

# A comprehensive firefighter fatigue management program 'Operation Stay Alert'

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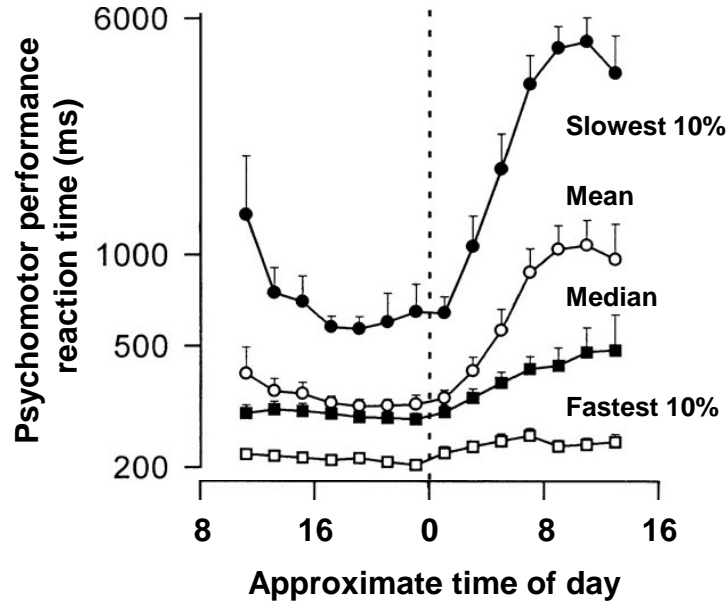
**Firefighter Cardiovascular Health & Safety  
Research Summit 2010  
September 16-17 2010**



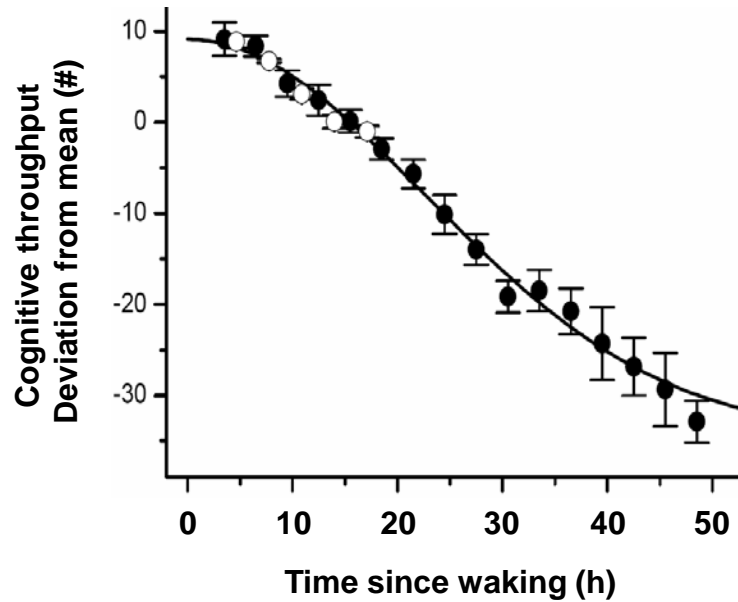
# Physiological determinants of fatigue

- **Biological time of day (circadian rhythms)**
- **Number of hours awake**
- **Nightly sleep duration (chronic sleep debt)**
- **Sleep inertia (time to 'get going' after waking)**

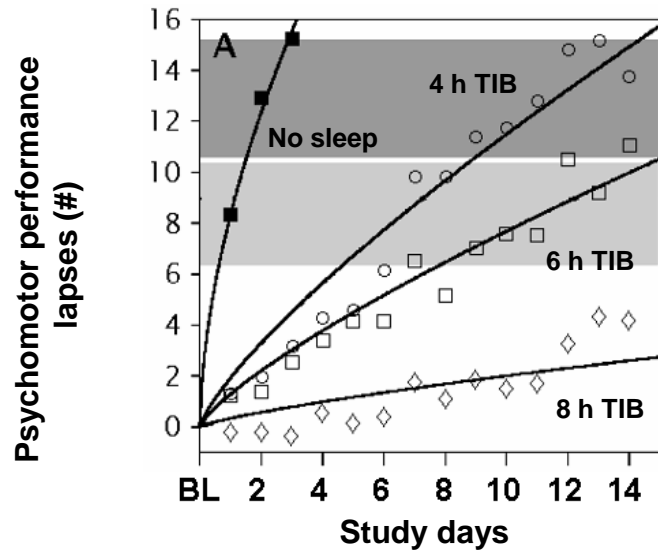
### 1 – Circadian time of day



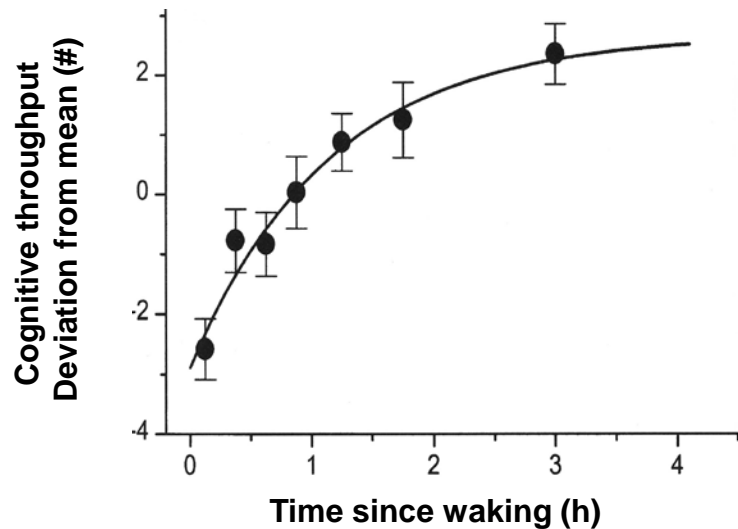
### 2 – Acute sleep deprivation



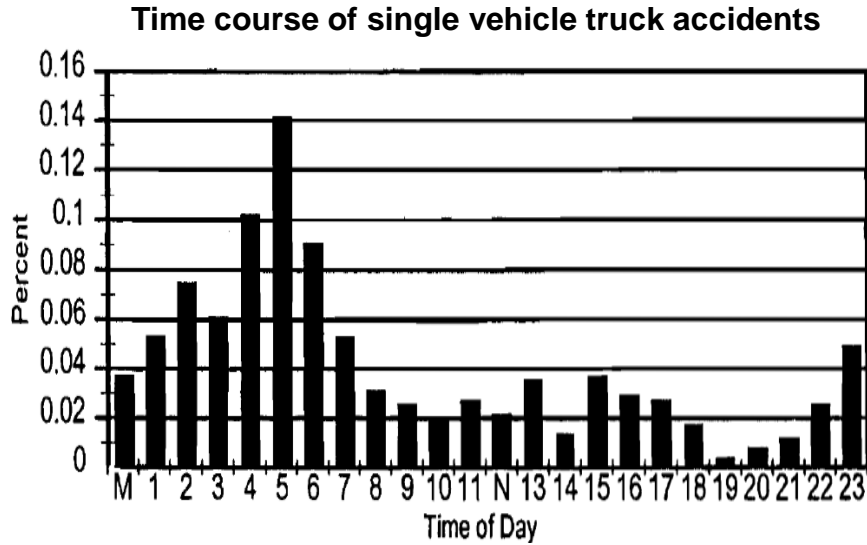
### 3 – Chronic sleep deprivation



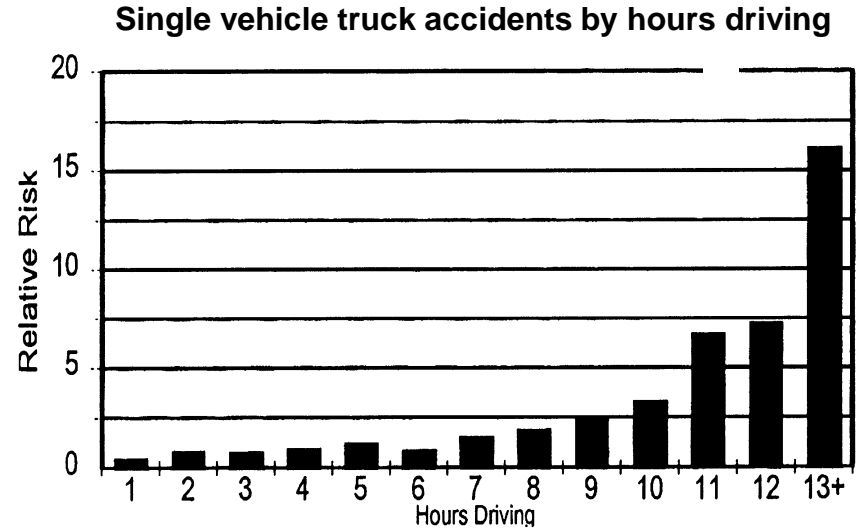
### 4 – Sleep inertia



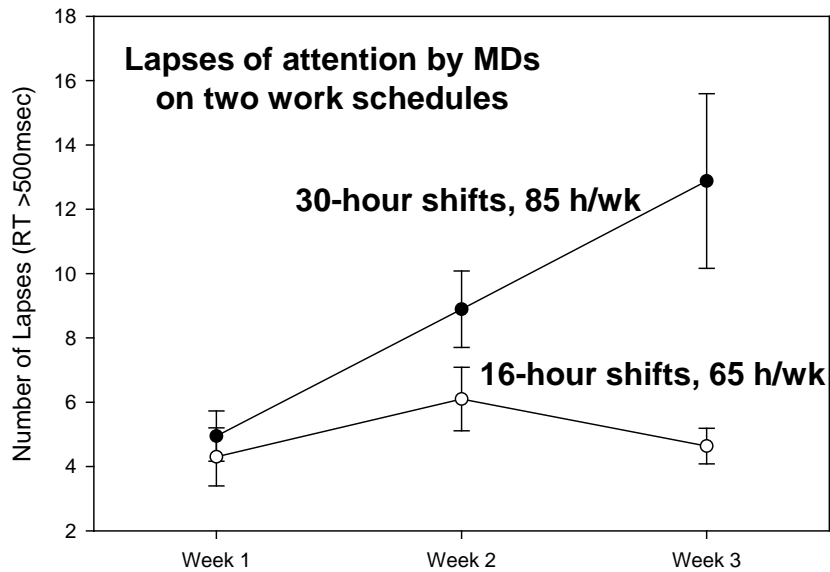
# 1 – Circadian time of day



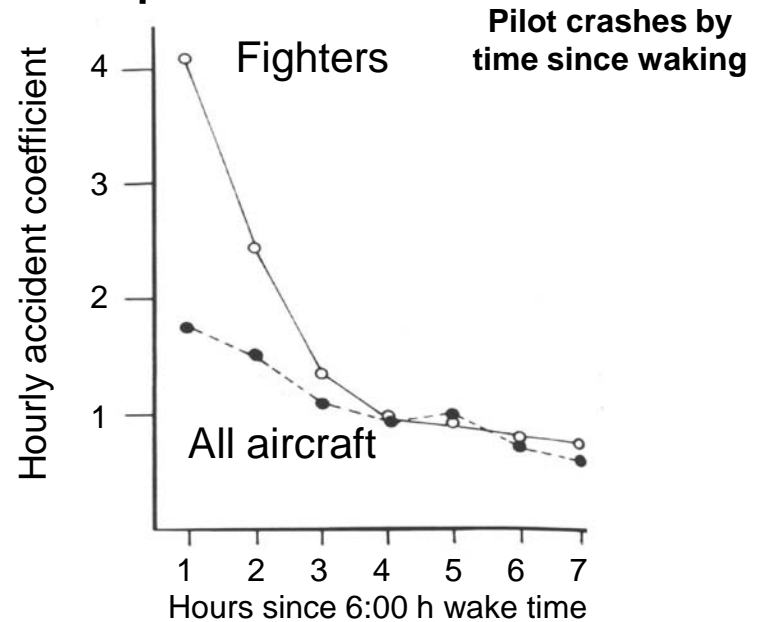
# 2 – Acute sleep deprivation



# 3 – Chronic sleep deprivation



# 4 – Sleep inertia



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%**.

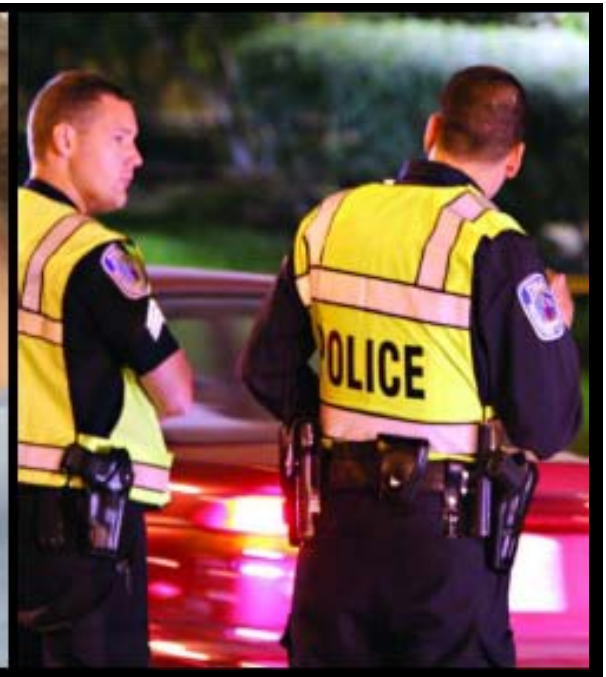
# Harvard Work Hours, Health and Safety Group

## Past research populations

**Astronauts**

**Resident physicians**

**Police officers**



# 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



# 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.\*

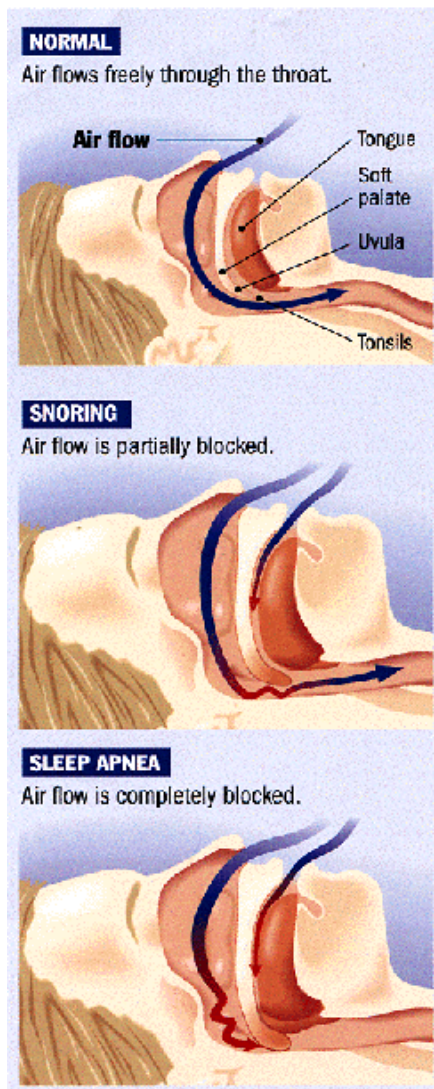
Variable	Extended Work Shifts (≥24 hr)	Nonextended Work Shifts (<24 hr)
Crashes		
No. reported	58	73
No. of commutes	54,121	180,289
Rate (per 1000 commutes)	1.07	0.40
Odds ratio (95% CI)	2.3 (1.6–3.3)	1.0
Near-miss incidents		
No. reported	1,971	1,156
No. of commutes	54,121	180,289
Rate (per 1000 commutes)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



# Physiological determinants of fatigue

- Biological time of day (circadian rhythms)
- Number of hours awake
- Nightly sleep duration (chronic sleep debt)
- Sleep inertia (time to 'get going' after waking)
- **Clinical sleep disorders**

# Obstructive Sleep Apnea (OSA)



Temporarily stopping breathing during sleep

- Caused by narrowing of airway during sleep
- Reduces oxygen to the lungs

Symptoms

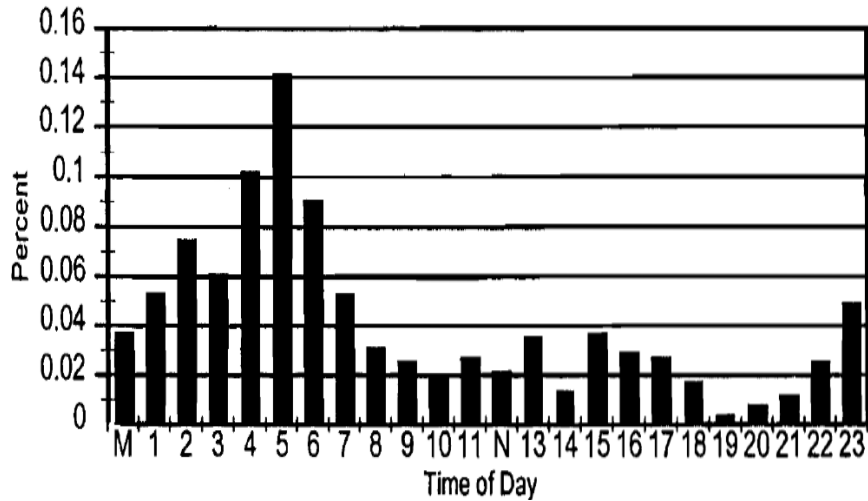
- Snoring plus 'gaspings' or stopping breathing
- Excessive sleepiness during wake
- Large neck size
- Obesity
- **High prevalence in overweight middle-aged men**
- **Higher risk of CV disease, hypertension, and stroke**
- **Higher rate of 'fall asleep' car crashes**
- Most people are undiagnosed

# Sleep duration and heart disease

- Risk of hypertension higher in those sleeping < 6h per night (adjusted OR 1.66 [gender, race, AHI,BMI]) and > 9 (OR 1.30) compared to those sleeping 7 to <8 h per night (n=5,900)  
*Gottlieb et al., 2006*
- Risk of hypertension higher in those sleeping  $\leq$  5h per night (adjusted HR 2.10 in middle-aged subjects (n=4,800)  
*Gangwisch et al., Hypertension 2006*
- Longer sleep duration associated with reduced coronary artery calcification (adjusted OR 0.67 per hour) (n=500)  
*King et al., JAMA 2008*
- Short sleep duration (<7.5 hours) in hypertensive patients is predictive of with incident CVD (stroke or heart attack) (HR, 1.68) (n =1255)  
*Eguchi et al., Arch Int Med 2008*

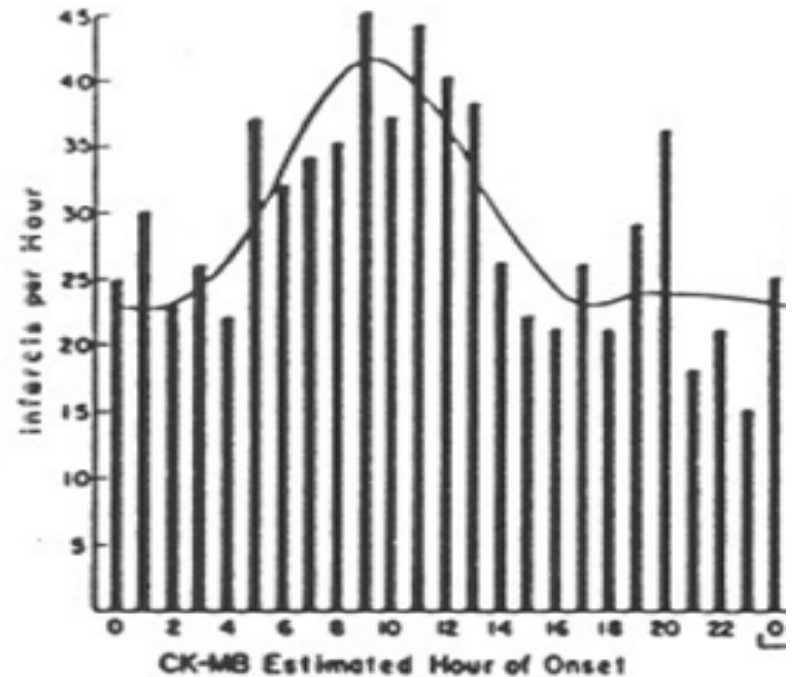
# 24-hour circadian rhythms in motor vehicle crashes and heart attacks

## Fatigue-related fatal crashes by time of day



**Peak rate at 5am**

## Onset of myocardial infarction by time of day



**Peak rate at 9am**

**TABLE. Number and percentage of fatalities among career and volunteer firefighters, by cause/contributing cause — United States, 1994–2004**

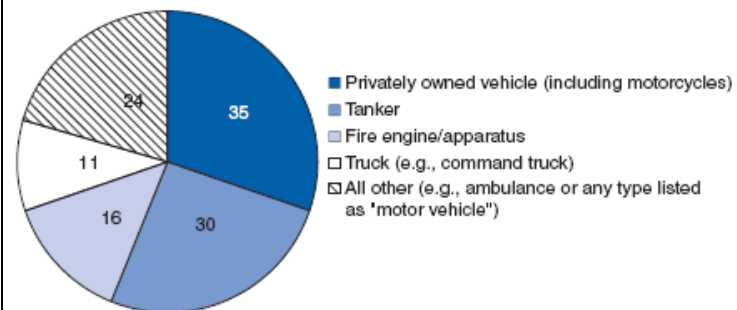
Cause/Contributing cause	Career		Volunteer	
	No.	(%)	No.	(%)
<b>Heart attack*</b>	142	<b>1<sup>st</sup></b> (39)	306	<b>1<sup>st</sup></b> (50)
Stress/Overexertion	138	(97)	301	(98)
Other	4	(3)	5	(2)
<b>Motor vehicle–related trauma</b>	44	<b>3<sup>rd</sup></b> (12)	160	<b>2<sup>nd</sup></b> (26)
Vehicle collision/crash	30	(68)	116	(73)
Struck by vehicle	12	(27)	33	(20)
Other vehicle-related (e.g., crushed by or fell from a vehicle)	2	(5)	11	(7)
<b>Asphyxiation</b>	74	<b>(20)</b>	45	<b>(7)</b>
Caught/Trapped	56	(76)	31	(69)
Other (e.g., lost inside a structure or exposed to smoke)	18	(24)	14	(31)
<b>All other†</b>	<b>108</b>	<b>(29)</b>	<b>99</b>	<b>(16)</b>
Caught/Trapped	32	(30)	19	(19)
Fall	8	(7)	15	(15)
Exposure (e.g., to smoke)	9	(8)	14	(14)
Stress/Overexertion	16	(15)	14	(14)
Structure collapse	8	(7)	3	(3)
Other	35	(32)	34	(34)
<b>Total</b>	<b>368</b>		<b>610</b>	

\* For example, myocardial infarction or arrhythmia.

† Includes deaths caused by burns, cerebral vascular accidents, drownings, electrocution, heat exhaustion, and trauma.

**61% of firefighter fatalities due to heart attack or motor vehicle crash**

**FIGURE 2. Number\* of vehicles involved in volunteer firefighter fatal crashes, by vehicle type — United States, 1994–2004**



\* N = 116.

**35% vehicles privately owned**

# Factors affecting firefighter fatigue

<b>Biological Time of Day (circadian phase)</b>	<b>Misalignment of circadian phase working at night</b>
<b>Number of Hours Awake</b>	<b>Acute total sleep deprivation scheduled frequently (<math>\geq 24</math> h shifts)</b>
<b>Nightly Sleep Duration</b>	<b>Chronic partial sleep deprivation resulting in cumulative sleep debt</b>
<b>Sleep Inertia</b>	<b>Performance often required within minutes of waking</b>
<b>Clinical Sleep Disorders</b>	<b>Potentially high prevalence of sleep disorders, especially Obstructive Sleep Apnea</b>



# **COMPREHENSIVE FIREFIGHTER FATIGUE MANAGEMENT PROGRAM**

**Federal Emergency Management Agency  
Harvard Work Hours, Health and Safety Group**

## ***Our primary aim:***

- **Improve alertness, sleep, health and safety of Firefighters**

## ***How we plan to achieve this:***

- **Sleep Hygiene Education**
- **Caffeine Use Re-education**
- **Sleep Disorders Screening and Treatment**
- **Policy Intervention where appropriate**



# **OPERATION STAY ALERT**

**Federal Emergency Management Agency  
Harvard Work Hours, Health and Safety Group**

**We will test the hypothesis that ‘Operation Stay Alert’ will:**

- **improve firefighters’ sleep, alertness and cognitive performance**
- **improve firefighters’ safety, as determined by:**
  - decreased rates of motor vehicle crashes
  - decreased on-the-job accidents and injuries
- **improve firefighters’ health, as determined by:**
  - diagnosis and treatment of sleep disorders
  - improved general health indices
  - decreased number of ‘sick’ days
- **improve firefighters’ performance**

# **OPERATION STAY ALERT**

**Federal Emergency Management Agency  
Harvard Work Hours, Health and Safety Group**

1. Sleep, health and safety education:
  - introductory video
  - education about effects of sleep loss on health, safety and performance
  - sleep hygiene
  - advice about strategic napping
  - booklets on sleep and sleep disorders provided

# **OPERATION STAY ALERT**

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## **2. Caffeine re-education:**

- basic caffeine facts and food/drink content
- training session on effects of caffeine
- firefighters provided with a plan for caffeine consumption based on shift

# **OPERATION STAY ALERT**

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Harvard Work Hours, Health and Safety Group**

## **3. Identification and treatment of firefighters with sleep disorders**

- **Obstructive Sleep Apnea**
- **Insomnia**
- **Restless Legs Syndrome**
- **Narcolepsy**
- **Severe and chronic Shift Work Disorder**

**individuals with increased risk of having a sleep disorder  
referred to a sleep physician for diagnosis and treatment**

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4. Potential future policy developments to improve alertness at work:
  - consultation with fire department and union
  - goal is to improve safety, health, productivity

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## **Outcomes**

- 1. Survey:**
  - a. Sleep and work schedules, sleepiness**
  - b. General health, mood, and functioning**
  - c. Injuries and motor vehicle accidents**
  - d. Job experiences and satisfaction**
- 2. Safety and job performance data from existing departmental databases**
- 3. Sleep logs and actigraphy in a sample to objectively validate self-reported sleep and work hours**
- 4. Clinical and sleep disorders outcomes**
- 5. Annual physical outcomes where available  
(in collaboration with Dr Stefanos Kales, HSPH)**

# Protecting confidentiality

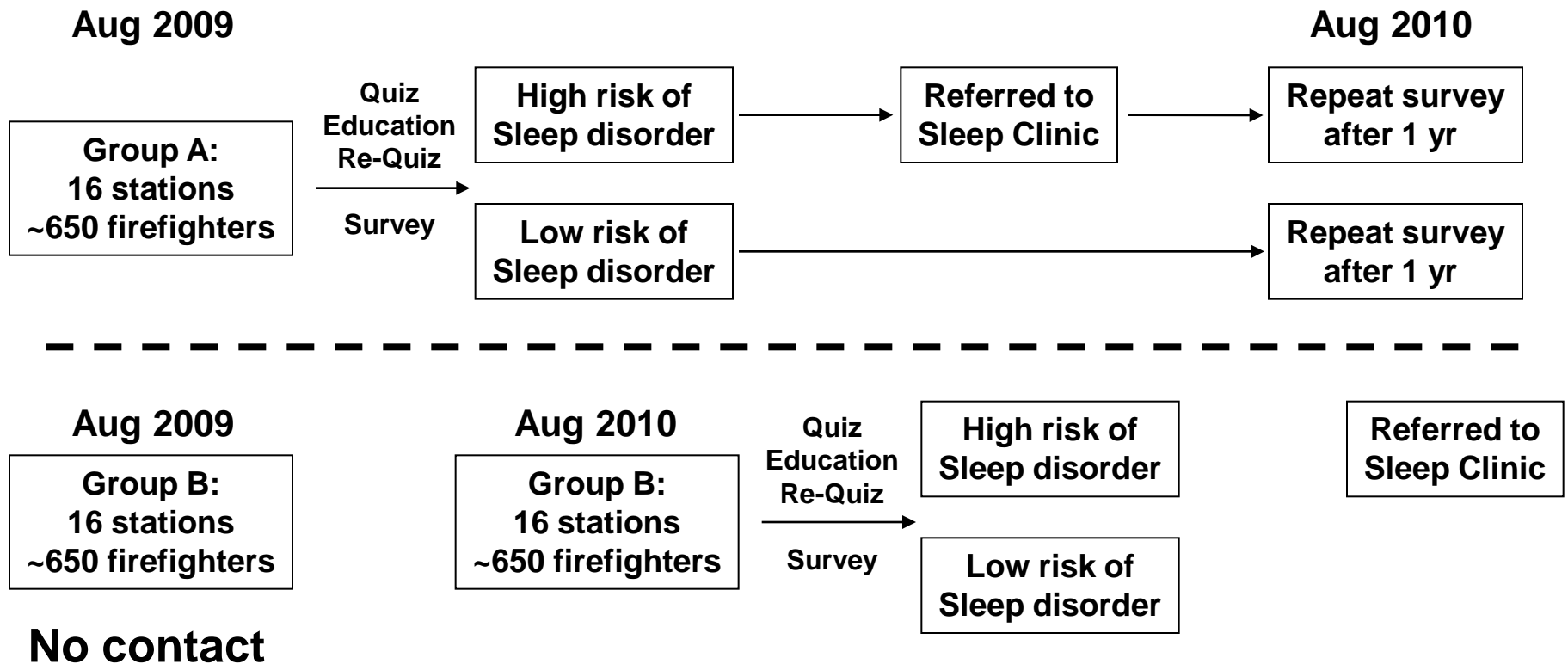
- De-identification of data
- Certificate of Confidentiality from CDC:
  - protects against involuntary disclosure of the identities of research subjects or the release of data for individual subjects participating in this study
- HIPAA Privacy Rule



# OPERATION STAY ALERT

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## Expert-led Program: Randomized Paired Design



# **OPERATION STAY ALERT**

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## **Expert-led Program: Randomized Paired Design**

- Program conducted in 16/32 Stations
- ~1,280 officers in potential cohort (50% in Y1)
- Mandatory training/Voluntary survey participation with informed consent
- 52 presentations given to 599 firefighters over 2.5 weeks
- Paper surveys completed by 464 firefighters (77%)
- Study Advisory Committee  
(Fire Dept & Union Representatives, Research Team)

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## **Outcomes – Firefighter Databases**

- Demographic data (e.g., gender, age, service)
- Work hours and leave, sick leave, temp transfers
- Motor vehicle accidents
- Accidents and injuries
- Physical exam record
- Sleep clinic record
- Confirming sleep and work hours with daily logs and wrist actigraphy for 3 weeks

# National Firefighter Sleep Disorders Management Program: Translation to Practice

Harvard Work Hours, Health and Safety Group

*Division of Sleep Medicine, Harvard Medical School, Boston*

*Division of Sleep Medicine, Brigham and Women's Hospital, Boston*



**Assistance to Firefighters Grants Program (AFG)**  
**Department of Homeland Security**  
**Federal Emergency Management Agency**  
**Annual Meeting, August 25 2010**



# **OPERATION STAY ALERT**

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**Tier 1: Randomized clinical study design, standard expert-led education (e.g., Columbus)**

**Tier 2: Web-based education**

**Tier 3: Train the trainer**

*Tier 4: Online survey only*

Flexible approach depending on local preferences:

- Education and survey presented via BWH research team, online or fire department trainers
- Survey available paper/pencil or online
- Existing departmental databases utilized (Tier 1 only)
- Existing annual physical data utilized (Tier 1 only)
- Sleep clinic data utilized (Tier 1 only)

**- Interested Fire Departments can still participate**

# Methods

## Tier 1 – In person

Month 1:

-Survey half Dept    -Leave half Dept

-Database measures last 12 mos  
-Data from last Physical Exam



Month 12:

-Year-end survey (online)    -Initial survey (online)

-Database measures last 12 mos  
-Data from last Physical Exam  
-Data from Sleep Clinics



Month 24:

- Year-end survey (online)

-Database measures last 12 mos  
-Data from last Physical Exam  
-Data from Sleep Clinics

Focus groups included

## Tier 2 – Web-based

Month 1:

-Survey whole Dept (pre-, post-exam)



Month 12:

-Survey whole Dept (End-year survey)

Focus groups included

## Tier 3 – Train the trainer

Month 1:

-Survey whole Dept (pre, post-exam)



Month 12:

-Survey whole Dept (End-year survey)

Focus groups included

# Harvard Work Hours, Health and Safety Group

## Research Team

### Division of Sleep Medicine

- Charles A. Czeisler, PhD, MD
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- Laura K. Barger, PhD
- Shantha M.W. Rajaratnam, PhD
- Christopher P. Landrigan, MD
- Kate Crowley, PhD
- Clare Anderson, PhD

### Harvard School of Public Health

- Stefanos N. Kales, MD

### Channing Laboratory, BWH

- Frank E. Speizer, MD
- Bernard A. Rosner, PhD

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- Jason P. Sullivan, Project Manager
- Salim Qadri, Programmer
- Amy Hallal, Research Assistant
- K.C. Root, Research Assistant
- Michael Shreeve, Research Assistant



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