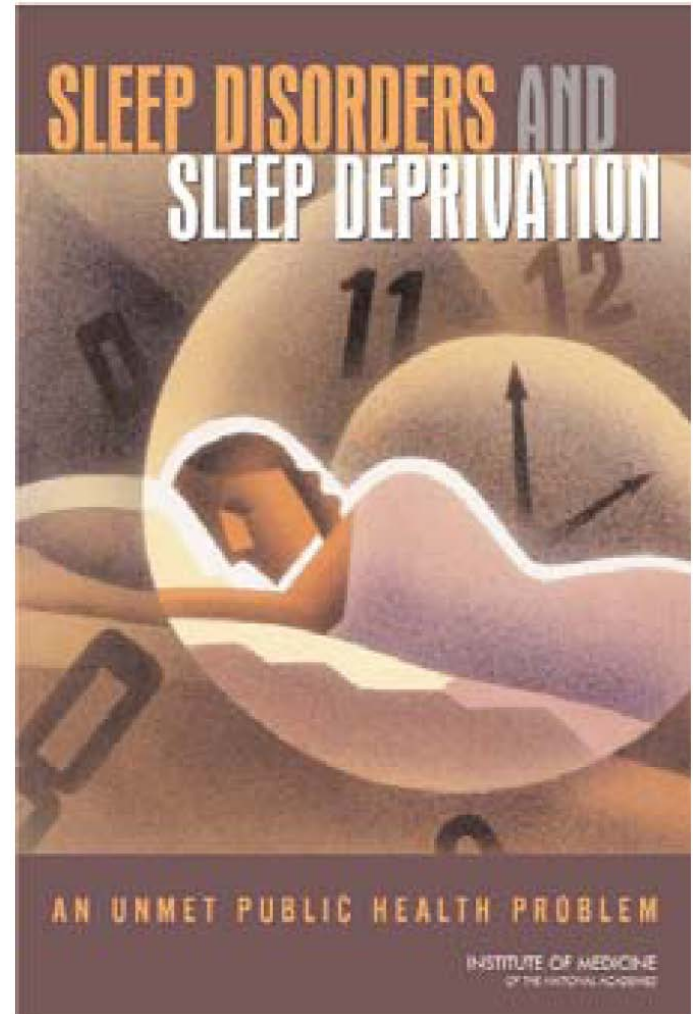
Shift-work patterns and accident risk

Comparison of different shift patterns



5 x 8 h days = risk of 1.0

“The cumulative effects of sleep loss and sleep disorders ... have been associated with a wide range of health consequences including an increased risk of hypertension, diabetes, obesity, **depression**, heart attack, and stroke.”



Institute of Medicine of the National Academies (USA), *Sleep Disorders and Sleep Deprivation: An Unmet Public Health Problem* (2006).

Circadian response to light

