Presentation to the Sub-Committee for investigating the 56 hour workweek

October 5, 2015

There is little research presenting information regarding fire departments moving to a 56 hour workweek and the emotional and social implications that occur. However, shift work has been researched, and there are demonstrated negative emotional and social effects on individuals working in this schedule.

In a paper presented by the Ontario Association of Fire Chiefs and Ontario Municipal Human Resources Association, researchers found:

1. An individual's physical performance declines after long periods without sleep.
2. An individual's cognitive performance declines after 24 hours without sleep. This decline is faster than the decline in physical performance.
3. The reduction in physical and cognitive performance is greater during periods of sustained operations.
4. Individuals working 24 hours or more make more mental and technical errors than those working no more than 16 hours.
5. The decline in individual performance happens sooner as worker age increases.
6. Positions in communications operations should not work more than 12-14 hour shifts.

(page 7 : Health and Safety Impact. http://www.iafc.org/files/24-Hour%20Shifts%20In%20Fire%20Departments%20-%20Report%20by%20OAFC%20_%20OMHRA%5B1%5D.pdf?hc_location=ufi) Back up

The implication is that even though the Cumberland fire department has moved to a 24 hour shift, adding an additional shift may affect the ability of the firefighters to respond appropriately to emergencies, and to carry out their daily duties to the best of their ability.

In the article **"Cost-Effective Work Schedules For Small-Town Protection"**, the problem of organizing and staffing issues in order to meet the demands of communities in the most cost-efficient manner was discussed. The research included descriptions of 24/48 hour work schedules, as well as the 10/14. The health impact was not discussed in this article, but firefighter satisfaction was presented. Maurno (1996) reports from an informal poll of several Boston-area departments that every chief, captain and fire fighter cited morale as the key benefit of the 24 hour shift. Another advantage is arriving at work rested, not exhausted by a second job or troubled by a domestic problem. The teamwork that is built by spending 24 hours together carried over to emergency scenes. Maurno says that fewer sick days are used with the 24-hour shift because by only working two days a week, the remaining fire days are sufficient to handle personal issues. He states that the shorter work week allows the fire fighters flexibility to have second jobs and more family time. Fire fighters cited day trips with their spouses and the ability to provide day care or coach their children's sporting events as advantages of the 24-hour shift. *(http://www.usfa.fema.gov/pdf/efop/efo31306.pdf)*

An additional shift will impact the ability of the firefighter to spend this quality time with his or her family.

According to the ***Lancet,*** (http://www.thelancet.com/journals/lancet/article/PIIS0140-6736%2815%2960295-1/abstract), people who work long hours have more of a risk of stroke than those who do not. The implication is that firefighters, being put into a situation where they are working a 53-56 hour work will can, over time, develop some serious long term health risks, including stroke. If we are looking for savings, this will not have the desired long term savings if we are paying higher medical bills and disability payments.

In an article in the February 1, 2012 magazine ***FireEngineering®,*** Todd L. Poole researched the 48/96 hour work schedule vs. the 24/48 (Kelly rotation) produced research in favor of the 24/48 schedule. Looking at employee satisfaction, as well as family satisfaction, the paper determined that there was a 20% reduction in the use of sick days, and moral increases. Families are also benefits of this schedule. Firefighters are able to wake up at home three out of six days, vs. three out of nine days. This factored into employee satisfaction. A concern about sleep deprivation with this schedule was discussed, with suggestions to address the issue.

(http://www.fireengineering.com/articles/print/volume-165/issue-2/features/the-48-96-work-schedule-a-viable-alternative.html)

Because there is little research on the health impact on a 56 hour work week, we must take the information and apply it to our situation. Currently, the department is working a 48/120 hour work week, providing firefighters a great deal of time to recover from the impact of the 48 hour schedule, giving members an opportunity to get over time, and spend quality time with their family. A drastic change to a 56 hour work week will have an impact on the social and emotional well-being of the firefighters, causing a drop in morale, and an increase of sick time. Firefighters will also have overtime options, but this will impact the health and wellness of that firefighter who has volunteered for extra shifts.

Various research indicates that firefighters are most susceptible to heart disease and cancer. Their longevity is less than the average worker and are frequently out on short term disability. Post-traumatic stress disorder is a common issue across the country, as firefighting is the number one profession for experiencing PTSD. They are exposed to horrific scenes, and will self-medicate with alcohol and other drugs. Family life is integral to firefighters, as consistency and support is a predictor for prevention of issues. If we increase the schedule for firefighters, they will lose this support.

4.2 Health and Safety Impact

Conclusions

1. An individual's physical performance declines after long periods without sleep. This is particularly prevalent in jobs that require self pacing and self motivation.
2. An individual's cognitive (problem solving) performance declines after 24-hours without sleep. This decline is faster than the decline in physical performance.
3. The reduction in physical and cognitive performance is greater during periods of sustained operations.
4. Individuals working 24 hours or more make more mental and technical errors than those working no more than 16 hours.
5. The decline in individual performance happens sooner as worker age increases.
6. Positions in communications operations should not work more than 12 to 14 hour shifts.

We found no objective scientific studies that assessed whether individual performance in the fire service improved or deteriorated as a result of working a 24-hour shift schedule. We found studies of extended shift scheduling in other professions, however, that raised some significant performance concerns.

A journal article written by Tom McLellan indicates that there are reductions in an individual's cognitive (mental, problem solving) and physical performance after 24-hours of sleep deprivation.[iv] These reductions were increased during periods of sustained operations.[v] Physical performance is more resistant than cognitive performance, but increased because some assignments such as training, code enforcement, and maintenance can be accomplished in the evening. With 24-hour shifts, most non-emergency assignments stop at 5:00 PM.

Rule admits that changing the work schedule will be met with resistance from fire fighters. However, he states that the fire service should adopt the work schedule that best serves the taxpaying public. Rule defends the 10/14 schedule because it retains the 56-hour workweek and no new personnel are needed to make the change. Rule says this schedule delivers more bang for the buck and it is time to take a serious look at this change.

Maurno (1996) reports from an informal poll of several Boston-area departments that every chief, captain, and fire fighter cited morale as the key benefit of the 24-hour shift. Another advantage is arriving at work rested, not exhausted by a second job or troubled by a domestic problem. The teamwork that is built by spending 24 hours together carries over to emergency scenes. Maurno says that fewer sick days are used with the 24-hour shift because by only working two days a week, the remaining five days are sufficient to handle personal issues. He states that the shorter workweek allows fire fighters flexibility to have second jobs and more family time. Fire fighters cited day trips with their spouses and the ability to provide day care or coach their children's sporting events as advantages of the 24-hour shift.

Maurno also discusses two disadvantages to the 24-hour shift; a high volume of calls can make a difficult 24 hours and extra duty time is paid at overtime rate.

Bramell (1997) reports on the Livermore Fire Department's innovative schedule for their division chiefs. They had been classified as battalion chiefs and had several staff functions assigned to them such as training and public education. However, there was little time dedicated to the staff functions because their primary function was to supervise suppression personnel.

THE 48/96 WORK SCHEDULE: A VIABLE ALTERNATIVE?

02/01/2012

BY TODD L. POOLE

A growing trend mostly among progressive western U.S. fire departments is the implementation of a 48/96 work schedule. In this alternative to traditional 56-hour workweek patterns, employees work 48 hours, followed by 96 hours off. My research has revealed benefits and challenges of the 48/96 schedule. A significant question, however, is do the benefits of a 48/96 schedule outweigh the potential negative effects that can result from working firefighters 48 consecutive hours?

BENEFITS

The idea of working a 48/96 schedule likely originated in Kern County, California.[1] Firefighters, unable to afford homes in the area, were forced to live great distances from their places of employment. The long commutes of the employees resulted in the development of the 48/96 rotation, which reduced by half the number of commutes for the employees and resulted in significant cost savings to the firefighters. As the 48/96 schedule became more prevalent, additional unintended benefits were observed. (1)

In evaluating the 48/96 work schedule for West Metro Fire Rescue in Lakewood, Colorado, Dr. Allison Hawkes discovered an overall increase in employee satisfaction.[2] Employees felt the 48/96 schedule interfered significantly less with activities outside of work than their previous schedule. Prior to implementing the trial of this new work schedule, only 52 percent of employees supported the change; however, after the six-month trial period, 68 percent of employees indicated the advantages of the new 48/96 schedule outweighed any disadvantages.

Although Hawkes found that employee perception of spousal support decreased from 88.9 percent satisfaction to 83.1 percent after transitioning to the new shift rotation, a later study refuted this finding. Hawkes reported that 11.9 percent of employees indicated their spouses were fairly or extremely unsupportive of their new work schedule, a significant increase from the 3.7 percent indicating unsupportive spouses before the shift schedule changed in January.

JVA Consulting, LLC was hired in 2006 to perform a focus group study on how the change to the 48/96 schedule affected West Metro Fire Rescue employees' quality of family life. Three focus groups, each consisting of 11 spouses and 13 firefighters with an average of 11.5 years of service, were established.[3] The focus group study revealed that overall spousal support remained high after transitioning to the 48/96 schedule. Spouses across all focus groups noticed their firefighter partners were happier, more relaxed, and less fatigued. (3) Additionally, spouses across all three focus groups indicated more quality family time was a significant strength.

However, spouses working a Monday-through-Friday 40-hour schedule expressed concern with firefighters working both Saturday and Sunday consecutively. (3) They found this phenomenon, which occurred every six weeks, difficult because of the lack of quality family time during those periods. (3)

Overall, it was discovered that disparity exists between an employee's perception of spousal support and the actual amount of support reported by the spouse. This finding suggests that perhaps further studies should be conducted in this area, given that spousal support contributes to overall employee satisfaction.

Employee Satisfaction

A further review of the literature was conducted in an effort to identify the underlying basis for increased employee satisfaction when working a 48/96 rotation. Several studies show a correlation between extended consecutive days off and employee satisfaction.[4-6] (2)

One researcher claims that "off-time work patterns of the shift employees' work schedule is the most significant determinant of family well-being." (4, 2) This theory is confirmed by the positive reports across all departments that indicate an increased quality of time at home when the employee was off for 96 hours in a row.[7] A noteworthy fact is that employees working a 48/96 schedule wake up at home three out of every six days. (1)

In contrast, firefighters working a 24/48 schedule, or Kelly rotation, wake up only one out of every three and three out of every nine mornings at home, respectively. (1) Surveys show that the increase in mornings when the firefighter wakes up at home has many benefits such as enabling them to see their children off to school more often and providing opportunities for them to reduce accumulated sleep debt by waking up later in the morning. (1)

In addition, firefighters working a 48/96 schedule have more complete weekends off to enjoy with their families, since children are often out of school during the weekends and the majority of working spouses have weekends off. (1, 2) In fact, a 48/96 schedule affords a firefighter 26 entire weekends off, where the Kelly and 24/48 rotations provide only 17. (1)

Although the firefighter is working an equal number of hours in any of the aforementioned schedule patterns, it is likely that families perceive the firefighter to be present more often because of this increase in weekends at home. However, every six weeks, the firefighter works both Saturday and Sunday consecutively, which may be perceived as an excessive amount of time away from home. (3) Overall, it is likely that the increased opportunity for firefighters and their families to enjoy more weekend trips outweighs the challenge of being unavailable because of this Saturday/Sunday phenomenon.

Along with improved quality family time, firefighters working 48/96 rotations find themselves significantly more productive at home and work. A survey of Roseville (CA) Firefighters Local 1592 suggests that firefighters are able to complete more substantive household projects when they have more consecutive days at home. (1) Similarly, employees indicated they were able to better tend to special projects at work when given 48 hours to complete tasks. (1) Some surveys indicate that firefighters are more organized to perform tasks when there is a reduction in transition between work and home routines. (1, 6)

Although employees perceived the 48/96 schedule to be negative prior to implementation, actually working a 48/96 schedule ultimately resulted in higher employee satisfaction when compared with other schedule variations. (1, 2) Being able to live farther away, a 50-

percent reduction in the overall number of commutes to work, and reduced auto insurance rates also add to employee satisfaction. (1)

Employer Benefits

West Metro Fire Rescue observed an overall reduction in injuries from 2004 to 2006. (2) Also, the number of sick days dropped from 13,277 hours in 2004 to 8,246 hours in 2006, after the implementation of the new schedule. (2) However, a procedural change to allow the use of sick leave to care for an ill family member coincided with the study. A further reduction of sick time use would likely be realized if the policy had not changed. Notwithstanding, additional studies would be needed to accurately determine the cause of this reduction in using sick days. Some theorize that there is less abuse of sick time given that employees are less likely to call off duty for nonqualified reasons if they are already on duty during the first 24 hours. (2) If this is true, then a potential 50-percent reduction in sick leave use may result.

One feasibility study indicated a correlation between the 48/96 schedule and a reduction in sick time use.[8] In the Pacifica (CA) Fire Department, there was a 20-percent reduction in the use of sick days, and the Manhattan Beach (CA) Fire Department reported a reduction of 80 percent. (8) No resource reported an increase of sick time after switching to the 48/96 schedule. With the literature indicating employees' morale improves with a 48/96 rotation, it is entirely feasible to correlate higher morale with less use of sick leave benefits. (8)

THE "TRADE-OFF": SLEEP PROBLEMS

Departments contemplating a change in work schedule patterns must consider the potential for dangerous fatigue and sleep deprivation among shift personnel.

Dr. Susan L. Koen, Ph.D, of Round-The-Clock Systems published a comparative analysis of the 48/96 schedule to determine whether dangerous sleep deprivation and fatigue exist among firefighters. (4) Her key question was, "Does the benefit of more consecutive days off provided by the 48/96 schedule create any negative costs in safety, health, on-duty performance, family distress, or individual morale and job satisfaction?" (4, p. 1) Her greatest concern was sleep deprivation among firefighters. The question remains: How much sleep is needed for firefighters to be fit for duty?

Koen defines sleep deprivation as "insufficient deep sleep or restorative sleep for the brain, [which] causes cognitive or brain fatigue that can result in slowed reaction time, decreased vigilance and impairment in complex reasoning skills." (4, p. 1) She argues that the quantity of sleep is not as vital as the quality of uninterrupted, deep restorative sleep. As such, departments with one or two sleep interruptions each night may not experience the negative effects of sleep deprivation, but employees experiencing three or more interruptions nightly will be too sleep deprived to work safely and effectively during the second 24-hour shift. (4) Although Koen claims the higher safety and performance risks for busy departments outweigh the benefits of 48/96, she does not offer any solutions for overcoming or preventing the negative effects of sleep deprivation. Other studies claim firefighter sleep deprivation can be successfully managed.

Robin Widmar, a driver/engineer and EMT with the Colorado Springs (CO) Fire Department, published an in-depth study on the management of firefighter sleep deprivation.[9] She asserts that firefighters are not immune to the mental and physical consequences of sleep deprivation. Extended periods without sleep can significantly contribute to workplace accidents. In the firefighting and emergency medical services industries, the consequences of workplace accidents could result in death or permanent disability in many cases. In fact, case law has been established that can hold a sleep-deprived firefighter, along with the employer, legally responsible for the neglect of his or her duties. (9) This has been exemplified by studies that show 18 hours without sleep is equivalent to a .05 blood alcohol content, and 24 hours without sleep is similar to the effects of having a .10 blood alcohol content. (9) Thus, a sleep-deprived firefighter can be equally as dangerous as a person who is chemically intoxicated. Not only does sleep deprivation affect performance, but health concerns also exist for employees deprived of deep restorative sleep.

In a 1983 study by the University of Chicago, rats became sick and died after only 2.5 weeks of being denied sleep. (9) However, the same study showed that rats that were allowed to sleep after becoming ill recovered fully. (9) The fact remains that sleep deprivation is cumulative and can lead to "sleep debt." (9, p. 46). Larger sleep debts can be managed by introducing proportional amounts of restorative sleep. (9)

Widmar argues that habitual sleep deprivation over time can lead to chronic sleep deprivation, causing hallucinations and paranoia. Thus, it is reasonable to conclude that negative health effects can result from chronic sleep deprivation. This introduces an additional problem: How do employers know when employees are sleep-deprived? Widmar reports the following:

- Self-awareness of sleep deprivation can be especially difficult to evaluate. Employees are often completely unaware of their own impairment.
- Several studies showed that employees fail to recognize they are making mistakes. This ultimately leads to "micro sleeping" or "dozing off," which can result in death or permanent disability. (p. 46)
- Automatic Behavior Syndrome, or sleeping with one's eyes open, is an additional negative effect of sleep deprivation. This syndrome is especially dangerous because employees will continue to perform their duties even though they are completely incapable of cognition. This was likely the cause of the 1989 Exxon Valdez accident in which a tanker carrying 55 million gallons of oil struck a reef in Prince William Sound, Alaska. The pilot at the controls was found to be "severely sleep-deprived and apparently asleep on his feet." (p. 48) It was later determined that Exxon's failure to provide a rested and sufficient crew contributed significantly to what was, at the time, the largest oil spill ever experienced in the United States.
- Human error causes 90 percent of all workplace accidents: "Inadequate sleep is a major factor in human error, at least as important as drugs, alcohol, and equipment failure." (p.48)
- In addition, shift workers are 40 times more likely than day workers to be involved in accidents at work, on the road, and at home. Thus, employers should implement controls to evaluate and manage fatigue for employees working all shift schedule patterns.

Managing Sleep Deprivation

Widmar maintains that implementing key policies and procedures can manage the negative effects of sleep deprivation. He suggests rotating busier crews to slower units throughout the work shift. This intervention would help to balance the workload among all crew members in an effort to avoid burnout. Second, employers should limit the time an employee can be assigned to an excessively busy station to counteract the effects of long-term fatigue.

Finally, Widmar recommends that napping be encouraged for all employees with the potential to work more than 18 hours consecutively. Naps as short as 20 minutes can be effective, but two-hour naps have been found to be highly restorative for firefighting employees. (9)

Other research has found that it is entirely possible that firefighters working 48/96 schedules are, in fact, less fatigued. (2) Employees slept more on average after the implementation of a 48/96 schedule. This increase in overall sleep was found to be distributed throughout workdays and off days. However, no departmental policies were offered to recommend how much sleep is required or allowable for on-duty employees. Neither was the quality of the sleep experienced identified. (2).

Another finding in the research is that employees often will sleep less the night before their scheduled workday. The amount of sleep lost by the employee depends on the time required to travel from home to work. An employee living one hour away may have to awake at 5 a.m. to be ready for a 7 a.m. shift start time. Because there are fewer frequent transitions from workdays and off days with the 48/96 schedule, there is less opportunity for lost sleep. (2)

There also may be additional opportunities for sleep if employees are permitted to remain at rest for a specified number of hours during the morning of the following 24-hour shift.

Based on the literature reviewed, it is reasonable to conclude that it is feasible for employees to work 48 hours if fatigue is closely monitored and efforts are implemented to counteract dangerous sleep deprivation. Although Widmar claims sleep deprivation can be managed through departmental policies, it is possible that departments would make sleep available as an option instead of implementing a compulsory sleep policy. This may prove to be dangerous considering that firefighters are generally not aware of their own fatigue until it is too late. Similarly, firefighters wishing to perform above and beyond employer expectations may be less likely to take advantage of extra rest on duty. Thus, department leaders should strongly consider a compulsory sleep policy and closely monitor sleep patterns in an effort to counteract the high potential for dangerous sleep deprivation.

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The literature reviewed revealed benefits and challenges of the 48/96 schedule. It is clear that firefighters were initially skeptical about working 48/96 rotations but indicated significant support for the schedule pattern after trial periods. Fire department managers can benefit from organizational cost savings in terms of reduced sick time, improved morale, and improved employee productivity while on duty.

However, the potential for sleep deprivation and fatigue over a 48-hour work period introduces additional risk to departments failing to implement preventative measures. In the absence of empirical studies to quantify the effects of sleep deprivation and fatigue among firefighters, it remains difficult to confidently determine the extent of risk assumed by firefighters working 48-hour shifts. Public safety agencies would benefit from an experimental study of fatigue and sleep deprivation among firefighters specifically. Such a study, combined with a larger independent study of 48/96 schedule implementations, would be beneficial for departments considering an organizational change of this magnitude.

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Additional Resources

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TODD L. POOLE, a member of the fire service since 2001, is a firefighter/paramedic with the Truro Township Fire Department in Reynoldsburg, Ohio. He has a B.S. in public safety management from Franklin University, Columbus, Ohio, and is a graduate student at Ohio University in the Executive Master of Public Administration program in the Voinovich School of Leadership and Public Affairs.

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Researchers Link Longer Work Hours and Stroke Risk

By CATHERINE SAINT LOUIS
AUGUST 19, 2015

People who work 55 hours or more per week than those working standard hours, researchers reported on Wednesday in the Lancet.

The new analysis includes data on more than 600,000 individuals in Europe, the United States and Australia, and is the largest study thus far of the relationship between working hours and cardiovascular health. But the analysis was not designed to draw conclusions about what caused the increased risk and could not account for all relevant confounding factors.

"Earlier studies have pointed to heart attacks as a risk of long working hours, but not stroke," said Dr. Urban Janlert, a professor of public health at Umea University in Sweden, who wrote an accompanying editorial. "That's surprising."

Mika Kivimaki, a professor of epidemiology at University College London, and his colleagues combined the results of multiple studies and tried to account for factors that might skew the results. In addition to culling data from published studies, the researchers also compiled unpublished information from public databases and asked authors of previous work for additional data.

Dr. Steven Nissen, the chief of cardiovascular medicine at the Cleveland Clinic, found the methodology unconvincing. "It's based upon exclusively observational studies, many of which were unpublished," and some never peer-reviewed, he said.

Seventeen studies of stroke included 528,908 men and women who were tracked on average 7.2 years. Some 1,722 nonfatal and deadly strokes were recorded. After controlling for smoking, physical activity and high blood pressure and cholesterol, the researchers found a one-third greater risk of stroke among those workers who reported logging 55 or more hours weekly, compared with those who reported working the standard 35 to 40 hours.

While the increase in risk for each individual was slight, experts said the effect was noteworthy in a large population in which many people are working long hours.

In his editorial, Dr. Janlert said, "Long working hours are not a negligible occurrence." Full-time American workers in nonagricultural industries labor for an average 42.5 hours per week, according to Bureau of Labor Statistics.

But workweek hours vary sharply depending on occupation and company culture. In , nearly four in 10 full-time American workers reported laboring at least 50 hours weekly, and half said they usually work more than 40 hours.

Dr. Kivimaki and his colleagues also found the risk of stroke increased as work hours lengthened. But he said, "we found no differences between men and women, or between older people and younger ones, or those with higher or lower socioeconomic status."

Dr. Stephen L. Kopecky, a professor of medicine in the division of cardiology at the Mayo Clinic, said that this analysis did not fully account for the effects of cholesterol, family history and blood pressure in all cases, so it is possible that long hours are not entirely to blame.

Furthermore, he argued, it matters to stroke risk whether an employee has a job with high demands and little control, which researchers call "job strain."

"You have higher blood pressure when you have job strain," Dr. Kopecky said. "And guess what that's associated with? Stroke."

Another limitation: individuals were asked just once the number of hours they work.

A randomized trial could shed light on whether working long hours actually causes strokes. For example, scientists could assign some people working long hours to reduce them, and other overachievers to keep up their long hours, and then measure the health consequences and track factors like blood pressure, sleep duration, and stress response.

Dr. Sacco, chairman of neurology at the University of Miami Miller School of Medicine, said a randomized study where "we can measure all the unmeasured factors" would help confirm these new results.

"It's not a practical trial to do," he said.

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DISCUSSION PAPER: 24-HOUR SHIFTS IN FIRE DEPARTMENTS

Ontario Association of Fire Chiefs
and
Ontario Municipal Human Resources Association

December, 2006

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EXECUTIVE SUMMARY

This study examines the health and safety, personal, legal and operational effects of implementing a 24-hour shift program in the fire service. The goal of the study is to identify the positives and negatives of a 24-hour shift rotation, identify potential areas of concern, and to determine the conditions and policies needed to make the 24-hour shift operationally viable.

Over 280 journal articles were reviewed in preparing this discussion paper. Although much has been written about 24-hour shifts and related issues, there were no objective studies found analyzing the improvements or deterioration to organizational performance that results from changing to a 24-hour shift schedule in the fire service or other occupations.

We also held discussions with the five Ontario fire departments that are operating or have run trials with 24-hour shifts. They indicated that moving to 24-hours shifts has an impact on operations that requires the negotiation of other changes to the collective agreement.

We identified some concerns with the 24-hour shift schedule. Individuals' cognitive and physical performance tends to decline after 24 hours without sleep. Occupational health and safety studies indicate longer shifts and shorter rest periods increase the probability that accidents will occur. Moving to a 24-hour shift may increase exposure to legal liability.

Fire departments considering a change to the 24-hour shift schedule should proceed with caution. They need to gather current shift performance statistics, establish a letter of understanding outlining the terms and conditions of a trial period, negotiate language changes and issues before the trial period, install a monitoring mechanism, and establish corrective action for any variances in targeted organizational, individual, and operational performance.

1. PROJECT PURPOSE

This study was undertaken by the Ontario Association of Fire Chiefs and the Ontario Municipal Human Resource Association to provide municipal fire departments with a comprehensive report that will assist them in determining whether or not 24-hour shifts are appropriate for their municipality. Over the last few of years a number of local Professional Fire Fighter Associations in Ontario have requested a change from the current 10/14 shift schedule to a 24-hour shift rotation.

We examined the health and safety, personal, legal and operational effects of implementing a 24-hour shift program in the fire service and other occupations. Our goal was to identify the positives and negatives of a 24-hour shift rotation, identify potential areas of concern, and to determine the conditions and policies needed to make the 24-hour shift operationally viable.

2. METHODOLOGY

There were three components of our research:

1. We reviewed research studies investigating the organizational behaviour, health and safety, and physiological effects of implementing a 24-hour shift schedule.

2. We conducted legal research on cases dealing with sleep-related accidents and liability.

3. We met with Fire Chiefs and employees within Ontario operating under the 24-hour shift schedule (Kingston, London, Toronto, Windsor, Woodstock) to obtain information on their experiences with extended shifts, to ask detailed questions that may not have been considered when originally implementing the program, to gather departmental data and to review specific contract language.

3. BACKGROUND

The 24-hour shift has been a norm in many parts of the Fire Service in the United States. In some areas, such as Minneapolis, the 24-hour shift has been used for over 50 years.[i] Typically, the 24-hour shift has been used as a way to manage the 56-hour work week of American firefighters operating under a three platoon system. With the 56-hour work week, the 24-hour schedule is considered the best system for aligning hours of work and call volume for both management and employees.

The Ontario experience with the 24-hour shifts is more limited. The fire departments that currently operate or have operated on 24-hour shift schedules include Windsor, Woodstock, London, Kingston, and Toronto.

In 1965, Windsor Fire and Rescue became the first Canadian fire department to operate under a 24-hour shift schedule, and still operates under such a schedule today. Windsor is unique in Ontario in that it also operates under a 48-hour work week rather than the standard Ontario 42-hour work week.

On January 1, 1996, the Woodstock Fire Suppression Division started working the 24-hour shift schedule. Its initial goal was to reduce absenteeism on weekends.

On January 1, 1997, the London Fire Services began using the 24-hour shift schedule. At the time the City of London was faced with fiscal pressures and would have had to lay-off upwards of eight fire fighters. The London Professional Fire Fighters Association (LPFFA) proposed the implementation of a 24-hour shift schedule to avoid lay-offs. By accepting the LPFFA request for 24-hour shifts, the City of London hoped it could achieve the savings necessary to avoid lay-offs.

In 2004, the Kingston Fire and Rescue Department started a 2-year trial of the 24-hour shift schedule, but it terminated the experiment near the end of 2005 as a result of operational concerns. We discuss these concerns later in this paper.

On January 1, 2005, the Toronto Fire Service launched a pilot study investigating the effects of 24-hour shift schedule on Toronto firefighters in one district. On January 1, 2006, all of Toronto entered into a one-year trial period.

4. RESEARCH FINDINGS: AREAS OF CONCERN

4.1 Introduction

Despite the fact that a number of American fire departments have been working the 24-hour shift for a number of years no detailed analysis has been done on the effects of 24-hour shifts on the organizations and employees.[ii] There has also been no detailed objective analysis on the effects of the 24-shifts based on the more limited Ontario experience.

Beyond the Fire Service, we found very few research studies which measured the impact of extended shifts on employees. The studies that do exist were conducted more recently and focus primarily on social and mental health issues rather than physical health.[iii]

Our findings below – which we have divided into health and safety, personal, legal and operational findings – discuss the conclusions in some of the limited but available research and are also based on our discussions with the five Ontario fire services with 24-hour shift experience.

4.2 Health and Safety Impact

Conclusions

1. An individual's physical performance declines after long periods without sleep. This is particularly prevalent in jobs that require self pacing and self motivation.
2. An individual's cognitive (problem solving) performance declines after 24-hours without sleep. This decline is faster than the decline in physical performance.
3. The reduction in physical and cognitive performance is greater during periods of sustained operations.
4. Individuals working 24 hours or more make more mental and technical errors than those working no more than 16 hours.
5. The decline in individual performance happens sooner as worker age increases.
6. Positions in communications operations should not work more than 12 to 14 hour shifts.

We found no objective scientific studies that assessed whether individual performance in the fire service improved or deteriorated as a result of working a 24-hour shift schedule. We found studies of extended shift scheduling in other professions, however, that raised some significant performance concerns.

A journal article written by Tom McLellan indicates that there are reductions in an individual's cognitive (mental, problem solving) and physical performance after 24-hours of sleep deprivation.[iv] These reductions were increased during periods of sustained operations.[v] Physical performance is more resistant than cognitive performance, but physical tasks that involve self-pacing and motivational efforts to continue are negatively impacted by sleep deprivation.[vi]

Dr. Christopher P. Landrigan compared medical interns working traditional schedules (24 hours or more) with those working an intervention schedule (no more than 16 hours). He found that there were 35.9% more serious medical errors during 24-hour shifts than during 16-hour shifts.[vii] Dr. Landrigan concluded that reducing the number of daily and weekly hours worked had a positive impact on performance.

Similarly, Doctors Eastridge and Hamilton found that surgical residents made twice the number of technical errors in simulated surgical skills during extended (24-hour) shifts.[viii]

Researchers have also determined that the length of shifts and the length of rest between shifts act as possible risk determinants for industrial accidents.[ix] In other words, longer shifts increase the probability of an accident. Dr. Dembe found that working at least 12 hours per day was associated with a 61% higher injury hazard rate. Working 60 hours per week was associated with a 23% increased hazard rate.[x]

Consistent with this research, Transport Canada has decreased the maximum on-duty time allowed for truckers in any consecutive 24 hour period from 16 hours to 14 hours. This decision was based on a Driver Fatigue and Alertness Study which showed that performance scores were lower at the end of trips than at the start.[xi] In addition, another driving-related research study found that sleep deprivation of 24 hours was equivalent to a blood alcohol level of 0.10%.[xii]

The age of the worker on extended shifts is also a factor. Studies in other areas show that as age increases low performance levels are reached sooner when operating under 24-hour sleep deprivation.[xiii]

In recognition of the need for cognitive alertness Woodstock and London fire departments have negotiated a clause in their collective agreements requiring 12-hour shifts in their communications operations (See Appendix 7.21 and 7.22).

4.3 Personal Impact of Extended Work

Conclusions

7. Schedule changes may positively or negatively affect morale depending on employee perceptions of their initial schedules.

8. Any improvements to the employees' mental health and well being resulting from a change in shift schedule seems to be short lived and disappears within one year.

9. Recent studies conclude that you cannot really adjust an individual's biological clock to shift changes, regardless of the shift pattern. The impact can be minimized but not eliminated.

There are two well-known studies on the impact of 24-hour shifts on employee mental health and well-being. The first study outlines the positive benefits of changing to a 24-hour shift and has been cited in some fire fighter association shift modification requests. The second study reports opposite conclusions.

In a study for the Toronto Fire Department, "Effect of Shiftwork on Health and Circadian Rhythm in 24-Hour Fire Fighters", Dr. Glazner reported improvements in fire fighter eating patterns, reduced overall sleep deficit, improved relations with family members, and increased feelings of good health when fire departments shifted from a 10/14 hour shift to a 24-hour shift (See Appendix 7.7). These findings led her to recommend a trial period for 24-hour shifts.

A.T. Polgar Associates reviewed Dr. Glazner's study and raised concerns with her methodology and conclusions (See Appendix 7.24).

In a different study Dr. Boudreaux measured the same variables as Dr. Glazner, but reported opposite results (see Appendix 7.8 "From 24 to 12: The Benefits of Shift Modification"). He concluded that shortening EMT work schedules from 24-hour shifts to 12-hour shifts leads to: an improvement in attitudes toward work schedules, an improvement in overall happiness and physical well-being, and fewer family and social disruptions.[xiv] He stated, "Analysis also revealed that participants endorsed less emotional exhaustion and feelings of burnout when working on the 12-hour schedule. It is well established that working 24-hour shifts can foster feelings of fatigue and exhaustion because of the effects of sleep deprivation and disruption in circadian rhythms."[xv] Dr. Boudreaux also reported that since job related stressors did not change, overall job satisfaction remained the same. Dr. Boudreaux concluded that the 12-hour schedule was the preferable schedule and appeared to be far less disruptive to participants' overall quality of life.

Dr. Boudreaux conducted follow-up studies after participating EMT's work schedules were modified from 24 to 12-hour shifts. At two month and one year intervals, he measured job satisfaction, occupational burnout, and attitude toward work schedules. Two months after the change, the reduction in the length of shift was associated with an improvement in general attitudes toward work schedules, less disruption of social and family life and decreased levels of emotional exhaustion. One year after the change the improvements attitude toward work schedules persisted but the measure of emotional exhaustion returned to the baseline – i.e. what it was before the schedule change. This suggests that morale can be positively or negatively affected by schedule changes depending on employee perceptions of initial schedules. The impact on morale, mental health, and well-being from changing shifts appears to be temporary. After approximately one year, morale levels appear to return to the levels that they were at prior to the change.

Apart from these two conflicting Ontario studies, others have studied the general health impact of working extended shifts. One study on EMS workers suggests that unconventional hours increase the secretion of stress hormones and cause changes in such factors as blood pressure, heart rate, coagulation, and lipid and glucose metabolism.[xvi] Another study associated extended work schedules with an increased risk of hypertension, cardiovascular disease, fatigue, stress, depression, diabetes, and general health complaints.[xvii] Extended shifts in the fire service may exacerbate these health issues.

Conventional wisdom once held that a person's circadian rhythms could essentially be reset, but contemporary research has demonstrated that this is generally untrue. These recent medical studies indicate that an individual's biological clock cannot adjust to changes in shifts.[xviii]

4.4 Legal Risks

Conclusions

10. A 24-hour shift is illegal in Ontario outside the Fire Service.

11. There are legal precedents for an employer being held liable for employee fatigue-related accidents.

12. Fire Departments should have due diligence systems in place to comply with occupational health and safety regulation and to protect them from civil liability.

When discussing the 24-hour shift it is important to remember that for most other workers in Ontario, a 24-hour shift is illegal. The Ontario *Employment Standards Act, 2000* (the ESA) places strict limits on hours of work. For example, section 18(1) of the ESA requires at least 11 consecutive hours free from performing work in each day. Although the *Fire Prevention and Protection Act* exempts fire service employers from this restriction, the section 18(1) of the ESA nonetheless indicates that a 24-hour shift is far greater than the normative shift length in Ontario.

Under the Ontario *Occupational Health and Safety Act* requires all employers and supervisors (i.e. Fire Chiefs) to “take every precaution reasonable in the circumstances for the protection of a worker”. Likewise, the *Criminal Code* now requires employers and supervisors take reasonable steps to prevent bodily harm to employees. Failure to meet these duties may lead to criminal liability.

Although occupational health and safety charges for a fatigue-related accident are certainly possible, we did not find any Ontario cases on such charges. We did, however, find two negligence cases from jurisdictions outside of Ontario in which employers were made responsible for fatigue-related accidents by tired employees.

Two other cases, in which drivers were held liable for driving while fatigued also raise the spectre of civil liability for employers who do not vigilantly manage the risks associated with working employees for long hours.

Faverty v. McDonald's

This case, although American, is an example of an employer being held liable for working an employee to the point at which he became so tired that he was a hazard to himself and others.

Matt Theurer was juggling work, school, and extracurricular activities. He had worked the preceding Sunday, attended school on Monday, and then worked at the McDonald's restaurant on Monday evening from 3:30 to 7:30 p.m. At the end of his scheduled shift he volunteered to come back to work for a special clean-up shift beginning at midnight. Theurer drove home from work at 8:21 am on Tuesday, he fell asleep at the wheel and was in a head-on-collision with Faverty. Theurer died instantly and Faverty was injured.

Faverty alleged that McDonald's was negligent in scheduling Theurer to work too many hours. A jury in Multnomah County, Oregon agreed and awarded Faverty $400,000 in damages.

McDonald's appealed, arguing that it had broken no labour laws. Theurer had worked his regular 4-hour shift, had 4.5 hours off, and then volunteered to return to work another eight hours. The accident occurred after Theurer had left work. McDonald's argued that it had no duty or ability to control Matt Theurer after he left work, and should not be held liable for Faverty's injuries. The Oregon Court of Appeals disagreed and affirmed the verdict. The court held that the defendant corporation knew or should have known that its employee was a hazard to himself and others when he drove home from the work place after working numerous hours.

Notably, McDonald's was made liable even though some of Theurer's fatigue may have resulted from his activities before reporting to work.

Robertson v. LeMaster

In this West Virginia negligence case, the Supreme Court of West Virginia ruled that the employer had breached a duty of care to a motorists by causing an employee to work unreasonably long hours and sending him onto the highway where there was a foreseeable risk of harm to other motorists.

The 19-year old employee was on a work crew at the site of a train derailment. He had repeatedly told his employer that he was exhausted and wanted to go home, and after 27 hours of work, the employer gave him permission to leave. A co-worker drove him from the work site to his car. The employee began the 50 mile trip to his house, but on the way he fell asleep at the wheel and had an accident with the another motorist, who successfully sued the employer for negligence.

Regina v. Gary Neil Hart

In this case from England, the Court found that a driver was guilty of driving while impaired due to fatigue. The driver fell asleep, his car left the road and stopped on train tracks. The driver fled the vehicle, but his car was hit by a train. Ten people died when the train derailed and was diverted into the path of an oncoming train traveling in the opposite direction.

The driver – who was attempting to drive 140 miles from work to his house after being awake for 17 hours and only having two hours of sleep the previous night – was convicted in Leeds Crown Court on 10 counts of causing death by dangerous driving resulting from fatigue. He was sentence to five years of imprisonment.

Erica Cadieux Case

A Quebec woman has recently been charged with the dangerous operation of a motor vehicle causing death. She was driving an SUV, allegedly fell asleep, jumped a curb in the Montreal suburb of Beaconsfield, and struck Erica Cadieux who was pushing her baby in a stroller. Cadieux died, but the baby was unharmed. The Court decided that while driving drowsy is not illegal, it must be proven that the accused was so fatigued that their actions were criminally negligent.

4.5 Operational Issues

We identified a number of operational issues that arise because of 24-hour shift scheduling.

4.5.1 Response To Calls

Conclusions

13. 24-hour shifts require the fire department to have sufficient on duty staff to provide rotation relief in the event of a busy shift or a major lengthy incident.

14. Under the 24 Hour shift the number of fire fighters available for call-in may be less than under the traditional 10-14 shift schedule.

Fire fighters who work at high call stations do not get much rest during a 24-hour shift.[xix] There have been anecdotal reports of fire fighter fatigue happening during this type of extended shift.[xx] A high number of calls coupled with a lack of rest also lengthens the individual's recovery time on that shift or the next shift (See Section 4.2 Individual Performance and Section 4.5 Occupational Health and Safety). This is especially important on the second work day if the department is running a cycle of one 24-hour day on, one 24-hour day off and the third 24-hour day back on.

To offset fatigue, the Toronto Fire Service has an unofficial practice of giving all fire fighters two hours of sleep time during their shift.[xxi] This time is referred to as "core sleep." The fire station will shut down for these two hours and another station will cover the first stations calls during this period. Toronto Fire Service did not provide information on how response times were affected by giving firefighters core sleep hours.

While large municipalities like Toronto may be able to address call volume issues, a smaller municipality with a lower number of stations may not be in a position to do so. Smaller municipalities may face response problems as one station may not be in a position to relieve another station that has experienced a busy day.[xxii] For example, if the stations are geographically far apart they will not be able to cover for each other (to provide rest time) and still provide the necessary response time and staff numbers to both areas.[xxiii] Alternatively, in cases of simultaneous calls, additional employees need to be called in on overtime rates to respond to the incidents.[xxiv]

A major incident requires a large number of people over an extended time period. People working long shifts will need to be rotated or relieved, as it may be a long time before the next platoon reports for duty.[xxv]

If it is necessary to call in extra people the 24-hour shift will reduce the number of people that are available for call backs[xxvi]. This may result in a situation where the next shift will have to work 36 hours or more continuously.[xxvii] Firefighters working other shifts may be in the middle of a multiple day off period and may not even be available locally (Some of the fire departments have reported that they are finding that a greater proportion of their fire fighters are living further away or outside the municipal boundaries.)[xxviii]

The lengthening of the shift rotation delays the arrival of relief firefighters (at regular rates of pay), requiring people to be called in at overtime rates which may lead to an increase in overtime costs.[xxix]

4.5.2 Training

Conclusions

15. Training is more difficult under a 24-hour shift system and provisions need to be made in the agreement to modify the shift schedule for training purposes.

16. Development of daily work schedules will help to ensure that all necessary training is carried out, that changes to policies and procedures are effectively communicated and that good documentation is maintained.

17. Use of the platoon system is recommended.

Management of the workplace becomes difficult under a 24-hour shift as the management staff and the fire fighters may be working different shift schedules and there are such large gaps between days on duty.[xxx] To ensure that all of the necessary fire fighter training is carried out, and that records of which fire fighter took training or was in attendance on any given day of training, the Toronto Fire Service developed a daily work schedule for every day of the year. These schedules were linked back to their departmental policies and procedures, and their health and safety training requirements. It also allows them to effectively communicate changes in policy or new procedures to everyone. In this manner they are able to make sure that every fire fighter is up to date on their training and has all of the latest information. A copy of one of the daily schedules is included in Appendix 7.2.[xxxi]

Windsor Fire & Rescue reported that the group system causes administrative difficulties and recommended that the Platoon system be used for a 24 Hour shift schedule.[xxxii]

The London Fire Service has expressed difficulty in the ability to train staff as a result of the 24-hour shift program. The LFS said that there are fewer occasions when the shifts of the two divisions coincide. Also there is a lack of continuity for the Training Division. This is because the “on platoon” has at least one day off between shifts.[xxxiii]

Toronto has not experienced problems because they made provisions in their agreement to modify the shift schedule to allow for consecutive training days when deemed necessary by training staff.[xxxiv]

Woodstock and Kingston did not change their collective agreement language and have found it difficult/expensive to carry out required training activities.[xxxv]

4.5.3 Hours of Work/Overtime

Conclusions

18. Regular workweek hours were not changed in any Ontario fire departments from switching to a 24-hour shift schedule.

19. There is a tendency for overtime costs to increase for Departments with a 24 hour shift.

The regular hours of work per week were not altered by fire departments changing to a 24-hour shift schedule. Ontario Fire Fighters operating under the 24-hour shift schedule work either 42 or 48 hours per week (averaged over a five-week period). The number of hours worked per week depends on the number of platoons or groups. Toronto, London, and Woodstock operate on 42 hours per week. Windsor maintains a 48-hour workweek (See Appendix 7.1).

In some cases overtime hours have increased. During the 24-hour shift trial in Kingston, the fire department reported that overtime expenditures had increased by 33.8% over the 22-month trial period (See Appendix 7.17). The primary reason for this increase was “staff shortages due to unscheduled absences”.

The Maryville Fire Department’s (IH, U.S.A) overtime costs increased after the conversion to the 24-hour shift trial period because:

- The overtime threshold was calculated at 171 hours of work and not the typical 212 hours (this is over a 28-day period).

- Maryville uses 171 hours since a firefighter is normally paid for 19 hours of work per day (they are not paid for the 5 hours of sleep they have on a 24-hour shift).

- During the 28-day cycle, a firefighter typically works 9 shifts. These 9 shifts multiplied by 19 hours equal 171 hours. Once every 3 months a firefighter works 10 shifts or 190 hours."[xxxvi] These additional 19 hours (190-171) are paid at time and a half.

- Fire fighters are given five hours of unpaid sleep time throughout the night. For any call during this period the fire fighter is paid for all five hours at time and a half.

As a result of this clause Maryville's overtime budget increased dramatically. This highlights some of the potential cost implications of trying to provide guaranteed sleep time during the 24-hour shift.

4.5.4 Absenteeism

Conclusions

20. There is a tendency for absenteeism to increase for Departments with a 24 hour shift.
21. The cost of absenteeism is greater because one day is equal to 24 hours.
22. Requirements for medical documentation need to be revised.

The following article appeared in the Windsor Star:

> "City Council Alan Halberstadt rang alarm bells this week over the disturbing propensity of Windsor fire fighters to phone in sick on weekends and holidays, which contributes to a scandalous overtime bill that must be borne by overburdened city taxpayers…Halberstadt said Wednesday he was told 19 fire fighters called in sick over Thanksgiving weekend, costing the city thousands of dollars in overtime because their peers had to pick up the slack….City ratepayers will spend at least $800,000 this year to cover overtime pay resulting from firefighters' sick days, more than $300,000 above the budged figure for the year." [xxxvii]

The ability of fire fighters to take on second jobs and the high absenteeism rates led the Windsor Star to question fire fighters' job commitment.

Windsor Fire and Rescue reports an annual cost of between $500,000 and $1,000,000 in order to maintain staffing levels of 57 throughout a 24-hour period. They have acknowledged that they have higher absence rates on weekends and that absences among long service staff are higher. Since one 24-hour period is equal to one day, an employee can miss two 24-hour days (48 hours) without having to provide a doctors note (48 hours is equal to 4.8 – 10 hour day shifts or 3 – 14 hour night shifts). In addition, these two "sick days" may be five days apart. Requirements for medical documentation need to be revised in the collective agreement and contract wording should be examined to remove references to days or shifts for absences or redefine the terms so that a one-day absence does not constitute 24 hours.[xxxviii]

The Kingston 24-hour shift trial reported average sick days increased from four to six days per employee per year (See Appendix 7.19).[xxxix]

London Fire Department has reported an absenteeism problem. In 2005, average annual days missed due to absenteeism was 10.8 (See Appendix 7.26). As a result, the LFD is going to implement an attendance management program.[xl]

4.5.5 Recruitment and Retention

Conclusions

23. The London Fire Department has experienced difficulties in attracting suppression fire fighters to transfer to their training division as a result of different hours of work regimes.

24. Fire departments with 24 hour shifts report an increase in staff that live outside the municipal boundaries.

The London Fire Department has reported difficulties in having suppression fire fighters wanting to transfer to their training division. The LFD attributes this problem to the training divisions work schedule. Training personnel work 8-hour days, five days a week. According to the LFD, this schedule may be less desirable than the 24-hour shift schedule.[xli]

For EMS, the issue of workforce recruitment and retention has been cited as one of the top problem areas. Irregular working hours have been cited as a major reason why employees leave many EMS jobs.[xlii] Some of the EMS departments that were running on the 24-hour shift schedule are now reverting back to a 10/14 hour shift schedule.[xliii]

In a phone interview, Dr. Boudreaux said EMS crews had a negative attitude towards their work schedule because of fatigue due to call volume.

Woodstock Fire Suppression Division reports that about half of their staff live outside the City of Woodstock.[xliv] Both Toronto and London have also reported an increase in staff moving outside of their respective cities since the introduction of 24-hour shifts.[xlv]

4.5.6 Swapping Shifts

Conclusions

25. Allowing employees to swap shifts without approval increases the employer's exposure to liability.

26. Swapping shifts may lead to lower job performance or higher accidents if it does not allow sufficient rest time between shifts.

Many fire departments have a practice of letting fire fighters swap shifts.

Windsor Fire and Rescue's collective agreement allows fire fighters to switch up to six shifts in a row without approval.[xlvi] This practice could potentially allow a firefighter to work two or more 24-hour shifts in a row.

The following information was published in the Boston Globe:

> "The City cannot prevent firefighters from swapping their shifts- even when they work around the clock to work fewer days – without a labour ruling, according to a Suffolk Superior Court order. The ruling sends the debate back to the Labour Relations Commission, where Boston fire fighters have already filed a grievance over a March 24, 2001 city order that would halt the 24-hour shift swap.[xlvii]

Allowing fire fighters to swap 24-hour shifts without approval may not only have a negative impact on personal performance (See Section 4.2), but it may increase the possibility of accidents and may also increase the employer's exposure to liability (See Section 4.4). Clear policies need to be developed around what is an acceptable shift swap (back-to-back 24-hour shifts present the greatest danger) or language needs to be put in the collective agreement that requires all swaps to be approved by the employer.

4.5.7 Contract Administration

Conclusions

27. In changing to a 24-hour shift all contact clauses must be inspected for possible changes. References to days and shifts may need to be re written.

28. Grievance timelines need to be examined to reflect what is possible under the shift schedule.

29. Vacation policies may need to be instituted to maintain staffing levels during peak vacation time.

30. Bereavement leave policies may need to be re-examined.

31. London has experienced an increase in bereavement time.

Grievances. We found no studies measuring an increase or decrease in grievance activity after changing to a 24-hour shift schedule.

The timelines for grievances in standard collective agreements are difficult to meet when changing to a 24-hour shift schedule. If a grievance occurs with a fire fighter on Thursday of Week 1, there may be up to five days before that firefighter is on duty again so that the grievance can get dealt with. This time lag is compounded if the fire fighter has swapped shifts (See Appendix 7.2).

This has not been an issue for both Toronto and Windsor because their timelines are not disputed.[xlviii] Fire departments that have stringent grievance timelines should look to renegotiate this clause.

Vacation time. London negotiated a reduction in vacation hours with the introduction of the 24-hour shift. London also negotiated fewer staff to cover vacation leave. Prior to the 24-hour shift schedule, a maximum of 10 staff members were permitted to be on vacation at the same time. Under the 24-hour shift schedule only eight members are allowed to be off at the same time in the off seasons and only nine in the peak summer period.[xlix]

Bereavement time. In shifting to the 24-hour shift London Fire Services experienced the following issue with respect to bereavement leave. The contract stipulated the number of "days" for bereavement leave depending on the relationship. Under the 24-hour system the use of days results in a large increase in the number of hours away from work. Again the spacing of the days on days off on a 24-hour shift schedule raises the question of whether the multiple days off for bereavement is required.[l]

10/14 Shift	**Time Off (hours)**	**24-Hour Shift**	**Time Off Hours (Now)**	**Increase in Time Off (hours)**
1 day	10 or 14	1 day	24	14 or 10
2 days	20 or 28	2 days	48	28 or 20
3 days	30 or 42	2 days[i]	48	18 or 6
4 days	40 or 56	2 days[ii]	48	8 or (8)[iii]

i With 3 days bereavement leave, on an 8 day cycle, employees will on miss a maximum of 2 shifts.

ii With 4 days bereavement leave, on an 8 day cycle, employees will on miss a maximum of 2 shifts.

iii (8) means a decrease in time off by 8 hours

5. CONCLUSIONS

This study has examined the 24 Hour shift system from the perspective of Health & Safety, the potential impacts on the employee, legal issues and operational issues such as overtime, absenteeism, and training to name a few. Before municipalities negotiate for collective agreement changes related to a 24-hour shift system, we suggest that they carefully consider some of the costs ad risks discussed in this paper. We have created the following checklist to assist in this exercise.

6. CHECKLIST

The following is a checklist of items to be dealt with prior to considering a change to a 24 Hour shift schedule.

1. Collect data and Conduct an Individual/Fire Station Assessment. This information will serve as a baseline for comparison at the end of the trial period.

    1.1 Gather Information on Individual and Organizational Performance while operating under the 10/14 shift schedule: emergency response times, endurance while on the fire scene, alertness while conducting emergency medical treatment, and reaction time while doing rescue operation drills.

    1.2 Gather Information on Call Volume

    1.3 Gather Demographic/Employee Information: distance from home to work, daily commute information, and age.

    1.4 Gather Financial Information: current levels of overtime and number of paid working hours.

    1.5 Gather Employee Relations Information: number of annual sick days, number of grievances, annual transfer requests, medical aid lost time, medical aid only, and incidents with no medical aid or lost time.

    1.6 Gather Social, Mental, and Physical Health Information.

2. Review All Contract Language to Look For Clauses Affected by the 24-hour Shift Program

    2.1 This information should examine the current collective agreement for all references to days or shifts and other collective agreements operating under the 24-hour shift program. Negotiate the contract language changes before the trial begins.

2.2 Establish that a *workday* is a 12-hour period beginning at 08:00-20:00 or 20:00-08:00, a *workweek* is one calendar week starting on Sunday 08:00 and ending on the following Sunday at 08:00, a *shift* is a 24-hour period from 08:00-08:00, a *lieu day* is a 12 hours, and a *sick day* is 12 hours (See Appendix 7.19). If these variables are not properly defined a sick day for example could be assumed to be one 24-hour shift.

3. Establish Adequate Rehabilitation Time

3.1 Fire fighters should have a minimum of 48-hours of off time between 24-hour shifts to recover.

3.2 Since the employer may be held liable for an accident caused by fatigue, it is important that management includes clauses, in both the initial letter of understanding and collective agreement, that employees will sign an agreement before each shift indicating they are well rested or have had adequate sleep (not less then 7.5 hours, the night before a shift).

3.3 If an employee did not sleep for at least 7.5 hours the manager will have the authority to send the employee home if they can not carry out their duties at any time throughout the shift.

3.4 The employer may also have to ensure that the employee is well rested before they drive home after their shift. This may require the fire fighter to get 2 hours of sleep (unpaid) after the end of a busy shift and before they can drive home. Failure to manage this properly may result in a legal liability for the employer if an accident occurs.

3.5 Since these regulations are to protect the safety and wellbeing of the employees and given that they will not be called upon to work during this sleep time, these hours should be unpaid.

4. Define and Collect Performance Data

   4.1 Define the Performance and Organizational Health Variables To Be Measured. Also develop an agreement on how these variables will be measured and recorded. Collect the data.

5. Develop Daily Work Schedules

   5.1 Look at all of your policies and procedures, health and safety and training requirements and develop a daily work schedule to ensure that all fire fighters get the necessary training, that of the tasks get done and that good documentation has been kept.

6. Develop a Letter of Understanding for a Trial Period

   6.1 The trial period should be a minimum of two years with a two-year extension provision to properly assess the impact of the 24-hour shift program.

   6.2 Outline the conditions of the agreement (See Appendix 7.19 & 7.20).

   6.3 Make provisions to allow changes to be made to correct problems during the trial period.

   6.4 Develop an Out-Clause that can be used by either the union or management based on changes to any of the previously mentioned variables. Stipulate that all hours of work contract amendments will revert back to those that existed before the introduction of the 24-hour trial period.

7. Schedule Quarterly Meetings

   7.1 Every 3 months management and the union representatives should meet to resolve outstanding issues related to the 24-hour shift trial period.

7.2 If an increase in absenteeism or worker fatigue has developed management and union members should work together to modify current contract language or resolve the problem.

7.3 Regular meetings will allow both management and union members to assess the feasibility of the 24-hour shift schedule.

8. Schedule Annual Meetings

8.1 Annual meetings should be scheduled to discuss long-term objectives and to review performance on each of them.

9. Prepare a Final Report

9.1 Three months before the end of the Trial Period analyze the data and prepare a report. Before the end of the Trial period make a conscious decision to stop the experiment and revert to the previous shift system, or to extend the trial (make necessary modifications) or to adopt the 24 hour shift schedule.

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[xxiv] Phone interview with Woodstock Fire Suppression Division.

[xxv] Phone interview with Windsor Fire and Rescue.

[xxvi] Phone interview with Woodstock Fire Suppression Division.

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Glossary

A

ACGME - Accreditation Council for Graduate Medical Education. Is responsible for the Accreditation of post-MD medical training programs within the United States. Accreditation is accomplished through a peer review process and is based upon established standards and guidelines.

AOA - American Osteopathic Association. The AOA serves as the primary certifying body for D.O.s, and is the accrediting agency for all osteopathic medical colleges and health care facilities. The AOA's mission is to advance the philosophy and practice of osteopathic medicine by promoting excellence in education, research, and the delivery of quality, cost-effective healthcare within a distinct, unified profession.

B

Bereavement Leave - Paid leave of limited duration granted to an employee upon the death of a member of his immediate family or household.

C

Circadian Rhythms – The circadian rhythm is a name given to the "internal body clock" that regulates the (roughly) 24 hour cycle of biological processes.

Coagulation - Blood clotting.

E

Extended Shifts – Any shift having a duration longer than 14 hours.

F

Fatigue - Fatigue is a feeling of excessive tiredness or lethargy, with a desire to rest, perhaps to sleep.

H

Hours Worked – The summation of a departments regular and overtime hours worked

Hypertension - Blood pressure above the normal range.

M

Mental Health –	Of or relating to the total emotional and intellectual response of an individual to their external environment. Mental health is how people look at themselves, their lives, and the other people in their lives; evaluate their challenges and problems; and explore choices. This includes handling stress, relating to other people, and making decisions.

O

Organizational Behaviour –	A field of study that investigates the impact that individuals, groups, and structure have on behaviour within organizations, for the purpose of applying such knowledge toward improving an organization's effectiveness.
Overtime -	Hours worked in excess of the maximum regular number of hours fixed by statute, union contract, or custom.

P

Physical Health –	Of or relating to the body.

R

Rehabilitation Time -	The restoration of, or improvement in, an employee's health and ability to perform the functions of his or her job.

S

Sleep Deprivation -	A shortage of quality, undisturbed sleep that results in detrimental effects on physical and mental well-being. Exhaustion, fatigue and lack of physical energy are common sleep deprivation symptoms.

Appendix 7.2

2006

WINDSOR FIRE DEPARTMENT
48 HOUR WORK WEEK
COMMENCED SUNDAY, DECEMBER 3, 1961

GROUPS WORK	SCHEDULE	SUN	MON	TUE	WED	THU	FRI	SAT
DEC 4 – DEC 10, 2005	AUG 6 - AUG. 12	1 - 2	3 - 4	5 - 6	7 - 1	2 - 3	4 - 5	6 - 7
DEC 11 - DEC 17, 2005	AUG 13 - AUG 19	3 - 4	5 - 6	7 - 1	2 - 3	4 - 5	6 - 7	1 - 2
DEC.18 - DEC 24, 2005	AUG 20 - AUG 26	5 - 6	7 - 1	2 - 3	4 - 5	6 - 7	1 - 2	3 - 4
DEC.25 - DEC.31, 2005	AUG 27 – SEPT 2	7 - 1	2 - 3	4 - 5	6 - 7	1 - 2	3 - 4	5 - 6
JAN 1 – JAN 7, 2006	SEPT 3 – SEPT 9	2 - 3	4 - 5	6 - 7	1 - 2	3 - 4	5 - 6	7 - 1
JAN 8 – JAN 14, 2006	SEPT 10 - SEPT 16	4 - 5	6 - 7	1 - 2	3 - 4	5 - 6	7 - 1	2 - 3
JAN. 15 – JAN 21, 2006	SEPT 17 - SEPT 23	6 - 7	1 - 2	3 - 4	5 - 6	7 - 1	2 - 3	4 - 5
JAN. 22 – JAN 28, 2006	SEPT 24 - SEPT 30	1 - 2	3 - 4	5 - 6	7 - 1	2 - 3	4 - 5	6 - 7
JAN. 29 – FEB 4	OCT 1 – OCT 7	3 - 4	5 - 6	7 - 1	2 - 3	4 - 5	6 - 7	1 - 2
FEB 5 - FEB. 11	OCT 8 – OCT 14	5 - 6	7 - 1	2 - 3	4 - 5	6 - 7	1 - 2	3 - 4
FEB 12 - FEB. 18	OCT 15 - OCT 21	7 - 1	2 - 3	4 - 5	6 - 7	1 - 2	3 - 4	5 - 6
FEB 19 – FEB 25	OCT 22 – OCT 28	2 - 3	4 - 5	6 - 7	1 - 2	3 - 4	5 - 6	7 - 1
FEB 26 – MAR 4	OCT 29 – NOV 4	4 - 5	6 - 7	1 - 2	3 - 4	5 - 6	7 - 1	2 - 3
MAR 5 - MAR. 11	NOV 5 - NOV 11	6 - 7	1 - 2	3 - 4	5 - 6	7 - 1	2 - 3	4 - 5
MAR 12 – MAR 18	NOV 12 – NOV 18	1 - 2	3 - 4	5 - 6	7 - 1	2 - 3	4 - 5	6 - 7
MAR 19 – MAR 25	NOV 19 – NOV 25	3 - 4	5 - 6	7 - 1	2 - 3	4 - 5	6 - 7	1 - 2
MAR 26 – APR 1	NOV 26 – DEC 2	5 - 6	7 - 1	2 - 3	4 - 5	6 - 7	1 - 2	3 - 4
APR 2 - APR 8	DEC 3 – DEC 9	7 - 1	2 - 3	4 - 5	6 - 7	1 - 2	3 - 4	5 - 6
APR 9 – APR 15	DEC 10 – DEC 16	2 - 3	4 - 5	6 - 7	1 - 2	3 - 4	5 - 6	7 - 1
APR 16 – APR 22	DEC 17 – DEC 23	4 - 5	6 - 7	1 - 2	3 - 4	5 - 6	7 - 1	2 - 3
APR 23 – APR 29	DEC 24 – DEC 30	6 - 7	1 - 2	3 - 4	5 - 6	7 - 1	2 - 3	4 - 5
APR 30 – MAY 6	DEC 31 – JAN 6, 2007	1 - 2	3 - 4	5 - 6	7 - 1	2 - 3	4 - 5	6 - 7
MAY 7 – MAY 13	JAN 7 – JAN 13, 2007	3 - 4	5 - 6	7 - 1	2 - 3	4 - 5	6 - 7	1 - 2
MAY 14 - MAY 20	JAN 14 – JAN 20, 2007	5 - 6	7 - 1	2 - 3	4 - 5	6 - 7	1 - 2	3 - 4
MAY 21 - MAY 27	JAN 21 – JAN 27, 2007	7 - 1	2 - 3	4 - 5	6 - 7	1 - 2	3 - 4	5 - 6
MAY 28 – JUNE 3	JAN 28 – FEB 3, 2007	2 - 3	4 - 5	6 - 7	1 - 2	3 - 4	5 - 6	7 - 1

JUNE 4 - JUNE 10	FEB 4 – FEB 10, 2007	4 - 5	6 - 7	1 - 2	3 - 4	5 - 6	7 - 1	2 - 3
JUNE 11 - JUNE 17	FEB11 – FEB 17, 2007	6 - 7	1 - 2	3 - 4	5 - 6	7 - 1	2 - 3	4 - 5
JUNE 18 - JUNE 24		1 - 2	3 - 4	5 - 6	7 - 1	2 - 3	4 - 5	6 - 7
JUNE 25 – JULY 1		3 - 4	5 - 6	7 - 1	2 - 3	4 - 5	6 - 7	1 - 2
JULY 2 – JULY 8		5 - 6	7 - 1	2 - 3	4 - 5	6 - 7	1 - 2	3 - 4
JULY 9 - JULY 15		7 - 1	2 - 3	4 - 5	6 - 7	1 - 2	3 - 4	5 - 6
JULY 16 - JULY 22		2 - 3	4 - 5	6 - 7	1 - 2	3 - 4	5 - 6	7 - 1
JULY 23 - JULY 29		4 - 5	6 - 7	1 - 2	3 - 4	5 - 6	7 - 1	2 - 3
JULY 30 – AUG 5		6 - 7	1 - 2	3 - 4	5 - 6	7 - 1	2 - 3	4 - 5

Appendix 7.3

24-hour Shift Schedule

24 hr - 2 off - 24 hr - 7 off - 24 hr - 1 off - 24 hr - 2 off - 24 hr - 2 off- 24 on - 2 off -24 hr - 5 off

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Week 1	C	D	A	C	B	A	B
Week 2	D	A	B	D	C	B	C
Week 3	A	B	C	A	D	C	D
Week 4	B	C	D	B	A	D	A

Appendix 7.4

24 hr PILOT PROGRAM **DAILY AGENDA**

Duty Officer's Name	Employee ID	Date
Station	Platoon	

6:30 – 7:30	E-PESC E-FLAG E-RAD(U) E-GENE E-OXYG E-DEFI Ensure equipment is on truck
7:30 - 8:30	E-IMSM A-CLEA(Appendix) E-PSAW A-AIR(W) A-AIR(D) E-CUTT A-PUMP F-DUTY - change Duty Officer (***P-EVAL – a reminder)*** A-DRI(L)
8:30 – 10:00	Firefighting Training, Tactics and Operational Drills
10:00 – 11:30	E-FIR E-PSAW operational check power saws A-AER(I) – tested operational the beginning of each tour E- HYDRO – inspect gloves if applicable E-THER F-FUEL F-BIOH – Duty Officer inspects Bio Hazard container F-CLEA(Hall as per Mon. Appendix)
11:30 – 13:00	Lunch
13:00 - 15:00	Training to be continued or building audits/pre-fire planning, district familiarization, school or building fire drills etc.
15:00 – 16:00	Physical Fitness training or Hall Duties if not Exercising
16:00 - 18:00	Flextime – to allow daily schedule adjustments due to calls E-PEBU - inspect bunker gear first shift first tour of calendar month ☐
18:00 – 19:00	Dinner
19:00 – 21:00	Evening Training, stand by time for emergency calls, programs
21:00 – 06:00	Stand-by time for emergency calls, recreation, rest and rehabilitation. Occasionally night training simulations/tours and other operational readiness exercises i.e. Subway tours etc.
Comments – why tasks not completed	

Appendix 7.5

A Hard Day's Night

by Michael Brewer, Med, EMT-P, & Clyde Deschamp, PhD, EMT-P

Journal of Emergency Medical Services - MAY 2006

Every EMS provider knows that emergencies don't always occur conveniently within normal work hours. We're required to respond at any time of the day or night and on weekends and holidays. As a result, EMS personnel must be on duty at all times. That requirement makes shift work and essential component of EMS practice.

Like in other processions, many EMS agencies use shift scheduling in order to meet the 24/7 demand for their services. Many pro-hospital personnel, therefore, find themselves working during nonconventional hours – time outside of the normal 8am to 6pm workday range – and a variety of shift lengths, ranging from eight hours to extended shifts lasting 72 hours or more.

Often, especially in the case of extended shifts, providers don't get adequate rest while on duty but are still expected to perform at their best. Time off between shifts varies, but in some cases may not allow for adequate recovery. In both scenarios, the end result is fatigue and sleep debt, which together are known to have serious consequences.

Working nonconventional hours isn't always bad. For many, shift work allows for greater flexibility; evening and night shifts allow more free daytime hours for personally or family time, and longer shifts may permit more time off between shifts. Also, many organizations offer some type of pay incentive to employees working shifts outside of normal work hours. Still, a shift worker's ability to enjoy the "advantages" of shift work may be diminished if they're not able to adapt to this type of work.

The ability to work nonconventional hours without experiencing problems is, in some cases, possible. A person's ability to modify their body's sleep/wake cycle, a process known as *circadian adaptation,* is well document, but is usually very slow and may take several days or weeks. [1,2] Individuals who are able to adjust are usually those who work nonconventional hours on a permanent basis. [3] The authors reporting the ability to adapt, however, make it very clear that the majority of individuals are *not* able to adjust their sleep/wake cycle and will almost always experience negative effects. [1,2,4]

When adjustment to the nonconventional work hours is slow or not possible at all, the individual may quickly begin suffering from fatigue. Such shift-work-induced fatigue (SWIF) is known to have negative effects at individual and organizational levels. [5] Moreover, the effects of shift work alone are exacerbated by the hectic and demanding nature of EMS. Although little research has investigated the effects of shift work on EMS personnel specifically, much available data does describe the individual and organizational effects in similar professions – and the findings are not encouraging.

IMPLICATIONS FOR THE INDIVIDUAL

Researchers have found that about 25% of the North American population is composed of shift workers. [6,7] It's estimated that 20% of that group can't tolerate shift work. [5,7] Many individuals, however, continue to work shifts outside of "normal" work hours for reasons ranging from lack of other available shift times to the need for time off during daytime hours.

Regardless of the reason, immediate and long-term negative effects are associated with shift work. It's well-documented that individuals who are not able to adjust to shift work are at increased risk for developing conditions that present a serious detrimental risk to their health and well being, including problems with sleep, physical health, and social and mental well-being. [8-10]

Sleep: A person's circadian physiology involves natural periodic variations in sleep, vital signs, digestion, hormones, feelings and behavior. [6,11,12] Our bodies have a natural "clock", located in the hypothalamus, which is linked to other physiological mechanisms, such as the secretion of the hormones melatonin and cortisol. Together, these structures and biochemicals mediate the sleep/wake cycle and are known to respond to internal and external cues, including social activities, food, exercise and light/day cycles. [7,13]

Rotating or alternating work shifts desynchronizes our cues and cycles, alters our physiology and changes the way we feel. In most individuals, shift work disrupts natural circadian rhythms and interferes profoundly with sleep. [10,14] In those affected, this interference manifests as poor sleep and chronic fatigue. [15-17]

Documentation shows that most shift workers have sleep problems. In fact, night shift workers sleep, on average, 25-33% less than day or evening shift workers and have poorer sleep quality. [9,19] A number of factors, including daytime distractions (eg., phone calls, noise, sunlight and visitors) and lack of the deepest stage of sleep (know as rapid eye movement, or REM), lead to chronic and cumulative sleep debt. [9,15] (*Editor's note:* For more on the stages of sleep and how your body responds to each, read From the Editor, "Dead Tired" February 2005 *JEMS*, available online at www.jems.com/jems/23-2).

Conventional wisdom once held that a person's circadian rhythms could essentially be reset, but contemporary research has demonstrated that this is generally untrue. [15, 17, 20]

It's now well known that individuals working fixed shifts during nonconventional hours may eventually suffer from a sleep disorder known as "shift work syndrome." [15,21] The effects of this phenomenon are more pronounced in people older than 40 years of age and in women,who often tend to their children and do family chores after their shifts. [11,22]

Physical health: When the body lacks sufficient recovery periods, shift-work-induced sleep disturbances and the resulting SWIF often lead to physical and mental health problems. In addition to fatigue, shift workers have higher rates of alcoholism, drug abuse, smoking and caffeine intake. [6,8,11,20,23] They also have higher rates of motor vehicle trauma and occupational trauma, [6,24] and are prone to a wide range of physical illnesses, including peptic ulcer disease and other gastrointestinal complaints, immune dysfunction, and infertility. [6,7,15,20,25,27]

Shift work is also known to exacerbate diabetes, epilepsy and sleep disorders. [15,18,27] Perhaps of most concern is the fact that shift work has been shown to increase rates of cardiovascular disease (CVD) and cardiac mortality. [28,29] Even after controlling for other risk factors and confounding variables, data shows that CVD rates rise with exposure to shift work. The risk of shift work has been equated to the risk of smoking one pack of cigarettes per day.

How can working nonconventional hours have such substantial effects on our health? One reason is that shift work is thought to induce increased secretion of stress hormones and cause changes in such factors as blood pressure, heart rate, coagulation, and lipid and glucose metabolism. [30] These factors, in turn, are known to cause CVD. In a paper published in 1999, 17 studies on shift work and CVD were reviewed. In reviewing all of these studies, it was concluded that shift workers had a 40% excess risk for CVD compared with individuals who work during normal daylight hours. [31]

Further, women seem to experience unique physical problems related to shift work, including abnormal hormone secretion, birth complications and interference with menstrual function. [31,32] Several studies have been conducted that examined the effects of shift work on pregnant females working in the nursing profession. A report in the *Journal of Clinical Nursing* found that secretion of the hormone prolactin is altered in nurses working nonconventional hours and may be related to the reported sleep disturbance and GI symptoms. [26]

Many studies have also shown significant relationships between shift work and birth complications, such as low birth weight, preterm birth and spontaneous abortion. [26,31] Further, a group of researchers found a significant increase in changes in menstrual cycle function and a higher incidence of painful menstruation among female nurses working nights and rotating shifts. In the study, those reporting changes in menstrual function also reported significantly more sleep disturbances. [32]

Social and Mental Health: In addition to the many documented physical effects of fatigue induced by shift work, the literature is full of studies documenting associated mental and social effects. Like the physical effects discussed, the mental and social effects may also have significant consequences. Social problems can be attributed to shiftwork due to individuals missing the critical window for social activities that occur between 4pm and 12am. [33] People working during these hours may experience adjustment problems in such areas as attitudes toward both home and work life. Research specific to the social effects of shift work on men show an increase in solitary activities because these activities are more flexible in terms of time and don't conflict with working hours.

Disruptions in circadian rhythms lead to mood changes, such as irritability, feelings of stress and fatigue, and relationship difficulties. [23] In the longer term, shift work has been associated with higher rates of substance abuse, depression, divorce, suicide, burnout and leaving an occupation altogether. [6,26,35,36]

Along with burnout, a study of nurses working nonconventional shifts found a greater incidence of depersonalization as a social effect of shift work. *Depersonalization* has been defined as "the tendency to cynically deindividualize patients and to treat them like objects" [26] The potential effects of depersonalization are serious, especially in an era of health care when the interpersonal aspects of patient care are paramount.

IMPACT ON THE ORGANIZATION

The vast majority of publications available on the effects of shift work focus on the physical and mental/social issues. The effects, however, are not isolated to individuals. As workers begin to experience the physical, mental and social effects of shift work, it's only a matter of time before the organization as a whole becomes affected.

An organization is only as strong as the individuals that form its core. Most health professions, including EMS, are collectively known as helping occupations and, as a result, are dependent on competent and caring practitioners to provide services to patients. Research on physicians and nurses has shown a clear relationship between the effects of shift work – fatigue, sleep debt and physical ailments – and negative effects on organizational areas, including risk management and organizational effectiveness, both of which have direct effects on patient care.

Risk management: Fatigue from long work hours, sleep deprivation and circadian disruption has been recognized as a substantial cause of serious human errors.[37] Human error due to fatigue has been implicated as the cause of transportation-related accidents, including plane crashes, train derailment and highway MVCs. It has also been implicated in large-scale disasters, such as the incident at Three Mile Island, the Chernobyl meltdown and the grounding of Exxon Valdez.[37,38] Although events of this magnitude have not occurred in EMS, the possibility of EMS errors and accidents is haunting.

Medical error has become a top priority in health care during the past decade, in part because of increased research and media coverage. As a result, health-care organizations have attempted to implement policies and procedures aimed at reducing the incidence of medical error. The research literature for health-care occupations, primarily for nurses and physicians, cites fatigue as a significant cause of medical error.

For example, an article in the New England Journal of Medicine reported that when it comes to the cause of medical errors, the public and physicians have agreed that fatigue of health professionals was a factor.[39]

A number of other studies of physicians have reported a significant increase in medical errors as a result of fatigue. In the early 1970s, researchers reported that interns made almost twice as many errors reading ECGs after an extended shift than after a night of sleep.[40] More recent studies have found that surgical residents made up to twice the number of technical errors in the performance of simulated surgical skills after working overnight than after a full night of sleep.[41,42]

In a study of intensive care unit (ICU) physicians, researchers found that these physicians made significantly more medical errors during extended shifts than during non-extended shifts.[43] Finally, another study compared the number of medical errors made by physicians when working more than 80 hours per week with the number of errors made when working less than 80 hours and found significantly fewer errors were made during the shorter workweeks.[44]

Although little U.S. research describes the impact of fatigue on EMS medical errors, research findings from other health-care occupations make a strong case for this correlation. It's reasonable to assume that specific EMS-related research would show fatigue as a significant cause of medical error in prehospital medicine as well.

Worker fatigue that results from shift work and nonconventional work hours is also known to compromise workplace safety and increase accidents.[13] A study of the effects of shift work on firefighters found that most accidents occurred during night shifts, between the hours of 10pm and 2am.[45] Other studies of a variety of occupations have shown slower and less accurate performance and an increased frequency of injuries during night and extended shifts. [23]

One study in particular showed that sleep deprivation of 24 hours can result in dangerous performance levels equivalent to those of a blood alcohol level of 0.10%. The study also showed that low performance levels are reached sooner in older individuals. [46] Overall, the study authors assert that environments involving "shift work should be viewed and managed as a hazardous place to work. " [47]

Effects on driving: Fatigue as a result of working long or odd shifts is also known to have profound effects on an individual's ability to drive. This fact should be of tremendous concern to those in EMS, because driving, often under hazardous conditions, is a key component of the services provided. In a study analyzing vehicle crashes among physicians, interns, researchers found that the odd of an intern being involved in an MVC after an extended work shift (<24 hours) were more than double the odds after a nonextended shift.

Researchers in the same study found that near-miss incidents were more than five times as likely to occur after an extended shift than after a non-extended shift. These findings further emphasize the fact that sleep deprivation degrades an individual's performance and increases an organization's liability for the person's actions.

The effects of combining sleep deprivation and driving also have potentially profound legal implications for individuals and organizations. The legal precedence has already been established in the United States and Great Britain for individuals found guilty of vehicular homicide in cases of driving while impaired by fatigue. [48-50]

Some states are in the process of amending reckless driving laws to include impairment by fatigue. Most notable, however, are two appellate courts in the United States that ruled that an employer's responsibility for fatigue-related crashes can continue even after an employee has left work. [51,52]

Sleep-deprived staff members are at increased risk for making mistakes and becoming involved in accidents. Because the organization holds ultimate responsibility for the actions of its employees, this is clearly a risk management issue. As the link between rotating shifts and compromised performance continues to build, employers will almost certainly be forced to assume more responsibility for fatigue-related problems.

Organizational efficiency: The issue of workforce recruitment and retention has been cited as one of the top seven EMS problem areas. Irregular hours are cited as a major reason why employees leave many health occupations, including some that are similar to EMS. (eg. Nursing and emergency medicine). [14] According to one study, employees who achieve a match between their preferred and actual schedule are more likely to be satisfied with and remain at their jobs. [54]

Little has been written concerning the impact of nonconventional work hours on absenteeism and presenteeism. Presenteeism is the practice of coming to work and only doing what is absolutely necessary in order to maintain a job. This trend may be seen in employees who are too exhausted to contribute to the organization in a meaningful way. In EMS, it may manifest through limited interaction with patients and coworkers, poor documentation and a stagnant learning mode, all of which detract from overall organizational performance and efficiency.

CONCLUSION

EMS plays an important role in our health-care system, and personnel must be available around the clock, making shift work a necessity. But shift work is known to lead to major health and wellness problems and has been a concern for shift workers in health-care professions for many years. Although little research has specifically focused on shift work and EMS, the finding in other health professions should emphasize shift work as a major concern for EMS personnel who already must endure the challenges of a high-stress job. Because working conventional hours is often not an option, EMS personnel must be aware of this potential adverse effects of shift work and employ sound strategies to minimize them. (*Editor's note:* For practical tips on how to curb the effects of shift work, read "Effects of Shift Work, Sleep Deprivation & Stress," a sidebar to the "2004 JEMS Salary & Workplace Survey," October 2004 JEMS, available at www.jems.com/resources/surveys/.)

EMS administrators must also recognize the potential effects of shift work on the organization. In the current healthcare environment in which administrators must take a proactive approach to preventing errors and accidents, the effects of SWIF cannot be ignored. Scheduling practices may warrant change in order to reduce fatigue while practitioners are on duty. Administrators must also recognize the impact that shift work has on the effectiveness of the organization in terms of staffing, employee retention and risk management.

Last, the effects of shift works on EMS personnel must become a subject of intense research in the field, as it has in other parts of the health-care spectrum. Only then will EMS as a profession understand what problems as a result of shift work are common or unique to the field and develop sound and safe ways of addressing them. In the interim, we must rely on the data produced by other healthcare professions and learn from their research and experience.

Michael Brewer, Med, NREMT-P, is an assistant professor and director of nontraditional EMT programs in the Department of Emergency Medical Technology at the University of Mississippi Medical Center. Contact him at mbrewer@shrp.umsmed.edu.

Clyde Deschamp, PhD, NREMT-P, is associate professor and chair of the Department of Emergency Medical Technology at the University of Mississippi Medical Center and executive director of the Central Mississippi EMS District. Contact him at cdeschamp@shrp.umsmed.edu.

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FIRE FIGHTER HEALTH AND SAFETY

Linda K Glazner DrPH RN COHNs CCM FNP CHES FAAOHN

OBJECTIVES

- By the end of this portion of the program, the participant shall be able to:
- Describe pertinent health and safety issues of fire fighters related to shiftwork
- Describe the positive health and safety effects of shiftwork
- Describe the negative health and safety effects of shiftwork
- Discuss actions individuals can take to minimize the negative effects

DEFINTIONS

- SHIFTWORK (working anytime outside 9AM-5PM)
- NIGHTWORK (working at night)
- SHIFT SCHEDULES (Rota) (For firefighters 10/14 and 24)
- MORNINGNESS/EVENINGNESS
- HEALTHY WORKER EFFECT

BACKGROUND

- In 2000, approximately 21 million people were engaged in some form of shiftwork
- Our body us controlled by circadian rhythms (cyclic patterns of biological and behavioral rhythms controlled by the biological clock) which are usually about 24 hours.
- Disruption of our circadian rhythm leads to desynchronization.
- Desynchronization is what makes people not feel well, have physical and psychological stress, not sleep well and perform less well at work.

ISSUES RELATED TO SHIFTWORK

- Alteration of sleep patterns; sleep deficit; continual complaints of sleepiness and fatigue.
- Psychological stress: increased divorce and separation; work-homelife disruptions.
- Increase workplace injuries and accidents in the night shifts (although some studies have shown yes and some studies have shown no)
- Some people adjust easier than others
  - youth
  - morningness

EVENINGNESS QUESTIONNAIRE

- 1.Do you prefer:
  - A. the morning to do work that requires the most thinking
  - B. the evening to do work that requires the most thinking
- 2.Do you prefer:
  A . to go to bed early
  B. to sleep late in the morning
- 3. If you don't get enough sleep on one night, do you feel:
  - A. tired all day and want more sleep
  - B. tired, but can function as needed
  - C. it is no problem

ISSUES RELATED TO SHIFTWORK, 2

- Negative health effects of shiftwork include:
  - Gastrointestinal disorders
  - Cardiovascular disorders
  - Reproductive irregularities
  - Exacerbation if existing disorders (i.e. asthma, diabetes, epilepsy and drug and alcohol use)

PREFERENCES

- If you answered:
- Yes to 1A, 2A and 3A you are morning-like
- Yes to 1B, 2B and 3B you are evening-like
- Yes to 3C you are neither morning-like nor evening-like
- Mixed for 1 and 2, you are neither morning-like nor evening-like

ISSUES RELATED TO SHIFTWORK, 3

- Shift workers and in particular, rotating shiftworkers, have a higher incidence of sick leave, more frequent visits to health care facilities at the work site and, in general, have more health complaints than day workers. (Glazner, L 1994)

WHY IS SHIFTWORK PROBLEMATIC

- Circadian rhythm
- Fatigue

CIRCADIAN RHYTHM

- 24+ hour body cycle
- Characteristic of all living things
- Follows external light as well as internal
- Sine wave

FATIGUE

- Sleepiness undermines your ability to assess fatigue accurately. You may be more tired than you think if you:
- Have disruptions in memory
- Find yourself reading and rereading
- Frequently face doing tasks you thought you already had completed

FATIGUE SCALE

- I feel worn out.
- I feel energetic
- I feel slowed down in my thinking
- I do quite a lot within a day
- I have trouble concentrating
- I feel drowsy
- Physically, I feel in good shape
- I have low output
- I have trouble with my memory
- I feel rested
- I can concentrate well (Iowa Fatigue Scale)

WHAT SHIFT DO FIRE FIGHTERS WORK (US)

- 70% of US Firefighters work 24 hour shift
- 19 of the 25 largest US fire departments work 24 (i.e. Chicago, LA, DC, Houston, Detroit)
- Allow 24 hour exchange (NYC, Baltimore, Philadelphia)
- In the last 5 years the ratio of FDs in MA on 24 increased for 1/3 to _ and NJ almost to 100%

WHAT SHIFT DO FIRE FIGHTERS WORK (CAN)

- 24 hour shifts (Halifax, Nova Scotia; Fredericton, NB) (Windsor, London and Kingston , ONT)
- Northeastern US/Can is the last region to adopt 24 hours
- Large western departments allow 24 hour exchanges

HEALTH AND SAFETY IN THE FIRE SERVICE

- ALL SHIFT PATTERNS
- 10 HOUR SHIFT PATTERN
- 24 HOUR SHIFT PATTERN

ALL SHIFT PATTERNS*

- High injury rate (27-50%)
- Negative impact on the immune system (high illness absenteeism)
- Presumptive cardiac and respiratory disease
- Heart rate higher while sleeping at fire hall than at home (Pealo&Nancarrow)
- Post Traumatic Stress disorder increase with fatigue (Nickle)
- Marriage/divorce/parenthood similar to general US population
- *All statistics are Glazner unless otherwise stated

10 HOUR SHIFT PATTERN

- Cumulative fatigue
- Injuries (50%) at the fire ground
- Injuries at the beginning of the shift
- Disruptions of the sleep/wake cycle
- Higher level of desynchronization (Motohashi)
- Higher rate of heart attacks (NIOSH)
- Low satisfaction scores on a variety of lifestyle questions

24 HOUR SHIFT PATTERN

- Injuries (27%) related to training
- Better opportunity for detoxification
- High satisfaction scores on a variety of lifestyle questions

GOOD EFFECTS OF SHIFTWORK

- more pay.
- group of people work the same shift and socialize when others are sleeping.
- no lines when they go shopping, to the bank or visit their health care providers.
- fewer supervisors around

PROMOTING ADJUSTMENT TO SHIFTWORK

- Work schedule design (shift rotation factors)
- Sleep scheduling (prophylactic naps; replacement and maintenance sleep)
- Environmental stimuli (ambient temperature; bright light)
- Physical activity and conditioning
- Pharmacologic aids(OTC; melatonin; Rx drugs; illicit drugs)
- Diet
- Individual behavioral techniques
- Special challenge for women

do what you need to get sleep

- Minimize sunlight exposure on your way home after work by wearing dark glasses. Sunlight has an alerting effect making daytime sleep shorter and less restful.
- Find a place at home for restful sleep
- Use foods containing tryptophan to encourage sleep after work
- Don't use melatonin (melatonin is a hormone. You wouldn't take insulin just because, so don't take melatonin)
- Find a sleep/wake cycle that best fits you
- Decrease caffeine use

FOODS HIGH IN TRYPTOPHAN

- Buttermilk
- Chicken
- Cottage Cheese
- Eggs
- Halibut
- Ice cream
- Lima beans
- Liver
- Macaroni
- Milk
- Nuts
- Oatmeal
- Parmesan cheese
- Peanut butter
- Rice
- Tuna

DRUGS HIGH IN CAFFEINE

- Dexatrim
- Vivarin
- Cafergot
- Migralam
- No-doz
- Excedrin
- Migral
- Fiorinal
- Anacin
- Bromo-seltzer
- Cope
- Vanquish

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E resources for shiftwork

http://www.cdc.gov/niosh/pdfs/97-145.pdf plain language about shiftwork manual

http://www.cdc.gov/niosh/docs/2004-143/ overtime and extended hours

http://www.findarticles.com/p/articles/mi_m0ISW/is_2003_April/ai_99164870

http://www.biomedcentral.com/content/backmatter/1476-069X-2-14-b1.pdf

http://www.fireinternational-mag.com/shownews.asp?secid=8&nav=1&newstype=&key=&page=&newsid=8062

Schedules

- Avoid permanent (fixed or non-rotating) night shift.
- Keep consecutive night shifts to a minimum.
- Avoid quick shift changes.
- Plan some free weekends.
- Avoid several days of work followed by four- to seven-day
- "mini-vacations."
- Keep long work shifts and overtime to a minimum.
- Consider different lengths for shifts.
- Examine start-end times.
- Keep the schedule regular and predictable.
- Examine rest breaks.

Appendix 7.6

ELSEVIER

Safety Science 21 (1996) 255–263

safety science

Factors related to injury of shiftworking fire fighters in the Northeastern United States

Linda K. Glazner *

School of Nursing and The Center for Occupational and Environmental Health, University of California at Los Angeles, Los Angeles, CA, USA

Abstract

Fire fighters, who provide society with an essential and life-saving service, are subjected to the effects of shiftwork and to the demands (physical and mental) and dangers of their profession, all of which can contribute to injuries. To identify factors involved in injuries to fire fighters, the timing, frequency, types, and places of occurrence of injuries sustained by fire fighters in three different municipal fire departments were examined. Data was obtained from analysis of Workers' Compensation forms. The most frequent injuries involved inhalation of hazardous materials and lacerations. Ninety-two percent of the injuries occurred at the fire scene, and their causes were related to fire fighting duties, such as rescue, extinguishment and overhaul. Although only 54% of fire alarms nationwide occurred from 12:00 to 16:00 and from 18:00 to 24:00 (42% of a 24 hour day), 68% of the injuries sustained by the fire fighters studied occurred during these time periods. Per alarm, at meal time or on the night shift fire fighters were more likely to be injured. Serious injuries were more prevalent at standardly accepted meal-times. The timing of the highest frequencies of injuries suggests that, due to the shiftwork nature of firefighting, both disruption of eating patterns and fatigue increase the risk of work-related injury to fire fighters. By understanding the contribution of factors, especially human ones, such as altered metabolism (due to disruption) and fatigue (due to time elapsed since awakening, alteration/disruption of sleep–wake pattern, or hypoglycaemia), interventions can be developed, which should decrease the incidence of injuries to fire fighters.

Keywords: Fatigue; Fire fighters; Injuries; Shiftwork; Workers' Compensation

1. Introduction

Fire fighters are repeatedly subjected to rapid, unanticipated transitions from the environment of a fire station to the hostile environment of a fire. The work of fire

* 10833 Le Conte Ave, Los Angeles, CA 90024-6919, USA. Tel: 310 206 3838. Fax: 310 206 7433.

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fighters encompasses periods of crisis, which require intense physical exertion, mental concentration, and a high level of teamwork, as well as, relatively undemanding, and sometimes even calm, periods of time between alarms. The work environment is also unpredictable, and while fighting a single fire, fire fighters are exposed to numerous safety and health hazards, including extremes of heat, sudden shifts from sedentary activity to high-speed and vigorous activity, and to air contaminants. The unpredictable aspects of firefighting, as well as, working shifts, are considered a principal cause of stress and, most probably, of injuries to fire fighters.

Since fire fighters must be available 24 hours a day, most career fire fighters work shifts (Schirmer and Glazner, 1983). Shiftwork is defined as working outside the daytime hours of 9:00 to 17:00. The "10–14" shift schedule, used by some fire departments in the United States, typically involves an average of 42 hours of work per week and an 8 week cycle for each firefighter. The 10 hour shifts are from 8:00 to 18:00 and the 14 hour shifts from 18:00 to 8:00. Another shift schedule, the "24 hour" shift, utilized by fire fighters involves 24 hours of duty followed by 72 hours off. Injury rates, which in the fire service approach 50% (International Association of Fire Fighters, 1985), effect the safety of fire fighters and the efficacy of the nations' fire service . Therefore, to determine factors that contribute to this high industrial injury rate, the timing, relationship to frequency of alarms, types, and places of occurrence of injuries sustained by fire fighters in the Northeastern United States were examined. Fire fighting in the Northeastern United States (i) often involves high-rise apartment buildings with combustible wood and plastic and industrial/chemical fires, and (ii) it is standard procedure for the fire fighters to enter the buildings during fire suppression.

Although comparison of industrial injuries incurred by different groups of workers and the causes for such injuries is difficult, these injuries appear to occur more frequently at certain times of the day, perhaps because worker performance can be effected by disruptions in circadian rhythms (Folkard, 1990). Sub-optimal worker performance, as measured by mistakes or the efficiency and quality of performing tasks, may contribute to work-related injuries. With telephone operators and gas meter readers, clear circadian patterns in the frequency of their mistakes were observed; the greatest number of mistakes occurred during the late afternoon, early hours of the morning, and at the end of the work shift (Bjerner et al., 1955). Experimentally, performance of simple tasks is worse on night than on day shifts, and the first few days after a sleep–wake cycle has been disrupted there is a drop in the efficiency of workers (Colquhoun et al., 1978). Performance is slower (Wojtczak-Jaroszowa, 1976) and less accurate on night shifts (Bjerner et al., 1955; Folkard, 1990), and appears to be accompanied by more injuries at night (Rutenfranz et al., 1985). Price and Hooley (1976) observed a periodicity to the injuries sustained by shiftworkers and suggested that the frequencies of such injuries increases at night, while Tasto and Colligan (1978) observed no statistically significant difference in injury rates among food processors and nurses who worked permanent day, evening, or night shifts. In chemical manufacturing, more injuries occurred to shiftworkers during the day and night shifts, than during the evening shift, however, the reasons for this have yet to be determined (Novak et al., 1990). Therefore, whether there was a periodicity to injuries of fire fighters, i.e., a connection to the shiftwork nature of their job, or if the high rate of injuries could be explained by other demographic, human, or work-related factors was examined in this exploratory study.

2. Methods

To identify factors that contribute to the injury of fire fighters who work shifts (i) all injuries reported on Workers' Compensation forms by the 3 fire companies were examined with regard to the timing, relationship to frequency of alarms, type, and place of occurrence of the injuries, as well as compared to the nationally reported data, and (ii) correlations between the injury experience of the fire fighters studied and selected demographic variables (age, socio-economic status, job title, marital status, and working more than 42 hours a week) were examined.

2.1. Subjects

To obtain participants for this study, a letter explaining the purpose of the study and requesting their participation, as well as, preliminary information, was mailed to the chiefs of 49 career fire departments in a Northeastern state, in cooperation with the Paid Fire Chiefs' Association. Of these 49 invitations to participate and preliminary surveys, 15 were returned, a response rate of 30%. A follow-up letter did not result in an increase in response. In the preliminary surveys, the fire chiefs identified the shiftwork pattern of their department, the number of fire fighters in total, and willingness to participate; information which was used to select departments for actual participation in the study. Of the 15 responding fire departments, only the 3 that had over 50 career fire fighters were chosen for this study. These 3 departments worked a "10–14" shift pattern (Table 1), were in different municipalities, and combined had 447 career fire fighters. They were also representative of the 49 departments in the state with regard to the number of fire fighters employed, their regional (North or South) distribution, and the union affiliation (International Association of Fire Fighters or Firemen's Mutual Benevolent Association) of their fire fighters. Of the 15 fire departments that responded, only 3 worked a "24 hour" shift pattern, so the "10–14" shift pattern of the 3 departments used for the study was also representative for fire fighters in that state.

Table 1
The shift schedule patterns of the participating fire companies

Company	Hours scheduled to work [a]														
	Day	1	2	3	4	5	6	7	8	9	10	11	12	13	etc.
A		10	10	–	14	14	–	–	–	10	10	–	14	14	etc.
B		10	10	10	–	–	–	14	14	14	–	–	–	10	etc.
C		10	10	14	14	–	–	–	–	10	10	14	14	–	etc.

[a] The 10 hour shifts were from 08:00 to 18:00 and the 14 hour shifts from 18:00 to 08:00. Patterns indicated were started on different days for each of the 4 platoons of the companies, to ensure complete coverage.
– indicates that not scheduled to work on that day.

2.2. Collection of data

Information regarding the injuries and demographics of the injured fire fighters was obtained from the First Report of Injury Workers' Compensation forms. This form was used by industrial supervisors in this Northeastern state to report work-related injuries to the Workers' Compensation Bureau. All 171 of the forms filed in 1985 by the 3 fire departments were analyzed to determine the time of occurrence, type, and site of injury and their correlation to demographic variables. The time of occurrence of 165 of these injuries could be assigned to a 2-hour period of the day.

2.3. Analysis

Analysis methods for this descriptive study included frequency distribution, chi square, and one-way analysis of variance (ANOVA) of the data obtained from Workers Compensation forms of 3 fire companies, and comparison of this data with national statistics for fire fighters in the United States.

3. Results

The distribution of injuries, as reported on the First Report of Injury forms by the 3 departments, varied over the 24 hours of the day, with the highest frequencies of injuries (27.8% and 40.6%) occurring from 12:00–16:00 and from 18:00–24:00, respectively (Fig. 1). These time periods, while representing only 42% of a 24-hour period, accounted for 68% of the recorded injuries and, nationwide, 54% of the alarms. Per shift, the hourly average percentage of the total injuries was 3.8 for the 14-hour night

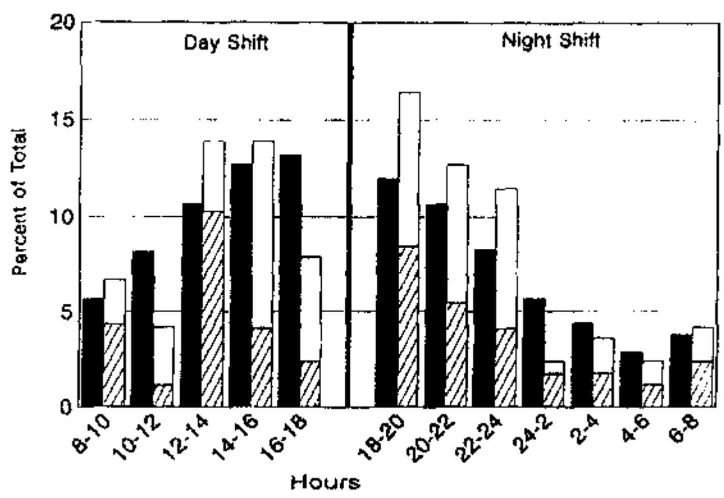

Fig. 1. Injuries and alarms by 2 hour periods. Alarms (solid bars), minor injuries (% of total; open bars), and serious injuries (% of total; hatched bars).

shift and 4.7 for the 10 hour day shift, a difference that was not significant. Since the time distribution of the alarms in the Northeastern state for the period in question was not available, the national data for alarms was used to calculate the injury per alarm values for this study. In the year of the study, nationwide, the hourly average percentage of alarms was 5.1 during the day shift (8:00–18:00) and 3.6 during the night shift (18:00–8:00). There appeared to be, based on percent total of each, an average hourly injury/alarm ratio of 0.92 for the day shift, compared to 1.06 for the night shift. Overall, the correlation (0.8) between alarms and injuries was high. Also, large fires were not observed to have preferentially occurred at any particular time of the day, but rather to have been randomly distributed over the 24 hour period.

Serious injuries were defined as injuries that require more than first aid, i.e., heat exhaustion, fractures, inhalation of hazardous materials, over exertion, and shortness of breath. The incidence of serious and minor injuries reported was about equal, 48 versus 52%. At 8:00–10:00, 12:00–14:00, and 16:00–18:00, 2, 3, and 2 times as many serious as minor injuries were reported. More minor than serious injuries were reported at 10:00–12:00, 14:00–18:00, and 20:00–24:00. However, these differences were not significant, since the number of injuries (serious and minor) reported in these 6 time periods were relatively low.

The injuries reported on the First Report of Injury forms by the 3 fire departments in 1985 were compared to those sustained by fire fighters nationwide (Table 2). While the overall injury rate (38%, 171 injuries per 447 individuals) in the fire fighters studied was lower than the nationwide rate (47%), their percentage of serious accidents (47%) was 3.4 times the national average. Nearly a quarter of the fire fighters studied were seriously injured as a result of their firefighting duties that year. The percentages of serious injuries and of lacerations sustained by the fire fighters studied were significantly different ($p \geq 0.05$) from those of fire fighters nationwide.

All three companies appeared to have an epidemic of injuries on one or more consecutive days. When the primary data was examined, for each fire company participating in this study, this "epidemic" of injuries occurred during one exceptionally large fire that took several days to extinguish and for which fire fighters were called in for duty, even if it was not their assigned shift.

The scene of the fire was the site at which the most injuries occurred (Table 2), both for the fire fighters studied and nationwide. However, the incidence of injuries occurring at the fire house in the studied fire fighters was significantly ($p \geq 0.05$) less than nationwide, probably because 24% more injuries occurred at the fire scene. The occurrence of injuries at sites other than the fire scene and fire house was low nationwide and was not reported on the First Report of Injury forms in the Northeastern state at the time of the study, therefore differences in the frequencies of injuries at these sites could not be assessed.

In this study, the injured fire fighters were male line fire fighters between 20 and 69 years of age. The majority of them were married, were middle class, and/or worked more than an average of 42 hours per week. ANOVA identified no significant relationship between the injuries of the surveyed fire fighters and their age, socio-economic status, marital status, job title, or working more than an average of 42 hours a week. During all shifts and at all times during each shift period, including meal times

Table 2
Injuries of the firefighters studied and nationwide in 1985

	Percent of total	
	Studied ($N=171$)	Nationwide ($N=107{,}000$)
Type of injury		
Inhalation of hazardous material	33	12
Sprains, strains, or pain	16	39
Lacerations [b], including contusions, abrasions, or bruises	10	22
Other	7	7
Over exertion	5	NA
Non-inhalation of hazardous material	5	3
Back, neck, or knee injuries	4	NA
Stabs or punctures	2	NA
Soreness, swelling, or numbness	2	NA
Eye injuries	4	5
Fractures	4	2
Heat exhaustion	3	2
Shortness of breath	2	NA
Burns	2	8
Cardiac abnormalities	1	1
Injuries due to cold	0	< 1
Serious injuries [b,c]	47	14
Injury site		
Fire scene	92	68
Fire house [b]	4	13
To/from fire	2	6
To/from false alarm	NA	< 1
While training	NA	3
While performing physical fitness exercises	NA	3
Assaulted at any location	NA	< 1
Other	2	8

NA = No available data.
[a] Source: International Association of Fire Fighters, 1985.
[b] Differences between the 2 groups are significant, $p \geq 0.05$.
[c] Serious injuries include heat exhaustion, fractures, inhalation of hazardous materials, over exertion, and shortness of breath.

and night shifts, the same number of fire fighters were on duty and available. Therefore, variations in the rate of injury also does not appear to be due to the availability of fire fighters.

4. Discussion

Injuries are predictable entities with known risk factors and can be effectively prevented by primary prevention. To lower the high injury rate of fire fighters, interventions must be adopted that will assist the fire fighters to (i) minimize detrimental effects due to their work schedules, (ii) cope with the dangerous situations their work subjects them to, and iii) minimize their exposure to harmful agents (Haddon and Baker, 1981; Glazner, 1991). To effectively achieve these goals, factors that contribute to the injury of fire fighters, who are shiftworkers, must be identified.

The conditions experienced by fire fighters are highly variable over 24 hours, therefore there is not an equal probability of an accident occurring at any particular time. As with other types of shiftworkers (Tasto and Colligan, 1978, Novak et al., 1990), the work-related injuries of the fire fighters studied occurred more frequently at certain times of the day (Fig. 1). An apparent circadian pattern to the alarms, with a peak at 16:00–18:00 and a trough at 4:00–6:00, corresponded to the presumed activity of the general populace at these times. However, a circadian pattern of injuries sustained by the fire fighters was not observed. In this study, the highest percentage of injuries and second highest percentage of alarms occurred at the beginning of the night shift, i.e., at 18:00–20:00. This high incidence of injury could be due to disruption of eating. In fact, the main meal of the fire fighters studied was the evening meal. There was also a high incidence of injuries at 12:00–16:00 and at 20:00–24:00. The timings of the high frequencies of injuries to the fire fighters contrast with reported increased incidence of injuries at the end of shifts and in the early morning hours of the day shift for other types of shiftworkers (Bjerner et al., 1955; Colquhoun et al., 1978). This may be because the frequency of injury correlated highly (0.8) with the frequency of alarms. With the studied fire fighters, 29% of the injuries occurred during meal times (12:00–14:00 and 18:00–20:00), even though only 23% of the alarms nationwide occurred during these same times, which suggests that disruption of eating patterns can contribute to an increased incidence of injury.

Although the hourly average percentage of total injuries incurred by the fire fighters during day and night shifts (4.7 and 3.8) was similar, the average hourly injury/alarm ratio was higher on the night shift (1.06 versus 0.92), a difference that is significant ($p \geq 0.05$). This supports that shiftworkers were more likely to be injured at night (Bjerner et al., 1955; Price and Hooley, 1976) and that performance on night shifts is inferior to that on day shifts (reviewed in Monk and Folkard, 1985). The incidence of injury at night was probably not even higher because firefighting is very alerting, and alertness should be protective of injuries (Dahlgren, 1981). The distributions with respect to time of the serious and minor injuries suggests that disruptions at meal-times can contribute to serious injuries. Further studies are needed to understand the basis of this association.

Fatigue, which has been associated with injuries and mistakes of shiftworkers (Bjerner et al., 1955; Colquhoun et al., 1978), may contribute to the injury of fire fighters. Fatigue can result from too much time elapsing since the time of awakening, disruption of the sleep–wake cycle, hypoglycaemia, and/or time elapsed since the beginning of the shift, variables which are not routinely documented or reported. For the fire fighters working a day shift, who came to work directly upon awakening, fatigue was not thought to be a major contributing factor to their injury. However, fatigue due to lack of sleep or disruption of sleep–wake patterns could have contributed to the injuries that occurred during the night shift. On the night shift, fire fighters awoke around 8:00 on the first day and, depending on alarms, might be required to stay awake until the next morning. The next two or three days, they usually slept from 9:00 until 12:00 or 14:00, and then reported to work by 18:00. The time elapsed since eating could also contribute to fatigue of fire fighters, since hypoglycaemia deprives body systems of their energy source. Assuming that when working a day shift, the fire fighters ate breakfast close to the beginning of their shift, then a hypoglycaemic slump would be expected at 11:00–12:00. However, an increase in injuries was not observed at this time. In contrast, high frequencies of injuries were observed at 14:00–16:00 and 20:00–22:00, which corresponded to the anticipated hypoglycaemic slumps after lunch of the day shift and after dinner of the night shift.

Disruption of sleep–wake cycles results in decreased efficiency (Tepas and Carvalhas, 1990). If decreased efficiency contributes to increases in the incidence of injuries, then disruption of sleep–wake cycles of fire fighters might account for the increased injury/alarm ratio at night. With the surveyed fire fighters, the lowest frequency of injuries occurred at 10:00–12:00 and 24:00–8:00. Therefore, if an increased incidence of mistakes by fire fighters occurred at these times, as observed with other shiftworkers (Bjerner et al., 1955), it did not appear to influence the frequency of injuries of these shiftworking firefighters.

The serious injury rate of the fire fighters studied was significantly higher than the national rate (Table 2), and in particular the incidence of inhalation of hazardous materials and of lacerations. This was probably due to the majority of the studied fire fighters not having adequate breathing protection equipment or gloves. Unexpectedly, even the use of self-contained breathing apparati has been reported to cause an increase of burns, falls, and smoke inhalation in fire fighters (Heineman et al., 1989). Due to the variety of injuries and the unpredictability of their type and time of occurrence, and to the current lack of prospective studies, at this stage, it is appropriate to combine different types of injuries of fire fighters for analytic purposes.

As expected, the fire scene, where the fire fighters are subjected to extremely hazardous conditions, was the place that most injuries to fire fighters occurred (Table 2). The fire fighters studied had statistically less injuries at the fire house than the national average, which may be because they experienced 24% more injuries at the fire scene.

Although demographic characteristics were expected to effect the incidence of injury of fire fighters, no significant relationship between the fire fighters' incidence of injury and demographic characteristics, such as age, socio-economic status, marital status, job title, or working more than an average of 42 hours a week was identified. In the same sample set, shiftwork was markedly disruptive to the sleep of only some of the fire fighters studied (Glazner, in preparation). Disruption of the fire fighters' eating and lifestyle patters was not as evident. All the deleterious effects were less, with respect to frequency and severity, than expected. This may be due to the fire fighters' excellent health status, overall fitness, and positive work satisfaction.

Due to the nature of firefighting, and the shift schedule it requires, fire fighters are subjected to substantial and varied risks. By understanding the contribution of factors, especially human ones, such as, altered metabolism, due to disruptions of digestion, and decreased alertness and increased fatigue, due to sleep disruption, interventions can be developed, which should decrease the incidence of injury to fire fighters. Fatigue, especially on the night shift, appeared to account for some of the observed injuries of the fire fighters. Unexpectedly, disruption of eating schedules also appeared to contribute to their injuries, especially serious ones.

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Appendix 7.7

Report of Dr. Linda Glazner

EFFECT OF SHIFTWORK ON HEALTH AND CIRCADIAN RHYTHM IN 24-HOUR FIRE FIGHTERS

<u>1. Significance</u>

A. Objectives

Is a 24-hour shift harmful in terms of health and circadian rhythm alteration to a pilot sample of Toronto Fire fighters? The hypotheses are: I. 24-hour shift fire fighters will have a profile of maladaption syndrome similar to those who do not adjust to shift work (negative health complaints in terms of eating and sleeping disorders, substance abuse, and lifestyle and job dissatisfactions); II. 24-hour shift workers will have altered circadian rhythm during the night shift; III. 10/14 hour shift workers will show less severe maladaption syndrome; and IV. 10/14 hour shift workers will show less circadian rhythm alteration. In this study, evidence of non-adjustment to the environmental stressors of night work can be seen if there is:

1) non-periodicity of circadian rhythm;
2) phase shifting of circadian rhythm;
3) desynchronization (or incoherence) between an individual's rhythm when working 10-14 shift or when working 10-14 shift compared to 24 hour shift.
4) increased incidence or prevalence of reported illnesses;
5) increase in complaints of disruption in eating or sleeping;
6) increase in use of drugs, alcohol or smoking;
7) increase in complaints of dissatisfaction with work and/or lifestyle;
8) increase in reporting more fatigue.

B. Significance

Fire fighting is an essential occupation. It requires fit, knowledgeable, skillful and dedicated personnel to fight fires whenever and wherever they occur throughout the day and night. Compared to most occupations where routine and repetition are the norm, fire fighting is highly unpredictable. The physical and physiological demands of fire fighting fluctuate sharply from heavy to light. They include times of crisis requiring intense physical exertion, mental concentration and a high level of teamwork compared to the relatively undemanding times between alarms. The work environment is unpredictable. In the course of fighting a single fire, fire fighters are exposed to numerous health and safety hazards, including marked extremes of heat and cold, sudden shifts from sedentary activities (or sleep) to high-speed vigorous activities and a variety of air contaminants, the concentration and toxicity of which are usually not known to the fire fighter. It is not surprising that a report to the US Congress stated, “By its very nature, fire fighting is a high stress occupation (US Dept of Commerce, 1980.)

The physiologic responses to extreme stress are known to include the release of adrenalin and similar substances in to the blood, an increased heart rate, and an increase in blood flow to the large muscles (Selye, 1974). These stress responses may be triggered simply by the sound of the fire alarm bells in the fire station (Schirmer and Glazner, 1982). Elevated adrenalin levels and heart rate are two of the human body's natural defense mechanism and, as such, they are likely to be present throughout the crisis period of the fire.

Alterations in circadian rhythm suggest that the individual is having difficulty adjusting causing their biological rhythms to be desynchronized. Desynchronization is associated with negative health effects. Comparisons of individuals with and without circadian rhythm alterations could support reported negative health findings.

2. Originality

A. Conceptual/Theoretical Framework

This study is based on several theoretical constructs. The first is that health is affected by changes in an individual's environment. These changes put a stress on the body which may cause a positive or negative effect (Dubos, 1965; Selye, 1974). If the effect is positive, then the individual is able to react, accommodate, adjust or adapt to various stimuli or stressors (Dubos, 1965). If the effect is negative, there is illness or negative health. In this study, evidence of non-adjustment to the environmental stressors of 24 hour shift work can be seen if there is:

1) non-periodicity of circadian rhythm;
2) phase shifting of circadian rhythm;
3) desynchronization (or incoherence) between an individual's rhythm when working 10-14 shift or when working 10-14 shift compared to 24 hour shift.
4) increased incidence or prevalence of reported illnesses;
5) increase in complaints of disruption in eating or sleeping;
6) increase in use of drugs, alcohol or smoking;
7) increase in complaints of dissatisfaction with work and/or lifestyle;
8) increase in reporting more fatigue.

The second construct assumes that normal sleep is restorative and necessary for the body to function. Sleep studies have shown that with increasing lack of sleep, people have more health complaints. Shift workers sleep fewer hours than non-shift workers (Foret and Benoit, 1978;) Further, those who are bothered by shift work usually complain first of lack of sleep (Tasto et al., 1978) and then of eating or lifestyle disruptions (Tasto et al., 1978; Walker, 1978).

Another construct is that the body has a normal biological rhythm, an assumption that has been tested (Aschoff 1960) and found to be true. In addition, this normal biological rhythm is circadian in nature. The circadian rhythm has a sine wave-like motion that parallels the phenomenon of the Earth spinning on its axis, and has approximately a 24-hour periodicity (Aaonsen, 1959; Aschoff, 1968; Monk and Folkard, 1983). Many systems in the body, including hormones, blood constituents, urine constituents, and body temperature, each posses their own circadian rhythm.

B. Background

Shift work is defined as work performed outside the daylight hours or the normal 9AM to 5PM shift (Leonard, 1981). This type of work existed even in ancient Rome when workers toiled through the night to bring goods and supplies into Rome. The city limited street traffic to the night time hours. With the advent of the industrial revolution, manufacturers employed continuous processes to promote the efficient use of expensive machinery in the production of goods and supplies. Workers were employed to use this investment around the clock. In addition, the public came to expect 24-hour services. Now, more than 20% of the population in America and Europe is engaged in some form of shift work (Monk and Folkard, 1983).

Moore-Ede and Richardson (1985) have given the name "Maladaption Syndrome" to a group of symptoms associated with people who have difficulty working shift. They feel the seriousness of the problem is underestimated because 1) shift workers who have serious problems adjusting to rotating schedules or night work move to day jobs whenever they can find them (Aansonen, 1959); 2) shift workers tend to visit physicians less often than day workers (because they find medical services are less available within their companies as well as in the community) (Koller, 1983; Tasto et al., 1978); and 3) there is a considerable difference in the health effects of different shift schedules (Orth-Gomer, 1983). Shift workers use more days of sick leave (Koller, 1983; Shiftwork Committee, 1979), have poorer scores on a variety of health indices (Shiftwork Committee, 1979) and report a higher prevalence of 1)sleep-wake disorders (Akersted et al., 1977; Angerspach et al., 1980; Harris, 1970); 2)gastrointestinal disorders (Angerspach et al., 1980; Shiftwork Committee, 1979; Koller 1983); and 3)cardiovascular disorders (Moore-Ede and Richardson, 1985; Orth-Gomer, 1983).

Although more research has been done on shift work's effects on biological phenomenon, its effects on social relationships are also important (Aanonsen, 1964; Tasto et al., 1978). Shift workers try to find friends and relatives who work the same shift (Wedderburn, 1978). Shift workers' perceptions of how they feel about their work are important. If there is a positive feeling of job satisfaction, then less ill health is evident (Mann and Hoffman, 1960; Tasto et al., 1978; Walker, 1978).

3. Study Sample or Population

The study population consists of fire fighters working in two (2) Toronto Fire Services Districts, 32 and 42. District 42 (West Toronto) has 220 fire fighters and District 32 (East

Toronto) with 208 fire fighters. These Districts were chosen based on several pertinent similarities. Toronto Fire has a total of sixteen (16) fire Districts.

4. Design

This descriptive correlational study uses a prospective cohort-control design. The workers will be in one of two groups. District 32 fire fighters are currently working 10-14 hours shift schedule. They will continue to do this. The study group will be District 42. Both groups will be studied three times, the first in 12/04 when both are working 10-14 shift schedule. The second time will be in spring 05 when District 42 will have worked about 3-4 months on the 24 hours shift and District 32 continues on the 10-14. The third time is in the Summer 05. District 42 will have worked about 7-8 months on the 24 hours shift and District 32 will continue to work the 10-14 hours shift. The comparison groups have been chosen so that environmental or seasonal similarities or differences can be observed. The times of 3-4 months and 7-8 months have been chosen because it is known that it takes about 6 months or more before a person can really feel adjusted to a new shift change. The emphasis is on differences between groups.

5. Measurement Strategies for Relevant Variables

Operational definitions of major research variables:
Adverse health effects: In this study, adverse health effects are defined as one or more of the following occurring in the study population: 1) non-periodicity of circadian rhythm; 2) desynchronization (or incoherence) between rhythms on 10-14 and 24 hour shifts; 3)increased incidence or prevalence of reported illnesses; 4)increase in complaints of disruption in eating or sleeping; 5)increase in use of drugs, alcohol or smoking; and 6) increase in complaints of dissatisfaction with work and/or lifestyle

Circadian rhythm: biological rhythm as obtained from oral temperature readings with a glass mercury thermometer. Readings will be taken every two hours while awake for a three day period.

6. Reliability, Validity and Sensitivity of Instruments

A questionnaire, oral thermometer recordings, and sleep diary comprise the instruments.

A. Questionnaire: The components of the questionnaire have all been used by the National Institute of Occupational Safety and Health in its study of the Health Consequences of Shiftwork (Tasto et al., 1978). This questionnaire includes the Cornell Medical Health Questionnaire which has a reliability of 0.91 and a standard error of measurement of 0.78. This inventory on health has proved to be valid for examining the physical work environment and for absenteeism (Dirken, 1966). The questionnaire includes questions on personal and health information, on occupational history, on tolerance of shift work including eating patterns, sleeping patterns, job satisfaction/dissatisfaction, and morningness-eveningness.

B. Thermometer: Temperature obtaining and recording is based on a protocol that combines suggestions of many authors (Baker et al., 1984). Baker et al., (1984) found there was no statistical difference between the results from a glass or electronic thermometer. A glass mercury thermometer will be used because it is readily available and inexpensive. For many reasons body temperature is a convenient marker for circadian rhythm. It is relatively easy to measure (Froberg, 1977) and its configuration has been known for a long time. It has been demonstrated that it reflects accurately the body's circadian rhythm and to also reflect changes in that rhythm (Froberg, 1977).

C. Sleep Diary: Sleep diaries have been used to document amount of time slept, where and perception of effectiveness of sleep. Stanford sleepiness index identifies feelings of sleepiness at any point in time (REFEREC)

7. Procedures for Data Collection

It was determined by a combined group of the Toronto Professional Fire Fighters Association: 3888 (3888) and management of the Toronto Fire Department (Joint Recommendation Committee) that the two Districts to be studied were District 32 and District 42. They are very similar in runs (having busy and slow fire halls), numbers and types of equipment and personnel. District 42 was selected as the study group and District 32 as the comparison or mirror group. A visit was made three times to each fire hall.

The first time in December 04, was to explain the study, answer questions, recruit voluntary participants, have informed consent signed and returned, and distribute questionnaires, sleep diaries, thermometers and stamped addressed envelopes for return of the confidential questionnaires to the researcher directly. These visits were made to each fire hall for each shift. The fire service arranged the schedule. People present at each visit besides the members of the fire service, were this researcher, a 3888 member of the 24 hour shift Committee, a manager member of the 24 hour shift Committee and others as needed.

The second visit was in the Spring 05. The above process was repeated. Fire halls were encouraged to continue participation or increase participation.

The third visit (and final visit) was made in Summer 05. Again the above process was repeated. Participation was encouraged at this final point.

8. Data Analysis

Several analysis methodologies will be used. Descriptive data will be presented for each variable or interest. For the circadian rhythm, observational comparisons of temperatures taken were used to see if there is periodicity in the rhythms, if phase shifting and/or desynchronization has occurred between and within individuals working 10-14 and 24 hours shifts.

This summary reports on selected issues that have proven in prior studies, by this researcher, to display differences between 10-14 and 24 hour shifts. This report summarizes the results of similarities and differences between the two groups. These variables were selected at this time in order to answer the questions raised in the hypotheses. Further analysis will be done at a later time.

DEMOGRAPHICS

In most ways the cohort (42 District) and control (32 District) are very similar (**Table 1**: Selected characteristics)

Average Age 42
Majority are married
More of 42 District lives in 905 area code while more of 32 District lives in 416
More than 2/3rds have children living at home
Most all have more than high school education
Both groups are more morning like or neither

This means that for comparison, they are very much alike.

Table 1: Comparisons of selected characteristics for the two Districts

Selected Characteristics	District 32	District 42
Age (average) in years	41	43
Marital status: Married	78%	84%
Divorced	4%	5%
Single	18%	11%
Other	0	0
Commute distance (Phone numbers)		
214	0	0
416	52%	20%
519	0	7%
613	2%	0
705	4%	16%
905	41%	57%
Have children	65%	71%

Highest grade	>high school	>high school
ME Score		
82-70 (Highly morning-like)	14%	10%
69-57 (Some morning-like)	30%	19%
56-45 (neither)	40%	47%
44-32 (Some evening-like)	15%	21%
31-19(Highly evening-like)	1%	3%

However, there is a difference in response. (**Tables 2 and 3**). Table 2 shows that at each phase (date) 42 District had a higher number of participants. Roughly this same proportion also participated in all 3 parts of the study (in Dec 04, in April 05 and again in August 05).

Table 2: Number and percentage of PARTICIPANTS BY DISTRICT (N=226)*

District	Date 1 12/04	Date 2 4/05	Date 3 8/05
32	58 44%	51 33%	38 33%
42	74 56%	98 66%	76 66%
Total	132	149	114

- currently there are 231 participants but all analysis is based on the 226

Table 3: Comparison of fire fighters who participated in all 3 phases (in numbers and percentage) (N=226)

	District 32		District 42	
Participated in all 3	70	31%	156	69%

We know that people who work shift have complaints about eating (with associated gastrointestinal complaints), sleeping (sleep deficit, sleeping problems, fatigue) and relationships (Glazner, 1999; Tasto and Colligan. 1994). People who work shift report more symptoms and ill health. People who are more morning-like are more likely to report difficulty in adapting to shift work. Finally, people who are having problems adapting to shift work have a desynchronized circadian rhythm.

The following tables compare the 2 Districts while both worked the 10-14 shift (in 04) and then in 05 when the study group (42 District) had worked at least 4 months on the 24 hour shift. There is limited information about the 42 District and their working 8 months on the 24 hour rotation (at this moment).

(Note: the tables are either in percentages or average. The percentages might add up to more than 100% because of rounding)

EATING

Table 4 shows a marked increase in satisfaction in nutrition issues with the 24 hour shift. If you combine very satisfied and moderately satisfied, 32 District in 04 was 70% and improved slightly in 05 to 76%. However, in 42 District, the 2 factors combined went from 21% in 04 to 74% in 05. Clearly there was great improvement in satisfaction with eating patterns.

Table 4: Comparison of satisfaction with nutrition on both shifts (in percentage)

		District 32		District 42	
	Year	04	05	04	05
1 very satisfied		23%	39%	12%	33%
2 moderately satisfied		47%	37%	9%	41%
3 slightly satisfied		8%	8%	40%	10%
4 slightly dissatisfied		11%	8%	25%	8%
5 moderately dissatisfied		9%	8%	12%	5%
6 very dissatisfied		2%	0%	3%	3%

SLEEPING

Table 5 shows that there is more consistency with sleep patterns on the 24 hour shift. Fire fighters either sleep once in 24 hours or take a nap plus longer sleep. Anecdotally, several fire fighters said they "sleep much better when on the 24 hour shift". They "always know that tomorrow night I will be in my own bed." The preferred sleep pattern is 2) or 3) take as nap plus a longer sleep or sleep once in 24 hours. Fire fighters reported anecdotally that when they worked the 10-14 shift, they often fell asleep on the way home after the night shift. They have not fallen asleep after the 24 hour shift.

Table 5: Comparison of description of sleep on both shifts (in percentage)

		District 32		District 42	
	Year	04	05	04	05
1 sleep few hours at a time		6%	13%	7%	8%

2 take naps plus longer sleep	21%	31%	13%	31%
3 sleep once in 24 hours	32%	28%	38%	49%
4 different for each shift	42%	28%	42%	11%

Table 6 shows that there was an improvement in sleep deficit in both groups. Sleep deficit was calculated by subtracting desired sleep from report of actual sleep. The less sleep deficit reported, the healthier a person feels. 42 District reported less sleep deficit of greater than 4 hours. They also showed an increase in report of no sleep deficit when 04 was compared to 05. 32 District report an increase also, however, 32 maintained a greater percentage of loss of sleep greater than 4 hours.

Table 6: Comparison of sleep deficit on both shifts (in percentage)

	District 32		District 42	
Year	04	05	04	05
No sleep deficit	13%	28%	27%	34%
1 hour lost	30%	7%	23%	25%
2 hours lost	42%	45%	48%	34%
3 hours lost	8%	10%	23%	7%
4 hours lost	4%	7%	2%	0
5 hours lost	2%	0	0	0
6 plus hours lost	2%	3%	0	0

RELATIONSHIPS

It is important to look at how fire fighters perceive others (especially significant others) feel about their work. Social support is very important with shift workers (Tasto et al). It is the opinion of this researcher that fire fighters, by the nature of their work require a strong support system. **Table 7** shows that there was a dramatic improvement in 42 District in 05 related to how people they live with like the shift. **Table 8** looks at how often significant others complain about the shift. Again, there was marked improvement in 42 District in 05. **Table 9** further shows that significant others clearly like the 24 hour shift.

Table 7: Comparison of satisfaction with how do the people you live with like your work hours on both shifts (in percentage)

	District 32		District 42	
Year	04	05	04	05
1. very satisfied	14%	23%	16%	50%
2. moderately satisfied	42%	52%	29%	38%
3. slightly satisfied	12%	13%	55%	7%
4. slightly dissatisfied	20%	6%	6%	0
5. moderately dissatisfied	6%	6%	6%	1%
6. very dissatisfied	2%	0	4%	0
7. I live alone	4%	0	6%	4%

Table 8: Comparison of how often significant others complain about the schedule on both shifts (in percentage)

	District 32		District 42	
Year	04	05	04	05
1. Never	13%	40%	21%	46%
2. Occasionally	76%	59%	53%	50%
3. Frequently	9%	3%	18%	2%
4. Always	0	0	3%	2%

5. Not living with anyone	2%	0	3%	0

Table 9: Comparison of how fire fighters feel significant others feel about their schedule on both shifts (in percentage)

	District 32		District 42	
Year	04	05	04	05
1. Likes it very much	22%	41%	10%	60%
2. Likes it somewhat	41%	38%	57%	28%
3. Dislikes it somewhat	28%	21%	28%	9%
4. Dislikes it very much	9%	0	5%	4%

Tables 10 and 11 shows how many friends, neighbors or relatives work the same schedule. There was no change over the time of the study. People who work the same shifts as others tend to like the shift more (Wedderburn, 1978, Tasto et al., 1978).

Table 10: Comparison of how many friends and neighbors work the same kind of schedule as you on both shifts (in percentage)

	District 32		District 42	
Year	04	05	04	05
1. all of them	0	0	0	0
2. most of them	0	0	0	0
3. some of them	21%	13%	17%	12%
4. none of them	79%	87%	83%	88%

Table 11: Comparison of how many relatives work the same kind of schedule as you on both shifts (in percentage)

	District 32		District 42	
Year	04	05	04	05
1. all of them	0	0	0	0
2. most of them	4%	0	0	0
3. some of them	19%	30%	19%	19%
4. none of them	77%	70%	81%	81%

MORALE

Morale can be defined many ways. Satisfaction/dissatisfaction, working conditions and anecdotal comments contribute to the definition. Morale is often shaped by the total holistic experience of each worker which includes a wide range of factors, some of which are, but not limited to; work/life balance, stress factors, job satisfaction, physical wellbeing (fitness, nutrition, etc), relationships (family/social), sleep patterns, etc. An individuals' morale is can be best measured through subjective communication or feedback and can have a direct impact on work performance, absenteeism and other issues.

SATISFACTION

Although more research has been done on shift work's effects on biological phenomenon, its effects on social relationships are also important (Aanonsen, 1964; Tasto et al., 1978). Shift workers try to find friends and relatives who work the same shift (Wedderburn, 1978). Shift workers' perceptions of how they feel about their work are important. If there is a positive feeling of job satisfaction, then less ill health is evident (Mann and Hoffman, 1960; Tasto et al., 1978; Walker, 1978).

Table 12 shows that fire fighters like the work they do, regardless of District or shift. **Table 13** shows they like the people with whom they work**.**

Table 12: Comparison of how fire fighters feel about the work they do on both shifts (in percentage)

	District 32		District 42	
Year	04	05	04	05
1 very satisfied	79%	37%	46%	59%
2 moderately satisfied	15%	60%	52%	39%
3 slightly satisfied	3%	3%	4%	2%
4 slightly dissatisfied	0	0	0	0
5 moderately dissatisfied	3%	0	0	0

6	very dissatisfied	0	0	0	0

Table 13: Comparison of how fire fighters like the people they work with on both shifts (in percentage)

	District 32		District 42	
Year	04	05	04	05
1. I like them very much	64%	73%	76%	69%
2. I like them a little	34%	23%	24%	30%
3. I dislike them a little	2%	3%	0	2%
4. I dislike them very much	0	0	0	0

Tables 14 and 15 shows that supervisors and others helped to make things easier and this was consistent in both shifts. Again, it is the opinion of this researcher that fire fighters, by the nature of their work require a strong support system.

Table 14: Comparison of satisfaction with how your supervisor makes things easier for you on both shifts (in percentage)

		District 32		District 42	
	Year	04	05	04	05
1	not at all	6%	13%	8%	11%
2	seldom	25%	25%	17%	44%
3	sometimes	30%	38%	53%	31%
4	often	40%	22%	23%	10%
5	no such person	0	3%	0	3%

Table 15: Comparison of satisfaction with how others make things easier for you on both shifts (in percentage)

		District 32		District 42	
	Year	04	05	04	05
1	not at all	5%	6%	0.1%	4%
2	seldom	24%	27%	22%	32%
3	sometimes	41%	38%	45%	49%

4 often	30%	22%	33%	13%
5 no such person	0	3%	0	0%

HEALTH

Moore-Ede and Richardson (1985) have given the name "Maladaption Syndrome" to a group of symptoms associated with people who have difficulty working shift. They feel the seriousness of the problem is underestimated because 1) shift workers who have serious problems adjusting to rotating schedules or night work move to day jobs whenever they can find them (Aansonen, 1959); 2) shift workers tend to visit physicians less often than day workers (because they find medical services are less available within their companies as well as in the community) (Koller, 1983; Tasto et al., 1978); and 3) there is a considerable difference in the health effects of different shift schedules (Czeisler et al., 1982; Orth-Gomer, 1983). Shift workers use more days of sick leave (Koller, 1983; Shiftwork Committee, 1979), have poorer scores on a variety of health indices (Shiftwork Committee, 1979; Smith et al., 1982) and report a higher prevalence of 1)sleep-wake disorders (Akersted et al., 1977; Angerspach et al., 1980; Harris, 1970); 2)gastrointestinal disorders (Shiftwork Committee, 1979; Koller 1983); and 3)cardiovascular disorders (Koller, 1983; Moore-Ede and Richardson, 1985; Orth-Gomer, 1983).

Table 16 and 17 shows slight improvement in self report of health in both groups. The number of symptoms also decreased in both groups with the 42 District showing a greater decrease in reports of symptoms. There were very few hospitalizations (no table). Fire fighters in Toronto report more symptoms than other fire fighters that this researcher has studied. However, the number is still lower than for shift workers. Also, a variety of symptoms are included here from belching, to bleeding most days. Further analysis will rank the seriousness of symptoms and then compare the two groups.

Table 16: Comparison of self report of health on both shifts (in percentage)

	District 32		District 42	
Year	04	05	04	05
1 excellent	42%	44%	36%	51%
2 good	56%	56%	58%	44%
3 fair	6%	0	5%	3%
4 poor	0	0	0	0
AVERAGE	1.6	1.4	1.7	1.1

Table 17: Comparison of self report of symptoms on both shifts (in percentage)

	District 32		District 42	
Year	04	05	04	05
0	5%	9%	0	13%
1-5	7%	12%	6%	5%
6-10	7%	12%	10%	18%
11-15	23%	21%	22%	16%
16-20	14%	12%	16%	18%
21-25	9%	12%	12%	10%
26-30	18%	9%	6%	5%
31-35	9%	12%	16%	5%
36-40	4%	3%	4%	12%
41-45	4%	0	9%	3%
46+	0	0	0	0

FATIGUE

Table18 shows that for both groups there was an improvement in not feeling tired. However, the improvement for 42 District was greater.

Table 18: Comparison of feeling of waking up tired in a week on both shifts (in percentage)

	District 32		District 42	
Year	04	05	04	05
1 not at all	2%	13%	3%	24%
2 occasionally	60%	56%	54%	58%
3 frequently	21%	28%	35%	14%
4 always	17%	3%	7%	4%

Table 19 shows that mathematically, fatigue stayed about the same for both groups over time. It could be explained by the fact that in Spring and Summer, people feel less fatigue. Fire fighters reported anecdotally that “I fell much less tired while on 24 hours shift” “I didn’t realize how tired I had been until I wasn’t tired anymore.”

Table 19: Comparison of Iowa fatigue on both shifts (averages)

Year	District 32	District 42
04	25.0	24.8
05	26.9	25.1

Table 20 shows that firefighters in 42 District improved dramatically in how they felt on the 24 hour shift. There was an increase in feeling active, vital, and wide awake from 17% in 2004 to 49% in 2005, while firefighters in 32 District only increased from 9% to 16%. The sleepiness score at the other end of the spectrum reveal that firefighters in 32 District remained at the same level of sleepiness.

Table 20: Comparison of SLEEPINESS SCORES on both shifts (in percentage)

	District 32		District 42	
Year	04	05	04	05
1 feeling active, vital, wide awake	9%	16%	17%	49%
2 functioning at high levels but not at peak, able to concentrate	30%	22%	38%	33%
3 awake but relaxed, responsive but not fully awake	20%	20%	28%	14%
4 somewhat foggy, let down	14%	20%	7%	2%
5 foggy, losing interest in remaining awake, slowed down	8%	6%	6%	0
6 sleepy, woozy, fighting sleep, prefer to lie down	14%	9%	4%	0
7 no longer fighting sleep, sleep onset soon, having dream-like thoughts	5%	6%	0	0

FITNESS

There was no decrease in ability to do fitness activities. However, there were some anecdotal opinions both ways. Some felt that they could maintain a fitness program better on 10-14 because they did it only at work and that meant more days available. Others felt that since they did their workouts at home, there were more days to do it.

COPING MECHANISMS

Often times, workers use maladaption coping mechanism in order to adjust to shift work. (The following information is not presented in table form). All the fire fighters did not use alcohol to help them sleep. A smaller percentage of fire fighters smoke than would be expected. They use coffee, tea, or soda or other caffeinated beverages, but do not abuse them.

In addition, **Table 21** shows a very marked decrease in the use of alcohol by fire fighters working the 24 hour shift compared to when they worked 10-24 or compared to the 32 District. Fire fighters on the 10-14 shift often socialize in bars/nightclubs after 4 days in a row. Fire fighters on the 24 hour shift have continued socialization but it now occurs at breakfast, golf, etc. on the morning after their shift. (anecdotal reports)

Table 21: Comparison of use of alcohol by fire fighters working both shifts (in percentage)

		District 32		District 42	
	Year	04	05	04	05
Yes		56%	35%	67%	13%
No		44%	65%	33%	87%

Table 22 shows that use of medication or stimulant stayed very much the same. Over the counter medications, such as No Doz are often used to help withstand the effects of night work. Fire fighters did not report using these.

Table 22: Comparison of increase in illness or use of medications or stimulants on both shifts (in percentage)

		District 32		District 42	
	Year	04	05	04	05
no		91%	84%	82%	86%
yes		9%	15%	18%	14%

MORNINGNESS/EVENINGNESS

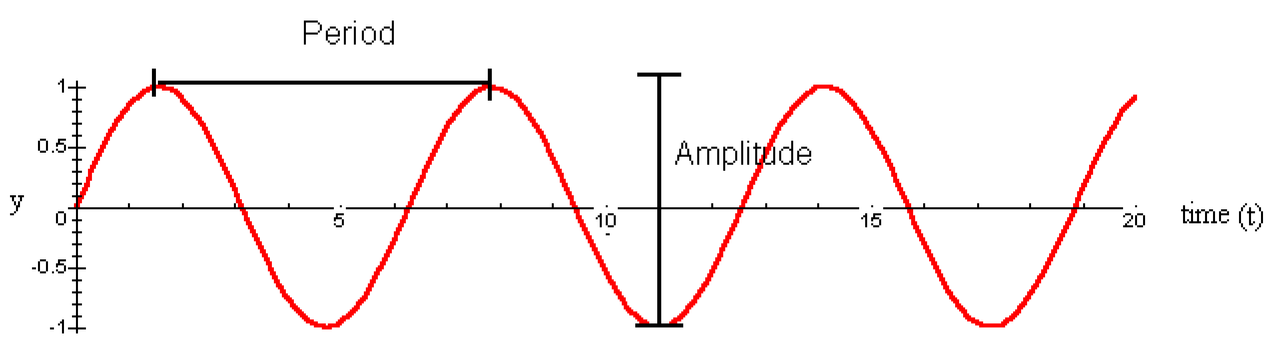
Table 1 shows that most fire fighters are neither morning or evening like. . Morningness/eveningness is derived from the fact that some people are more alert in the day (larks or morning-like) and others are more alert at night (owls, or evening-like). People who are morning-like have more difficulty adjusting to shiftwork

	32	42
ME Score		
82-70 (Highly morning-like)	14%	10%
69-57 (Some morning-like)	30%	19%
56-45 (neither)	40%	47%
44-32 (Some evening-like)	15%	21%
31-19 (Highly evening-like)	1%	3%

CIRCADIAN RHYTHM

This researcher is sharing graphs from temperatures taken by fire fighters. In order to read and understand them, a brief review of circadian rhythm and sine waves is necessary. Circadian rhythms are essentially sine waves with periods of 24 hours and variable amplitudes. Quantifying properties of circadian rhythms, such as amplitude and period, can help us understand the mechanisms controlling rhythms.

Circadian rhythms produce repeating patterns over time. We can quantify properties of waves such as the amplitude and period. The amplitude of a wave is the height from peak to crest. For the simplest sine wave, y = sin t, the amplitude is 2. The period of a wave is the time for completion of one cycle. For y = sin t, the period is 2π.



(M. Beals, L. Gross, S. Harrell , 1999). Desynchronization occurs when there is no discernable pattern, or the amplitude is flattened.

Comparisons are shared. There are a limited number of fire fighters in both Districts who took their temperatures over two time periods. Ten graphs are shared for each District (32 who remained on 10-14 shift throughout the study; 42 who went form 10-14 shift to 24 hours shift.). Remember that the body needs time to adapt. It was expected that 6 months would be sufficient time to see if a positive adaptation had taken place.

In addition, single graphs of temperatures of those working either the 10-14 hour shift or the 24 hour shift are shared.

Some temperature graphs had to be excluded because there was no variability. There is a list of 2 people whose temperatures could not be used.

Looking at the comparison groups, firstly 32 District. For each individual, his/her temperature in 04 is presented first with their 05 temperature second. The researcher has commented at the bottom of each graph. All of them, with the exception of participant 53, show no circadian rhythm.

Looking at 42 in the same way, again we see that temperature recordings for 04 and 05 are charted. Again, this researcher has made comments at the bottom of each graph. In all cases, there were no pattern in 04 and the beginnings of a pattern can be discerned in 05 in 6 of the 10 (60%).

Clearly, several impressions arise

1) For most people who worked the 10/14 shift, there is desynchronization of the circadian rhythm. The amplitudes are flattened and there is no pattern.
2) When fire fighters moved to the 24 hour shift, a circadian pattern became somewhat evident in several of the individuals.
3) For those fire fighters who remained on the 10/14 shift, the desynchronization of the circadian rhythm remained.

Looking at the charts of those who only recorded their temperature one time, this researcher has separated the people who work 10-14 and those who work the 24 hour shift. Looking first at the 10-14 shifts. This includes everyone in 32 District, whether their temperature was taken in 04 or 05, as well as 42 District when they took their temperatures in 04. Of the 30 individuals (97%), show desynchronization. 2 (98 and 14) show an approximation of a pattern. It is expected that just by chance some people will not have altered circadian rhythm.

Those who work the 24 hour shift and recorded their temperatures in the Spring, show the beginning of having a patterned circadian rhythm. In general these 14 people (100%) are showing a trend in a positive direction.

Again, those who are working the 10-14 shift are desynchronized and there is a trend towards patterning in the 24 hour shift.

Summary and conclusion:

Questions were chosen at this time to be analyzed based on identifying non-adjustment. on the hypotheses to be tested. In this study, evidence of non-adjustment to the environmental stressors of night work will be seen if there is:

1) non-periodicity of circadian rhythm;
2) phase shifting of circadian rhythm;
3) desynchronization (or incoherence) between an individual's rhythm when working 10-14 or 10-14 compared to 24 hour shift
4) increased incidence or prevalence of reported illnesses;
5) increase in complaints of disruption in eating or sleeping;
6) increase in use of drugs, alcohol or smoking;
7) increase in complaints of dissatisfaction with work and/or lifestyle;
8) increase in reporting more fatigue.

Shift workers sleep fewer hours than non-shift workers or report more sleep deficit (Foret and Benoit, 1978) Further, those who are bothered by shift work usually complain first of lack of sleep (Tasto et al., 1978) and then of eating or lifestyle disruptions (Aanonsen, 1959; Tasto et al., 1978; Walker, 1978).

There has been a subjective improvement for the Toronto fire fighters working the 24 hour shift. This improvement is in a positive direction. It is well known that it takes over six months to adjust to a new shift. Most shift changes include a transition period, therefore some of the improvements may increase over time as the shift change is physically and mentally accepted, and the workers' lives are built around the new shift. The subjective data analyzed does not include August information. It is expected that when the August information is included, there will be even stronger improvement in a positive direction. Clearly though, there was strong improvement in eating and how significant others react to the new shift. Also, anecdotal information supports an improvement in fire fighters' fatigue and energy levels.

The displayed improvement in circadian alteration is cautious but optimistic. In December 04 all who worked on the 10-14 shift display desynchronization of circadian rhythm. The amplitude is flattened and there is no pattern. This continues for fire fighters working the 10-14 shifts. However, for some of those fire fighters working the 24 hour shift, the desynchronized circadian rhythm becomes synchronized with a distinct pattern. While the number of temperatures used to make these statements appears small, it is, in fact, one of the largest studies done to date assessing circadian rhythm. That is a strong statement that the 24 hour shift is healthier for at least some of the fire fighters. This researcher believes that over time, and with more data analyzed, their will continue to be an increase in synchronized circadian rhythm.

After reviewing both the objective and subjective data collected through three rounds (not all data examined or statistically correlated) of Toronto Fire Fighter Health and Wellness

surveys, sleep diaries, fatigue levels and temperature tracking, my preliminary findings and recommendations are as follows:
(Data summary was inclusive to both the study group, 42 District and control group, 32 District))

To date, the developing trend is steady improvement for 42 District employees now working the 24 hr shift (the study group). Results of the subjective research showed 42 District employees experienced a lower incidence of fatigue, sleep deprivation and circadian rhythm de-synchronization than their 32 District counterparts on the 10/14 hour schedule. They exhibited a higher level of morale, felt better overall, were more rested when reporting for duty, and reported a better life/work balance.

Based on the scientific and anecdotal data collected and analyzed to date, the evidence is positive in regards to the 24 hr shift. I recommend proceeding to a city wide trial period. We now have a great breadth of data but require more focused depth of information. I also recommend that we continue collecting objective and subjective data to ensure we capture both short and long term effects of the shift on Toronto Firefighters' Health and Wellness and apply corrective measures or coping strategies where required.

Yours truly,

Linda K Glazner DrPH RN COHNs CCM CHES FNP FAAOHN

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- Comparisons of temperatures for firefighters in 32 District working 10-14 in 04 and 05
- Comparisons of temperatures for firefighters in 42 District working 10-14 in 04 and 24 hours shift in 05
- People working 10-14 shift
- On 24 Hours shift
- Can't use

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Appendix 7.8

From 24 to 12 – The Benefits of Shift Modification

by Edwin Boudreaux, MA; Cris Mandry, MD, FACEP; Phillip J. Brantley, PhD; and Shawn Jeffries, MA

Journal of Emergency Medical Services – March 1997

While shift work is an accepted and vital part of today's 24-hour society, much research suggests that shift work can lead to severe physiological and psychological reactions. This is especially true of schedules requiring prolonged vigilence. (ie., 24-hour shifts).

Despite the obvious importance of this area of research, few field studies have been conducted specifically with emergency medical providers. The present study attempted to evaluate the effects resulting from modifying EMTs' work schedules so that they were shorter and more in tune with natural sleep-wake cycles.

All full-time EMTs working for the public EMS system from a large southern city were eligible to participate in this study. The organization is a free-standing system with nine units working two-man crews. There are six full-time EMT-paramedic field supervisors working two per shift. Crews rotate stations monthly. On the original schedule, employees worked 24-hour shifts (one day on, two off). On the new schedule, they worked 12-hour shifts (three days on, two off, two on, three off) and alternated one month working nights and one month working days. The pre-assessment was conducted one month prior to the schedule change, and the post-assessment was conducted two months after the change.

Of a possible 70 EMTs, 51 completed both stages of they study, resulting in a final catchment rate of 72.9 percent. The results indicated that the schedule modification was associated with improvements in several important variables. The most pronounced and relevant change occurred in participants' perceptions of their work schedules. Participants showed a substantial improvement in their attitudes toward their schedule under the new 12-hour shift. They believed the change helped to make them more productive, encouraged them to do their best work and had a positive influence on their overall happiness and physical well-being. Furthermore, participants reported less family and social disruption arising from their new schedules. Clearly, the 12-hour schedule was the preferred schedule and appeared to be associated with far less disruption in the participants' overall quality of life.

Analyses also revealed that participants endorsed less emotional exhaustion and feelings of burnout when working on the 12-hour schedule. It is well-established that working 24-hour shifts can foster feelings of fatigue and exhaustion because of the effects on sleep deprivation and disruption in circadian rhythm. Therefore, it is reasonable that a scale assessing the perceived emotional demands of ones job and feelings of being drained, fatigued and burned out would be sensitive to changes in work schedule that allowed for shorter hours that were more consistent with natural circadian rhythms.

Finally, the lack of changes in several other variables included in this study are noteworthy. The schedule change did not correspond with any changes on a measure assessing the sum total of job-related stressors. This was not totally unexpected, considering the fact that many stressful aspects are related to working in EMS besides poorly scheduled work hours. In fact, the only other existing published study investigating shift modifications in EMTs found similar results.[1] Reviews of the research indicate that stressors, such as alienated administration, traumatic calls, lack of public respect and limited career ladder may account for much of an EMT's stress. Modifying work schedules would not have any logical effect on many of these stressors, thus accounting for the lack of change in global job-related stressors. There were also no observable changes in global job satisfaction. This may be attributable to the fact that the ratings were relatively high to begin with, making improvements difficult to achieve. This suggests that, even though participants were very dissatisfied with their old 24-hour schedule, they still held their job in considerable esteem.

Several unavoidable limitations were associated with this study. First, since the shift change was an organization-wide policy change, it was impossible to obtain a non-treatment control group. Including a no-treatment control group, while increasing the scientific rigor of a study and offering many advantages, is often impractical in field research.

Second, this study was limited to a single urban EMS department located to a southern city. Although participants were demographically similar to participants in other studies, it is possible this department may not be representative of other departments or EMT subpopulations (eg. Paid vs. volunteer, urban vs. rural). Related to this point, the reason the change was initiated was because the number of calls received has consistently increased over the past 15 years and had progressed to the point that working for such a prolonged period of time under such high-demand conditions became unmanageable. Consequently, the results obtained here may not apply to departments with lower call-rates.

Third, the schedule changed from a highly undesirable and “extreme” one to a highly desirable and more “moderate” one. Changes in the variables observed in this study may not apply to other types of schedule changes. If the differences in schedules are less pronounced (i.e., going from 8 to 12-hour shifts), the changes in outcome variables may not be as pronounced.

Based on these preliminary data, changing EMTs working schedules from 24 to 12-hour shifts appears to be associated with greater satisfaction with their work schedule, reduced schedule-related social/family disruption, and decreased levels of emotional exhaustion and feelings of burnout. However, it was associated with little or no changes in global job satisfaction, global job stress, cynical attitudes toward patients and feelings of personal accomplishment. This implies that schedule modifications are no panacea. Simply because an EMT likes his new schedule and does not feel as fatigued and exhausted after work does not mean his attitude toward patients has changed or that the other administrative hassles he experiences are less irritating. To help address some of the limitations associated with this study, a one-year follow-up assessment is planned, and objective measures of organizational health, such as sick leave, turnover rates, workman's compensation claims and rate of on-the-job injuries, will be obtained.

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Appendix 7.9

The NEW ENGLAND JOURNAL *of* MEDICINE

ORIGINAL ARTICLE

Effect of Reducing Interns' Work Hours on Serious Medical Errors in Intensive Care Units

Christopher P. Landrigan, M.D., M.P.H., Jeffrey M. Rothschild, M.D., M.P.H., John W. Cronin, M.D., Rainu Kaushal, M.D., M.P.H., Elisabeth Burdick, M.S., Joel T. Katz, M.D., Craig M. Lilly, M.D., Peter H. Stone, M.D., Steven W. Lockley, Ph.D., David W. Bates, M.D., and Charles A. Czeisler, Ph.D., M.D., for the Harvard Work Hours, Health and Safety Group

ABSTRACT

BACKGROUND

Although sleep deprivation has been shown to impair neurobehavioral performance, few studies have measured its effects on medical errors.

METHODS

We conducted a prospective, randomized study comparing the rates of serious medical errors made by interns while they were working according to a traditional schedule with extended (24 hours or more) work shifts every other shift (an "every third night" call schedule) and while they were working according to an intervention schedule that eliminated extended work shifts and reduced the number of hours worked per week. Incidents were identified by means of a multidisciplinary, four-pronged approach that included direct, continuous observation. Two physicians who were unaware of the interns' schedule assignments independently rated each incident.

RESULTS

During a total of 2203 patient-days involving 634 admissions, interns made 35.9 percent more serious medical errors during the traditional schedule than during the intervention schedule (136.0 vs. 100.1 per 1000 patient-days, P<0.001), including 56.6 percent more nonintercepted serious errors (P<0.001). The total rate of serious errors on the critical care units was 22.0 percent higher during the traditional schedule than during the intervention schedule (193.2 vs. 158.4 per 1000 patient-days, P<0.001). Interns made 20.8 percent more serious medication errors during the traditional schedule than during the intervention schedule (99.7 vs. 82.5 per 1000 patient-days, P=0.03). Interns also made 5.6 times as many serious diagnostic errors during the traditional schedule as during the intervention schedule (18.6 vs. 3.3 per 1000 patient-days, P<0.001).

CONCLUSIONS

Interns made substantially more serious medical errors when they worked frequent shifts of 24 hours or more than when they worked shorter shifts. Eliminating extended work shifts and reducing the number of hours interns work per week can reduce serious medical errors in the intensive care unit.

From the Divisions of Sleep Medicine (C.P.L., J.W.C., S.W.L., C.A.C.), General Internal Medicine (J.M.R., R.K., E.B., D.W.B.), Infectious Disease (J.T.K.), Pulmonary and Critical Care Medicine (J.W.C., C.M.L.), and Cardiology (P.H.S.) and the Internal Medicine Residency Program (J.T.K.), Department of Medicine, Brigham and Women's Hospital; the Division of Sleep Medicine, Harvard Medical School (C.P.L., J.W.C., S.W.L., C.A.C.); and the Division of General Pediatrics, Department of Medicine, Children's Hospital Boston and Harvard Medical School (C.P.L.) — all in Boston. Address reprint requests to Dr. Landrigan at the Division of Sleep Medicine, Department of Medicine, Brigham and Women's Hospital, 221 Longwood Ave., Boston, MA 02115, or at clandrigan@rics.bwh.harvard.edu.

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In a pioneering study published in the *Journal* 33 years ago, Friedman and colleagues reported that interns made almost twice as many errors reading electrocardiograms after an extended (24 hours or more) work shift than after a night of sleep.[1] More recent studies have similarly found that surgical residents made up to twice the number of technical errors in the performance of simulated laparoscopic surgical skills after working overnight than after a night of sleep.[2,3] Although many prior studies have been methodologically limited by the use of nonvalidated self-reports on the timing of sleep and inadequate accounting for circadian phase and chronic sleep loss, as reviewed elsewhere,[4-6] the literature as a whole suggests that sleep deprivation causes substantial decrements in physicians' performance of discrete neurocognitive and simulated clinical tasks.[4-8] The clinical importance of sleep curtailment has remained unclear, however,[4-6] owing to a lack of studies conducted in clinical care environments[4,9] and the possibility that scheduling interventions designed to mitigate sleep deprivation may simultaneously introduce discontinuities in care.[10,11]

Within hospitals, of all trainees, interns (postgraduate year 1) typically work the greatest number of hours per week.[12,13] The extended (24 hours or more) work shifts and long workweeks of interns may make them especially prone to fatigue-induced errors. In a survey of house officers, 41 percent reported fatigue as a cause of their most serious mistake. Most of these events occurred while they were interns, and 31 percent reportedly resulted in fatalities.[14]

To understand the effects of interns' sleep deprivation on serious medical errors, we conducted a comprehensive comparison of errors while interns followed a traditional work schedule and errors while they followed an intervention work schedule that was designed to reduce sleep deprivation. Our goals were to compare the rates of serious errors directly involving interns on the two schedules, since interns were the focus of our scheduling intervention, and to compare the overall rates of serious medical errors in order to track the effects of interns' schedules on the system as a whole.

METHODS

The Intern Sleep and Patient Safety Study was conducted as part of the Harvard Work Hours, Health and Safety Study from July 2002 to June 2003 in the medical intensive care unit (MICU) and coronary care unit (CCU) of Brigham and Women's Hospital, a large academic hospital in Boston, after approval by the institutional review board. The MICU and CCU were selected for study because they are the rotations of this internal-medicine training program with the longest work hours and because medical errors have been detected at higher rates in critical care settings than in other settings.[15,16] Both units have 10 adult critical care beds. Data were not collected on patients admitted for fewer than four hours, patients undergoing elective allergy desensitization, or the rare patients who boarded on the units but who were not cared for by the MICU or CCU team.

DESIGN OF INTERVENTION TRIAL

In collaboration with the leadership of the residency program and unit directors, we designed an intervention work schedule for interns that eliminated extended (24 hours or more) work shifts and reduced the number of scheduled hours of work to 63 per week (Fig. 1). The traditional MICU house-staff team consisted of three interns and three third-year residents, whereas the CCU team consisted of three interns and two second-year residents. Each intern and resident on these teams worked overnight in the hospital every third night. A resident from another hospital service assumed patient care responsibilities in the CCU on nights when neither of the daytime CCU residents was working. Under this rotation, interns' scheduled workweeks averaged 77 to 81 hours, depending on the clinic assignment, with up to 34 continuous hours of scheduled work when clinic occurred after they were on call (Fig. 1A).

During the intervention schedule, interns' work hours and overnight work schedules were changed. Interns' traditional extended work shifts were divided in two: a "day-call" intern worked the first half of a traditional call (from 7 a.m. to 10 p.m.); a "night-call" intern worked the second half (from 9 p.m. to 1 p.m. the following day). To effect this schedule, four interns shared patient care responsibilities during the rotation. The maximal scheduled hours of work were 60 to 63 per week, with consecutive hours of work limited to approximately 16 hours (Fig. 1B). The intervention did not alter the schedules or staffing of second- or third-year residents or other clinical personnel.

Our goal was to improve interns' opportunities to sleep while minimizing errors due to handoffs of patient care and cross-coverage.[10] To minimize cross-coverage errors, we developed a sign-out template for interns to use in all critical care rotations (both intervention and traditional schedules)[17] and incorporated an hour of overlap in the evenings for interns on the intervention schedule to sign out formally (see Figure A of the Supplementary Appendix, available with the full text of this article at www.nejm.org) under the supervision of the senior resident.

After providing written informed consent, interns were randomly assigned to work either the intervention schedule in the CCU and the traditional schedule in the MICU or the converse; these rotations were distributed throughout the year. Data collected during a pilot intervention schedule involving four interns that was discontinued after the first ICU rotation were not included. As detailed in the article by Lockley et al. in this issue of the *Journal*,[18] although actual work hours often exceeded those scheduled during both the tradi-

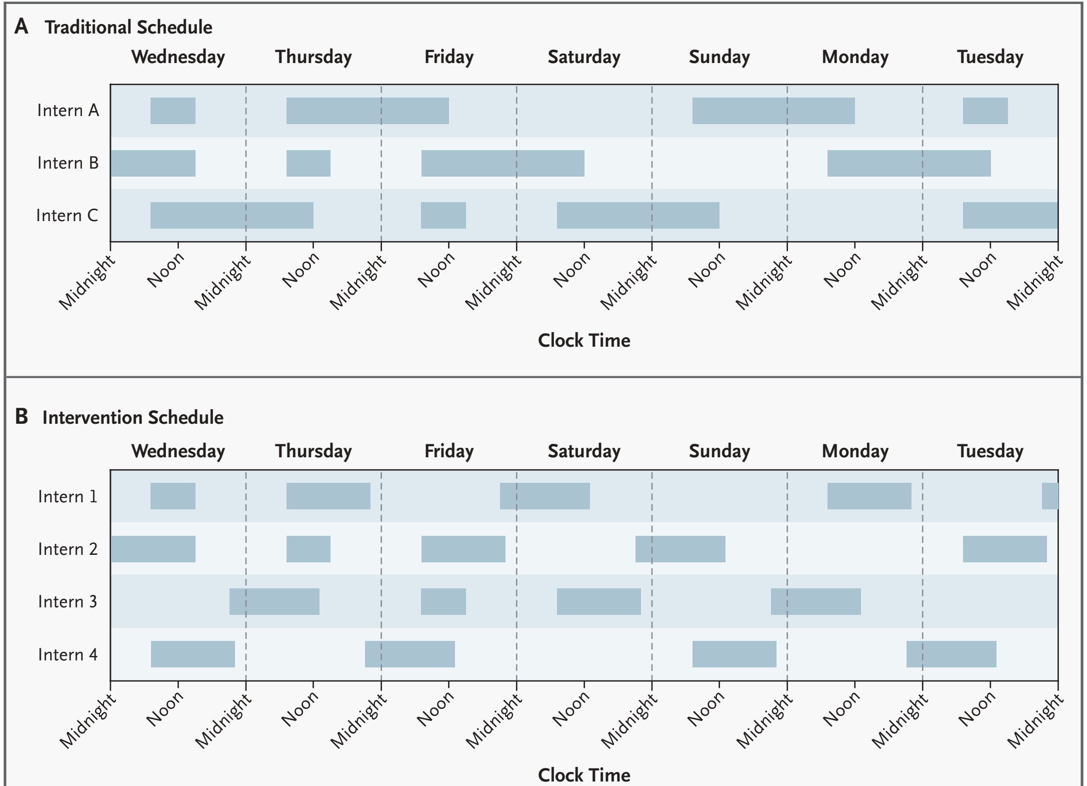

Figure 1. Representative Work Hours during a Single Week for the Whole Team of Interns during the Traditional Schedule (Panel A) and the Intervention Schedule (Panel B).

Scheduled work hours are indicated by the bars. Panel A shows the traditional rotation in which a team of three interns provided continuous coverage on a repeated three-day schedule, consisting of a daytime "swing" shift on day 1 (7 a.m. to 3 p.m.) (e.g., Wednesday for Intern A), followed by an extended on-call shift from 7 a.m. on day 2 to noon on day 3 (e.g., Thursday through Friday for Intern A). Interns had the day off when a swing shift was to occur on a Saturday, Sunday, or Monday (e.g., Saturday for Intern A). Interns staffed weekly ambulatory clinics when they coincided with a swing shift or the latter half of an extended on-call shift. Panel B shows the intervention rotation in which a team of four interns provided continuous coverage on a repeated four-day schedule. Day 1 is the standard swing shift (e.g., Wednesday for Intern 1); day 2 is "day call" from 7 a.m. to 10 p.m. (representing the first half of the traditional call) (e.g., Thursday for Intern 1); days 3 and 4 are "night call" from 9 p.m. on day 3 to 1 p.m. on day 4 (representing the second half of a traditional call) (e.g., Friday through Saturday for Intern 1). There is a one-hour scheduled overlap between the outgoing day-call intern and the incoming night-call intern (e.g., Wednesday from 9 p.m. to 10 p.m. for Intern 4 and Intern 3, respectively); this overlap was often extended as clinically required. Interns had the day off when a swing shift was to occur on a Saturday, Sunday, or Monday (e.g., Sunday for Intern 1). Interns only attended clinics when they coincided with the swing day.

tional and intervention schedules, the intervention successfully eliminated shifts of 24 hours or more, reduced the number of hours worked by interns by nearly 20 per week, increased the average daily duration of sleep by nearly an hour, and reduced attentional failures.

DATA COLLECTION AND CLASSIFICATION

To measure patients' safety during the two schedules, we developed an intensive system of data collection and evaluation that expanded on methods previously used in the study of medication errors[16,19] and also included continuous observation of interns by physicians. In this study, we focused on procedural and diagnostic errors in addition to medication errors. The definitions used to classify incidents are provided in Table 1.

A team of two nurse chart reviewers and six physician observers collected data, supplemented by voluntary reports from clinical staff and a computerized event-detection monitor. Direct observation was the principal means of detecting serious errors in which interns were directly involved; physician observers followed study interns continuously, day and night in the hospital. In the afternoons after work rounds, when more than one intern was working simultaneously, only one intern was observed at a time owing to staffing limitations. Residents and other personnel on the units were not directly observed. Data collection for personnel other than interns was less comprehensive and relied on chart review, voluntary reports, and computerized event-detection monitoring. Other methods of data collection, though less comprehensive, were designed to identify all serious medical errors — both those in which interns were involved and those in which they were not involved. Before beginning data collection, all staff received intensive training in the consistent, objective collection of data using standardized forms. Because it was not possible to blind data collectors to the study schedule, determinations of the preventability and classification of events were not made by the primary data collectors. Instead, each suspected error or adverse event identified was independently rated by two physician investigators who were unaware of the identity of those involved or whether the incident occurred during the traditional or intervention schedule.

In the vast majority of cases, the serious errors identified by observers were promptly addressed by medical staff with no need for action on the part of the observers. Nonintercepted serious errors were generally detected by observers when they were discussed by clinical staff. In the handful of cases in which observers identified possible errors in the making with substantial potential to cause harm, they immediately alerted clinical staff to prevent harm to the patient.

Blinded reviewers categorized each incident as an adverse event, nonintercepted serious error, intercepted serious error, or error with little potential for harm (a category that was excluded from the

Table 1. Definitions Used in the Study.

Term	Definition
Medical error	Any error in the delivery of medical care, whether harmful or trivial
Serious medical error	A medical error that causes harm or has substantial potential to cause harm, including preventable adverse events, nonintercepted serious errors, and intercepted serious errors, but not including errors with little or no potential for harm or unpreventable adverse events
Intercepted serious error	A serious medical error that is intercepted before reaching the patient
Nonintercepted serious error	A serious medical error that is not intercepted and therefore reaches the patient but causes no clinically detectable harm
Adverse event	Any injury due to medical management
Nonpreventable adverse event	Unavoidable injury resulting from appropriate medical care
Preventable adverse event	Injury due to a nonintercepted serious error in medical management
Serious medication error	A serious medical error related to the ordering or administration of pharmaceutical agents, blood products, or intravenous fluids
Serious procedural error	A serious medical error related to the performance of an invasive procedure, such as placement of a central venous or arterial catheter
Serious diagnostic error	A serious medical error related to history taking, the performance of a physical examination, or the ordering or interpretation of a diagnostic test

analysis) and rated the preventability of adverse events using a Likert scale (was prevented, was definitely preventable, was probably preventable, was probably not preventable, or was definitely not preventable); the preventability scale was dichotomized to include only "preventable events" and "nonpreventable events" before analysis. Events deemed more likely to be due to patients' underlying illness than to medical therapy were excluded. Disagreements were resolved by discussion; the interrater reliability was calculated before such discussion by means of the kappa statistic, as described below.

STATISTICAL ANALYSIS

Patients' characteristics and the mean daily census of the units during the intervention and traditional rotations were compared by means of Fisher's exact test; Wilcoxon's nonparametric test for dichotomous, nonnormally distributed continuous variables; and a t-test for normally distributed continuous variables. All statistical tests were two-tailed. The rates of diagnostic tests and procedures per patient-day were compared between the two schedules, and the distribution was assumed to be binomial. We compared the rates of medication orders per patient-day between the two schedules, assuming a Poisson distribution, since the presence of rates of more than one order per patient-day precluded the use of the binomial distribution.

We compared the rates of intern-associated serious medical errors per patient-day (for all interns combined) and of total serious medical errors per patient-day between the intervention and traditional schedules, assuming a binomial distribution. The rates of all serious medical errors include all intern-associated serious errors (those detected by direct observation and other methods) plus non–intern-associated errors (identified by chart review, staff reports, and the computerized monitor). We also compared the rates of type-specific errors (medication, procedural, and diagnostic) per patient-day, assuming a binomial distribution. For all tests, two-tailed P values of less than 0.05 were considered to indicate statistical significance.

The study was powered to determine differences in rates of serious medical errors. Analyses of the rates of adverse events were performed, but the results were considered exploratory since we had only 11 percent power to detect a 25 percent difference in intern-associated preventable adverse events. By contrast, the study was designed to have 80 percent power to detect a 16 percent difference in the rate of serious errors between groups.

We evaluated the reliability of the primary data-collection process by conducting dual direct observation for a total of 10 patient-days; there was 82 percent agreement between independent observers with respect to the occurrence of a serious medical error. At the review stage conducted by the blinded investigators, we performed comprehensive reliability testing of all incidents rated using the kappa statistic. For reviewers' judgments about whether an incident was an adverse event, an intercepted serious error, a nonintercepted serious error, or an excluded event, the κ was 0.90; the κ was 0.80 for the preventability of adverse events.

RESULTS

PATIENT POPULATION

The study involved 2203 patient-days (1294 during the traditional schedule and 909 during the intervention schedule), representing 634 admissions to the units (385 during the traditional schedule and 249 during the intervention schedule) and 5888 hours of direct observation of interns. The patients' characteristics and the units' characteristics were very similar during the traditional and intervention schedules (Table 2). The number of days included in the traditional schedule exceeded that of the intervention schedule primarily because four interns were required for the intervention schedule as compared with only three for the traditional schedule. Since all interns rotated through both schedules, more traditional than intervention rotations were required to allow each intern to spend three weeks on each schedule. The patients' length of stay and mortality rate did not differ significantly between the two schedules.

SERIOUS MEDICAL ERRORS BY INTERNS

Interns made 35.9 percent more serious medical errors during the traditional schedule than during the intervention schedule (136.0 vs. 100.1 per 1000 patient-days, P<0.001) (Table 3). Interns made 27.8 percent more serious errors that were intercepted during the traditional schedule than during the intervention schedule (70.3 vs. 55.0 per 1000 patient-days, P=0.02) and 56.6 percent more nonintercepted serious errors that reached the patients (44.8 vs. 28.6 per 1000 patient-days, P<0.001). The rates of preventable adverse events did not differ significantly between the two schedules.

ALL SERIOUS MEDICAL ERRORS AND ADVERSE EVENTS

The rate of all serious medical errors was 22.0 percent higher during the traditional schedule than during the intervention schedule (193.2 vs. 158.4 per 1000 patient-days, P<0.001) (Table 3). Intercepted serious errors occurred 37.2 percent more frequently during the traditional schedule than during the intervention schedule (95.1 vs. 69.3 per 1000 patient-days, P<0.001). The overall rates of nonintercepted serious errors did not differ significantly between the two schedules, nor did the rates of preventable adverse events. There was no significant difference in the rates of total adverse events (preventable plus nonpreventable) between the traditional and intervention schedules (85.0 vs. 93.5 per 1000 patient-days, P=0.31). Secondary analysis of the rates of serious medical errors in which interns were not involved revealed no significant differences between the traditional schedule and the intervention schedule (40.2 vs. 38.5 per 1000 patient-days, P=0.69).

TYPES OF SERIOUS MEDICAL ERRORS

Interns made 20.8 percent more serious medication errors during the traditional schedule than during the intervention schedule (99.7 vs. 82.5 per 1000 patient-days, P=0.03). Interns made 5.6 times as many serious diagnostic errors during the traditional schedule as during the intervention schedule (18.6 vs. 3.3 per 1000 patient-days, P<0.001). The rates of serious procedural errors among interns did not differ significantly between the two schedules (Table 3).

Analysis of the types of all errors (errors made by interns plus errors in which interns were not involved) showed similar patterns (Table 3). Serious medication errors occurred 17.1 percent more frequently during the traditional schedule than during the intervention schedule (135.2 vs. 115.5 per 1000 patient-days, P=0.03). The rates of serious procedural errors did not differ significantly between the two schedules. Serious diagnostic errors were nearly twice as common during the traditional schedule as during the intervention schedule (21.6 vs. 11.0 per 1000 patient-days, P<0.001).

Examples of each type of serious medical error and adverse event observed in the study are provided in Table 4. Subcategories of medication and nonmedication errors are available in Table A of the Supplementary Appendix.

Table 2. Characteristics of the Patients and the System.*

Characteristic	Traditional Schedule	Intervention Schedule
Patients		
No. of patients	354	227
No. of unit admissions	385	249
No. of patient-days	1294	909
Mean age — yr	64.9±0.8	63.2±1.10
Male sex — no./total no. of unit admissions (%)	214/385 (55.6)	126/249 (50.6)
Charlson comorbidity index†	4.0±0.2	4.1±0.2
APACHE II score‡	17.7±0.5	17.9±0.7
Length of unit stay — days		
Median	2.9	3.0
Interquartile range	5.1	5.7
No. who died in unit/total no. of unit admissions — %	49/385 (12.7)	36/249 (14.5)
CCU and MICU		
Daily censuses	9.2±0.1	9.4±0.1
Interns		
No. of medication orders/patient-day	8.2	7.8
No. of procedures/patient-day§	0.28	0.33¶
No. of interpretations of diagnostic tests/patient-day‖	0.28	0.29

* Plus–minus values are means ±SE.
† Scores for the Charlson comorbidity index can range from 0, indicating no serious coexisting conditions, to 6, indicating the presence of metastatic cancer or infection with the human immunodeficiency virus.
‡ Acute Physiology and Chronic Health Evaluation (APACHE) scores can range from 0 to 71, with higher scores indicating an increased likelihood of death.
§ Procedures performed by interns included placement (or rethreading) of central venous catheters, placement of arterial catheters, drawing of arterial blood, intubation, thoracentesis, placement of nasogastric and orogastric tubes, lumbar puncture, and removal of central catheters or tubes.
¶ P<0.001 for the comparison with the traditional schedule.
‖ Interpretations of diagnostic tests by interns included interpretation of chest radiographs, other radiographs, electrocardiograms, and arterial blood gas values.

DISCUSSION

Interns made 36 percent more serious medical errors during a traditional work schedule than during an intervention schedule that eliminated extended work shifts. These included significantly more serious medication errors and 5.6 times as many serious diagnostic errors. As a consequence, the overall rates of serious medical errors were significantly higher during the traditional schedule than during the intervention schedule. Fortunately, most

Table 3. Incidence of Serious Medical Errors.

Variable	Traditional Schedule	Intervention Schedule	P Value
	no. of errors (rate/1000 patient-days)		
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

serious medical errors were either intercepted or did not result in clinically detectable harm to the patient. Although the study was not designed to have sufficient statistical power to detect a difference in preventable adverse events, the incidence of intern-associated preventable adverse events was 27 percent higher during the traditional schedule than during the intervention schedule, a difference that was not statistically significant (20.9 vs. 16.5 per 1000 patient-days, P=0.21). The overall rates of preventable adverse events (intern-associated and non–intern-associated) were not significantly different during the traditional and intervention schedules (38.6 and 38.5 per 1000 patient-days, respectively; P=0.91), although our intervention and observations were focused on the interns. This study was not designed or powered to assess comprehensively the effect of the intervention on adverse event rates in the units as a whole. Therefore, it remains to be determined whether the decrease in the rate of serious medical errors by interns will translate into a reduction in the rate of adverse events.

The prospective, randomized nature of this study allowed for a rigorous evaluation of the effects on patients' safety of an intervention designed to improve interns' sleep and thus decrease medical errors. Prior studies using before-and-after cohort designs to assess the effects of scheduling interventions have provided limited and conflicting data. A before-and-after analysis of a scheduling intervention in one hospital that reduced residents' work hours and decreased cross-coverage of unfamiliar patients by senior residents found that the efficiency of care increased and the rates of errors among residents decreased.[20] In contrast, an unblinded, retrospective study of a New York State regulation that decreased the number of hours worked by house staff but increased cross-coverage found that the efficiency of care declined and rates of medical complications increased.[11] Each was limited by a before-and-after design, which precluded the exclusion of secular trends, increasing experience of house staff, cohort effects, or other external confounders as possible explanations for the changes. Because of concurrent changes in work hours, cross-coverage, and other aspects of care in these studies, it was not possible to identify the elements that may have been responsible for the findings.

The overall incidence of serious errors and adverse events we detected is similar to that reported in other studies of patients' safety in the ICU. For example, Giraud et al.[21] and Rubins and Moskowitz[22] documented the occurrence of 13 to 40 preventable adverse events per 1000 patient-days. The Harvard Medical Practice Study[23] reported lower rates but used a less comprehensive method of data collection and a more restrictive definition of harm, since it sought to detect injuries due to negligence. Donchin et al. reported a higher rate of 1.7 errors per patient-day but included errors with little potential for harm.[15] The rates detected by Donchin et al. may also be higher because they focused on errors in the unit as a whole, whereas we directly observed only interns. Moreover, during daytime hours, when two or more interns were working simultaneously in different parts of the units, our staffing limitations allowed us to observe only one intern at a time. Consequently, the true rate of serious errors in the units as a whole may have been higher.

The article by Lockley et al.[18] demonstrates that eliminating extended work shifts and reducing the number of hours worked by interns led to signifi-

Table 4. Examples of Serious Medical Errors and Nonpreventable Adverse Events.

Category and Type	Description
Intercepted serious error	
Procedural	As intern is preparing to perform a thoracentesis on the left side of the patient's chest, the senior resident enters the room and informs the intern that the pleural effusion is on right side of the patient's chest.
Diagnostic	Several days after a patient with a history of flash pulmonary edema is admitted for congestive heart failure, intern reports that patient is in clinically stable condition, having miscalculated that 24-hour input and output volumes are well matched (positive by 20 ml). The nurse is concerned that patient seemed overloaded with fluid and in mild respiratory distress and requests a reevaluation. A recalculation by the senior resident reveals an error by a factor of 100: the patient's input and output volume has, in fact, been positive by 2000 ml for the prior 24 hours. Furosemide is promptly administered and the patient's symptoms improve.
Medication	Intern orders an intravenous vasopressin drip at rate of 0.2 U/min (overdose by a factor of 10). Nurse intercepts the order, and the rate is changed to 0.02 U/min.
Nonintercepted serious error	
Procedural	Patient with defibrillator implanted on left side urgently needs central access for inotropic support. Intern inserts a central venous catheter in the left subclavian vein. Not recognizing that the vein contains the wire from the defibrillator, the intern is having repeated difficulty advancing the introducer. In the middle of the placement, the cardiology fellow enters and asks the intern to abort the procedure immediately. The catheter is removed before it can interfere with or dislodge the defibrillator wire.
Diagnostic	A middle-aged patient with a complete heart block is admitted to the CCU. The intern fails to examine the patient's back. The following day, the patient is noted to have a well-developed erythema migrans rash on the back, consistent with the presence of Lyme disease, which is later confirmed by serologic testing. Initiation of Lyme therapy is delayed.
Medication	Intern orders an antibiotic for a patient with a listed allergy to the medication. One dose is given before the error is detected, but the patient does not have an allergic reaction.
Preventable adverse event	
Procedural	A right-sided tension pneumothorax develops after a technical error during placement of a subclavian venous catheter leads to pleural-space puncture.
Diagnostic	The attending physician devised a plan to transfuse a patient for a hematocrit of <30. Despite these instructions, the intern fails to check laboratory results for 36 hours. When the laboratory results are finally checked, hematocrit is found to have been 26 in the interim. The patient has tachycardia for a protracted time as a consequence.
Medication	Bradycardia and hypotension develop owing to an inadvertent overdose of a benzodiazepine.
Nonpreventable adverse event	
Procedural	Transfusion is required for severe bleeding resulting from placement of a medically indicated nasogastric tube in a patient with coagulopathy. There is no error in placement or technique.
Medication	A rash related to nafcillin develops in a patient with no known drug allergies.

cant improvements in interns' sleep and reductions in attentional failures. Although causality cannot be established, it was our a priori hypothesis that increases in sleep resulting from the elimination of extended work shifts and reduction of work hours would lead to a decrease in serious medical errors.[24] There were no significant differences between the two schedules in the patients' severity of illness or other individual or systemic variables that could independently account for the observed differences in the rates of medical errors. Our randomized study design greatly diminished the likelihood of hidden confounding owing to secular trends, seasonal effects, learning over the course of the year, or other external factors unrelated to our study.

Before we initiated the intervention schedule, concern was expressed that decreasing the number of hours interns worked might diminish their role in the units, thereby shifting the burden of order writing and procedures and, hence, the risk of errors to more senior staff. Our results did not bear out this concern: the number of medications ordered and tests interpreted by interns per patient-day did not differ significantly between the two schedules, and interns performed significantly more procedures per patient-day during the intervention schedule. Moreover, the error rates among senior residents and other staff members were not increased during the intervention schedule. Thus, the substantially lower rates of errors by interns during the intervention schedule cannot be due to shifting of errors to more senior staff.

The Institute of Medicine's report "To Err Is Human"[25] was notably silent regarding the issue of sleep deprivation, largely because data directly linking sleep deprivation and medical error have been lacking. Our study helps to fill this knowledge gap and provides data suggesting that the sleep deprivation associated with the traditional extended shifts of 24 hours or more worked by interns may contribute to the high risk of medical errors in critical care units.

It is important to emphasize that not all interventions that reduce interns' work hours will increase interns' sleep[26] or improve patients' safety. Schedule design is a critical factor in determining the extent to which around-the-clock work schedules disrupt wake–sleep cycles, even when the number of weekly work hours remains the same.[27] Furthermore, any systemic intervention that reduces work hours necessarily increases either providers' workload (i.e., the number of patients covered by a provider at any time) or the number of handoffs in care between medical personnel on shorter work shifts. Either can lead to increased rates of errors and adverse events.[10] "Night-float" systems, which use residents on night shifts to allow physicians working extended work shifts protected time for sleep, have their own set of risks. Night-float residents often know patients less well than do other team members (particularly if multiple residents share responsibilities as night floats over the course of a week, or if night floats are responsible for an increased number of patients), and may themselves be sleep-deprived and error-prone.[28] For these reasons, we ultimately decided not to implement a night-float system as a means of reducing interns' work hours, as originally planned.[24] Our data support the hypothesis that elimination of extended work shifts in a system that minimizes cross-coverage can improve patients' safety. These gains might not be realized in systems that use extensive cross-coverage.

Although our intervention decreased the rate of serious errors overall, our efforts to optimize the sign-out process were only partially successful. The computerized template was never fully adopted, and the effectiveness of the planned evening sign-out was frequently suboptimal. Although some groups of interns worked successfully as teams and effectively signed out every evening, even in the absence of formal training in team management, others did not. In the latter case, the night-call intern was often unaware of historical details regarding patients admitted by the day-call intern and sometimes performed poorly when describing these patients on morning rounds. This led to a widespread impression that communication on the intervention schedule was problematic, making the improvements in patients' safety we observed all the more remarkable. We suggest that future scheduling interventions address this issue by adding formal evening rounds for the entire team. Such improvements, coupled with the elimination of extended work shifts, could further improve patients' safety.

Our study has several limitations. The intervention schedule improved work hours but still involved shifts that were long enough to induce a number of attentional failures that was greater than would be expected among fully rested people.[18] We studied two ICUs in a single hospital, and our results may not be generalizable to other settings. In addition, although our study was very large as compared with prior observational safety studies,[15] the study was not powered to detect differences in the rates of preventable adverse events. Larger-scale, multicenter trials are needed to investigate this aspect.

Another important limitation was our inability to blind the medical observers to the schedule of the interns, an issue commonly encountered in investigations of systemic interventions to maximize patients' safety. We addressed this in two ways: first, we instructed observers — none of whom were study investigators — in the importance of consistent, objective detection of serious errors, regardless of study schedule. Second, all initial observations were also reviewed by two independent investigators who were blinded to the study's conditions and who classified incidents with extremely high reliability. Nonetheless, we cannot exclude the possibility that some bias may have resulted from the inability to blind the primary detection process, though our reliability data suggest that this bias was probably minimal.

Notably, our data on the high incidence of intercepted serious errors in ICU settings indicate that the ability of other personnel to act as interns' safety net — nurses, pharmacists, and senior medical staff — is very important in preventing injury to patients as a result of interns' errors. Therefore, future studies should seek to improve and measure objectively the sleep and performance of all clinical unit personnel, since team performance may critically affect patients' safety.[29] Having interns on a different schedule than supervising residents may have introduced discontinuities in education and interfered with the traditional resident–intern mentorship bond. We would recommend that future studies investigate the effects of eliminating the extended work shifts of interns and senior residents, both to avoid this problem and because it is unlikely that interns are uniquely susceptible to the adverse effects of sleep deprivation.

Prior interventions that have proved successful in reducing serious medical errors in ICU settings have included the use of computerized provider order entry (CPOE)[30] and on-site monitoring of orders by clinical pharmacists.[31] The higher intern-associated rate of serious medical errors during the traditional schedule, even in the presence of CPOE, clinical pharmacists, unrestricted use of caffeine by interns,[32] and a perceived increase in the risk of handoff errors, indicates the extent of impairment associated with extended work shifts. This observation corroborates the prior experimental finding that a single night of continuous sleep deprivation causes decrements in performance similar to those induced by a blood alcohol level of 0.10 percent.[33]

By reducing consecutive and weekly work hours, our scheduling intervention attempted to address both acute sleep deprivation and chronic partial sleep deprivation. By reducing interns' sleep deprivation and, hence, depth of subsequent sleep, we also indirectly addressed the adverse effects of sleep inertia (i.e., an increased tendency to err on awakening) on performance, since such impairment is a function of sleep depth.[34] The schedule was also designed to attenuate the circadian performance nadir by taking advantage of the blunting of this nadir that occurs when the homeostatic sleep drive is lower.[35,36] By providing interns with the opportunity to sleep in the afternoon before working overnight, the schedule thereby muted the effect of circadian misalignment on performance. Medical or surgical simulators could help isolate the effects of these interacting factors, since the relative importance of these variables remains unclear. Strategic use of a novel regimen of caffeine[32] or ambient light of specific intensity and wavelengths[37,38] may further mitigate the deterioration in performance resulting from circadian misalignment.

In conclusion, the rates of serious medical errors in two ICUs were lowered by eliminating extended work shifts and reducing the number of hours interns worked each week. Our results may have important implications for health policy, since more than 100,000 physicians are currently in training in the United States.[39] Most of these residents are regularly scheduled to work 30-hour shifts, since extended work shifts and long workweeks continue to be permitted, even under the scheduling reforms instituted last year by the Accreditation Council for Graduate Medical Education. Further modifications of these standards, particularly with respect to the duration of work shifts, may be needed to improve patients' safety in teaching hospitals nationwide.

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EDITORIAL

Sliding Down the Bell Curve: Effects of 24-hour Work Shifts on Physicians' Cognition and Performance

Comment on Saxena AD, George CFP. Sleep and motor performance in on-call internal medicine residents. *SLEEP* 2005; 28(11): 1386-1391.

Philibert I. Sleep loss and performance in residents and nonphysicians: a meta-analytic examination. *SLEEP* 2005; 28(11): 1392-1402.

Christopher P. Landrigan, MD, MPH

Division of Sleep Medicine, Brigham and Women's Hospital; Children's Hospital Boston Inpatient Pediatrics Service, Harvard Medical School, Boston, MA

IN 1999, THE INSTITUTE OF MEDICINE ESTIMATED THAT MEDICAL ERRORS RESULT IN MORE THAN A MILLION INJURIES AND UP TO 98,000 DEATHS EACH YEAR IN THE United States,[1] making medical error the sixth leading cause of death nationwide.[2] Since that time, an expanding body of research has shown that a major contributor to this astonishingly high incidence of serious error is the inadequate sleep of health care providers themselves.[3-8] The Harvard Work Hours, Health, and Safety Study found that interns working traditional in-hospital extended "on-call" shifts of 24-30 hours every other shift (a "q3" schedule) suffered twice as many polysomnographically-recorded attentional failures while working at night, and made 36% more serious medical errors in the care of their patients – including 5 times as many serious diagnostic errors – as interns limited to 16 hours of scheduled consecutive work.[9,10] Arnedt et al recently found that pediatric residents working "heavy call" (>24 hour shifts every fourth to fifth night) performed on standardized neurobehavioral and simulated driving tasks similarly to residents with a blood alcohol level of 0.04 to 0.05%.[11] Rogers et al found that nurses working longer than 12 consecutive hours or more than 40 hours per week had more than 3 times the odds of making a medical error.[12]

Two papers published in this issue of SLEEP further define the role of sleep loss in patient safety and suggest how far we must still go to address this problem adequately. In "Sleep and Motor performance in On-Call Internal Medicine Residents," Saxena and George find that internal medicine residents working on-call shifts (28 consecutive hours) every 3 to 6 shifts (a "q4" to "q7" schedule) suffer significantly more reaction time lapses than rested physician controls, regardless of whether tests were administered post-call or on other days.[13] The persistence of impaired reaction times throughout the month, even following several nights' sleep at home, demonstrates the powerful detrimental effects of extended shifts and chronic partial sleep deprivation on house officers' performance. Even call as infrequent as "q7" did not allow full sleep recovery between on-call episodes, and led to lasting performance deficits. Very significantly, residents failed to perceive this impairment. Although aware of their sleepiness when post-call, they rated their alertness highly when not post-call, despite Psychomotor Vigilance Test data to the contrary.

In the second article, "Sleep Loss and Performance in Residents and Non-Physicians: A Meta-Analytic Examination," Philibert has conducted a rigorous, comprehensive meta-analysis of 60 studies investigating the effects of sleep loss on the performance of 959 physicians and 1,028 non-physicians.[14] Prior meta-analyses have sought to systematically gather the evidence regarding sleep deprivation and human performance, but none have focused so extensively on physicians as a sub-group. Two important contributions of this study is its isolation of the effects of sleep deprivation on physicians' clinical and non-clinical tasks, and its differentiation of the effects of varying degrees of total acute sleep deprivation (24 to <30 hours, 30 to <54 hours, and >54 hours) on physicians' performance. Philibert finds that even sleep deprivation of 24 to <30 hours, an amount within current Accreditation Council for Graduate Medical Education (ACGME) work hour limits for resident physicians,[15] leads to extreme degradation of residents' cognitive and clinical performance.

Acute sleep deprivation degrades physicians' performance to a frightening degree. In Philibert's analyses, the average cognitive performance of physicians experiencing consecutive sleep loss of 24-30 hours fell 0.986 d scores to the fifteenth percentile of rested performance levels. 24-30 hours of sleep loss degraded clinical performance even further, to that of the seventh percentile of rested physicians (-1.536 d scores). To put such drops in intellectual performance into perspective, it may be useful to consider what an analogous drop on a familiar population-based performance metric – the Intelligence Quotient – would mean. A reduction in human cognitive performance to the fifteenth percentile would be equivalent to decreasing the average human IQ from 100 to 85;[16] a drop to the seventh percentile would be analogous to a drop to nearly 70, a level bordering on mild mental retardation.

Although the magnitude of cognitive loss this analogy suggests is quite disturbing, the finding that sleep loss deeply impairs thinking and performance is not new. Extensive, decades-old data from across occupations have established that sleep deprivation and circadian misalignment greatly increase the risk of industrial errors and accidents.[17-19] Recognizing these risks, safety-sensitive industries such as aviation and trucking implemented limits on

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Address correspondence to: Christopher Landrigan, MD, Division of Sleep Medicine, Brigham and Women's Hospital Research Director, 221 Longwood Ave., 4th floor, Boston, MA 02115; Tel: (617) 525-7310; Fax: (617) 732-4015; E-mail: clandrigan@rics.bwh.harvard.edu

consecutive work hours years ago.[20-22]

Physicians need to come to terms with their biological limits, and take steps to prevent these limits from harming their patients. Current ACGME policy continues to endorse resident work weeks of 80 hours and shifts of 30 consecutive hours, including time for transfer of patient care. The justifications for perpetuation of such long shifts has been to limit the possibility of hand-off errors as well as to foster resident training through intensive continuous in-hospital experience. Evidence demonstrating that long shifts are necessary either to assure good training or avoid hand-off errors, however, is notably absent. By contrast, as demonstrated so eloquently by Philibert in this issue of Sleep, a wealth of evidence substantiates the very real risks to patients of physician sleep deprivation. In the only randomized trial to test a system with traditional 30-hour shifts and few hand-offs against a system with more frequent hand-offs of care but no extended shifts, the no-extended-shifts system was far safer, despite the avoidable miscommunications that occurred.[10,23]

Few passengers would be comfortable flying with an exhausted pilot who had been working in the cockpit for 24 consecutive hours, never mind one who had done so every third or fourth night for the past several years. Yet this is the norm in medicine, largely because we have fostered a professional ideal that doctoring requires unceasing self-sacrifice and sleeplessness in the service of the patient. The sad irony, however, is that in refusing to care for themselves, to acknowledge their own essential biological needs, physicians do not care well for their patients. Exhausted physicians make critical errors, injuring the very patients they seek to heal.

The public, incidentally, recognizes the risks of physicians' sleep deprivation. A 2002 National Sleep Foundation poll found that half of the public believe physicians should work 10 hours or fewer; 86% would be "extremely anxious" to learn that their surgeon had been awake for 24 hours, and 70% claimed they would likely ask for a different doctor.[24] The fact that patients rarely make such requests underscores the lack of transparency in the medical consent process, and patients' consequent unawareness of the risks to which they are exposed in hospitals. It demonstrates how much more we must do to involve patients in the process of improving patient safety.

Philibert cautiously suggests that "the weekly hours and continuous wakefulness permitted under the current national minimum standards for residents may not completely guard against the negative effect of sleep loss on cognitive and clinical performance." Her data and the emerging literature, however, go much further than this. Residents working 30 hours in a row under the current guidelines of the ACGME perform as poorly as if intoxicated. The intelligent, motivated, highly-educated graduates that our medical schools produce are reduced by an overnight, 24-hour shift to a fraction of their intellectual selves. Our patients are endangered by their work hours. And as Barger et al demonstrated recently, our trainees' themselves and the general public are endangered; residents driving home after shifts of >24 hours have twice the odds of crashing their cars.[25]

It is well past time that we eliminate residents' extended shifts. If we wish to assure that hand-off errors do not endanger patients, we should seek to improve our hand-off systems. If we wish to assure that our residents are well-trained, we should seek to increase the efficiency and quality of their training experience. Neither of these imperatives require the prolonged, traditional shifts that are so patently endangering our patients, house staff, the public, and ultimately, ourselves. To protect our trainees and patients, the dangerous tradition of 24-hour shifts must at last be put to rest.

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Effect of Reducing Interns' Weekly Work Hours on Sleep and Attentional Failures

Steven W. Lockley, Ph.D., John W. Cronin, M.D., Erin E. Evans, B.S., R.P.S.G.T., Brian E. Cade, M.S., Clark J. Lee, A.B., Christopher P. Landrigan, M.D., M.P.H., Jeffrey M. Rothschild, M.D., M.P.H., Joel T. Katz, M.D., Craig M. Lilly, M.D., Peter H. Stone, M.D., Daniel Aeschbach, Ph.D., and Charles A. Czeisler, Ph.D., M.D., for the Harvard Work Hours, Health and Safety Group

ABSTRACT

BACKGROUND

Knowledge of the physiological effects of extended (24 hours or more) work shifts in postgraduate medical training is limited. We aimed to quantify work hours, sleep, and attentional failures among first-year residents (postgraduate year 1) during a traditional rotation schedule that included extended work shifts and during an intervention schedule that limited scheduled work hours to 16 or fewer consecutive hours.

METHODS

Twenty interns were studied during two three-week rotations in intensive care units, each during both the traditional and the intervention schedule. Subjects completed daily sleep logs that were validated with regular weekly episodes (72 to 96 hours) of continuous polysomnography (r=0.94) and work logs that were validated by means of direct observation by study staff (r=0.98).

RESULTS

Seventeen of 20 interns worked more than 80 hours per week during the traditional schedule (mean, 84.9; range, 74.2 to 92.1). All interns worked less than 80 hours per week during the intervention schedule (mean, 65.4; range, 57.6 to 76.3). On average, interns worked 19.5 hours per week less (P<0.001), slept 5.8 hours per week more (P<0.001), slept more in the 24 hours preceding each working hour (P<0.001), and had less than half the rate of attentional failures while working during on-call nights (P=0.02) on the intervention schedule as compared with the traditional schedule.

CONCLUSIONS

Eliminating interns' extended work shifts in an intensive care unit significantly increased sleep and decreased attentional failures during night work hours.

From the Divisions of Sleep Medicine (S.W.L., J.W.C., E.E.E., B.E.C., C.J.L., C.P.L., D.A., C.A.C.), General Internal Medicine (J.M.R.), Infectious Disease (J.T.K.), Pulmonary and Critical Care Medicine (C.M.L.), and Cardiology (P.H.S.) and the Internal Medicine Residency Program (J.T.K.), Department of Medicine, Brigham and Women's Hospital and Harvard Medical School; the Division of Sleep Medicine, Harvard Medical School (S.W.L., J.W.C., C.P.L., D.A., C.A.C.); and the Division of General Pediatrics, Department of Medicine, Children's Hospital Boston and Harvard Medical School (C.P.L.) — all in Boston. Address reprint requests to Dr. Czeisler at the Division of Sleep Medicine, Department of Medicine, Brigham and Women's Hospital, 221 Longwood Ave., Boston, MA 02115, or at caczeisler@hms.harvard.edu.

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The Accreditation Council for Graduate Medical Education (ACGME) has recently limited work hours for U.S. medical residents to less than 320 hours in a four-week period, with up to 32 additional hours for programs granted exceptions.[1] Largely missing from the debate[2-11] are objective data quantifying trainees' actual work and sleep hours. Subjective reports indicated that, before the new regulations were implemented, some trainees worked up to 140 hours per week,[12-16] although the validity of such reports has been questioned.[3,17]

Although residency training may restrict participants' opportunities to sleep, given that there are only 168 hours in a week,[14] some have suggested that reducing residents' work hours may not increase their duration of sleep.[13,18] Neither the restrictions implemented by the ACGME nor reforms proposed by other proponents of reducing the number of hours worked by residents[2] were evaluated a priori to determine their effect on sleep or work-related performance.

As part of the Harvard Work Hours, Health and Safety Study, the Intern Sleep and Patient Safety Study was designed to quantify work hours, sleep, and the rates of medical errors among interns working in critical care units. In the present study, we tested the hypothesis that eliminating interns' extended work shifts would significantly increase their duration of sleep and reduce attentional failures, as compared with the traditional work schedule. In another article in this issue of the *Journal*, Landrigan and colleagues[19] tested the hypothesis that eliminating extended work shifts would significantly decrease the rates of medical errors among interns.

METHODS

The objectives of the study were to quantify work hours and sleep in interns during a traditional schedule; compare subjective reports of work hours and sleep with simultaneous, independent, objective measures; and measure the effect of an intervention designed to eliminate extended work shifts on physicians' work hours, sleep, and attentional failures. Details of the methods are provided in the Supplementary Appendix (available with the full text of this article at www.nejm.org).

SUBJECTS

In March 2002, all 72 persons who had accepted a position in the internal-medicine residency training program (postgraduate year 1) at Brigham and Women's Hospital in Boston were asked to participate in the study (Fig. 1). Fifty-one interns volunteered for the study, and the first 24 interns (on the basis of the date the consent form was signed) whose schedule was compatible with the study schedule were enrolled. There were 11 women and 13 men, and the mean (±SD) age was 28.0±2.0 years. The human research committee of Partners Healthcare and Brigham and Women's Hospital approved all procedures, and all participants provided written informed consent.

COVERAGE SCHEDULES

Using a within-subjects design, we studied 20 interns during two three-week rotations in the medical intensive care unit (MICU) and coronary care unit (CCU) while they followed a traditional schedule with extended work shifts of 30 consecutive hours scheduled every other shift and an intervention schedule in which work shifts were a maximum of 16 consecutive hours scheduled. The remaining four subjects were studied while they followed a pilot intervention schedule that was discontinued after the first MICU rotation (data not included). During the traditional schedule, three interns provided continuous coverage on a three-day cycle, officially consisting of a day shift (approximately 7 a.m. to 3 p.m.) on day 1 followed by an extended work shift from 7 a.m. on day 2 to noon on day 3, although in actual practice, interns often worked beyond those hours (Fig. 2A). The interns staffed weekly ambulatory clinics when the clinics coincided with day 1 or day 3, and the average scheduled hours totaled approximately 77 to 81 hours per week, depending on the clinic assignment. During the intervention rotation, four interns provided continuous coverage on a four-day schedule, consisting of a standard day shift (approximately 7 a.m. to 3 p.m.) on day 1, "day call" on day 2 from 7 a.m. to 10 p.m. (the first half of the traditional extended work shift), and "night call" on days 3 through 4, from 9 p.m. on day 3 to 1 p.m. on day 4 (the second half of the traditional extended shift), although the interns often worked longer than their scheduled hours on the intervention schedule as well (Fig. 2C). The maximal scheduled duration of a shift was 16 hours. Interns staffed clinics only during day shifts (day 1); thus, the maximal number of scheduled work hours was approximately 60 to 63 hours per week. To counter the effects of extended wakefulness before night work, interns were advised to take an afternoon nap before starting the night call. During the traditional schedule, no such opportunity was available, owing to the requirement to work continuously during the day and night. In the two weeks before each study rotation, the interns worked primarily on an ambulatory clinic rotation.

WORK-HOUR MEASUREMENTS

Interns recorded work hours in a daily log. Study staff also kept independent logs of interns' work hours, whenever possible. Concurrent data were available for 75 percent of work shifts and were significantly correlated in all subjects (mean r=0.98; range, 0.91 to 0.99; P<0.001 by Student's t-test). Weekly work hours were compared between the two schedules by within-subjects paired Student's t-tests. The proportion of hours worked during extended shifts was compared between rotations by means of a chi-square test.

SLEEP MEASUREMENTS

Interns completed a daily log recording details of sleep episodes. At least three days per week during MICU or CCU rotations, interns underwent continuous ambulatory polysomnographic (Vitaport-2/3, TEMEC Instruments) monitoring[20] while at work or at home. On the basis of an average (±SD) of 334.5±33.4 hours of interpretable polysomnographic recordings with concomitant sleep logs per subject, 95.6±1.8 percent of the 30-second intervals, termed "epochs" (as defined in the Supplementary Appendix), during which polysomnographic data were scored concurred with the sleep-log entries. The total sleep time per rotation derived from the two methods was also correlated across the 20 interns (r=0.94, P<0.001).

The weekly duration of sleep was compared between the two schedules by within-subjects paired Student's t-tests. The number of hours of sleep in the preceding 24 hours was calculated for each work hour and compared between rotation types by means of a chi-square test.

ATTENTIONAL-FAILURE MEASUREMENTS

Attentional failures were identified by means of continuous electrooculography (EOG) and defined as intrusion of slow-rolling eye movements into polysomnographically confirmed episodes of wakefulness during work hours. The number of slow eye movements recorded during all waking polysomnographic epochs was determined by a single scorer according to established criteria in an unblinded fashion.[21] Results were then validated in a blinded fashion by an independent scorer who compared them with the rates recorded from 9 p.m. to 3 p.m. in a subgroup (10 percent) of EOG recordings (r=0.94, P<0.001). The number of 30-second EOG epochs containing at least one slow eye movement was expressed as a percentage of a subject's time awake and compared within subjects at corresponding clock times between the two schedules by means of Student's t-test.

All statistical tests were two-tailed. Error estimates represent the standard deviation of the mean unless specified.

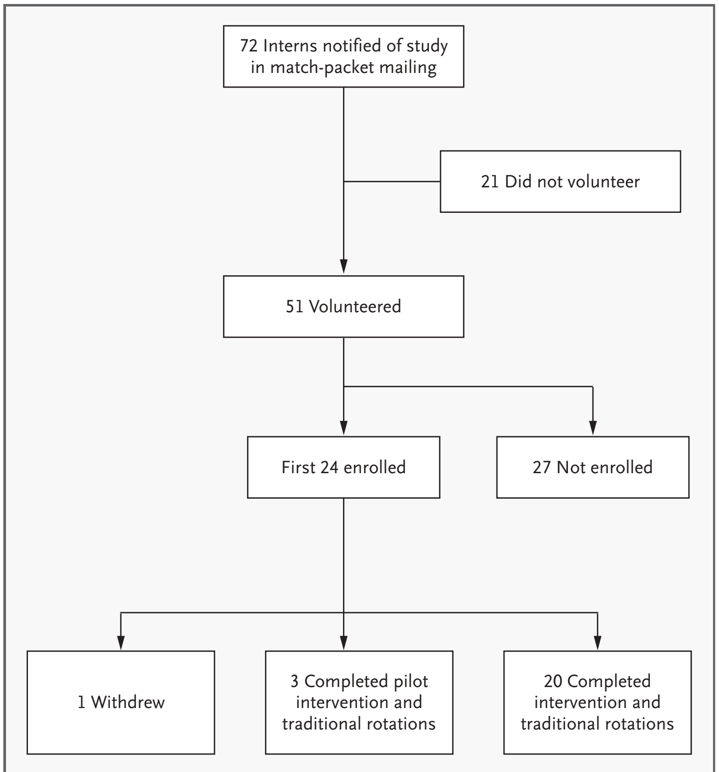


Figure 1. The Recruitment Procedure.

RESULTS

WORK HOURS

All 20 interns worked longer during the traditional schedule (mean, 84.9±4.7 hours per week; range, 74.2 to 92.1) than during the intervention schedule (mean, 65.4±5.4 hours per week; range, 57.6 to 76.3; P<0.001) (Fig. 3A). Seventeen of the 20 interns

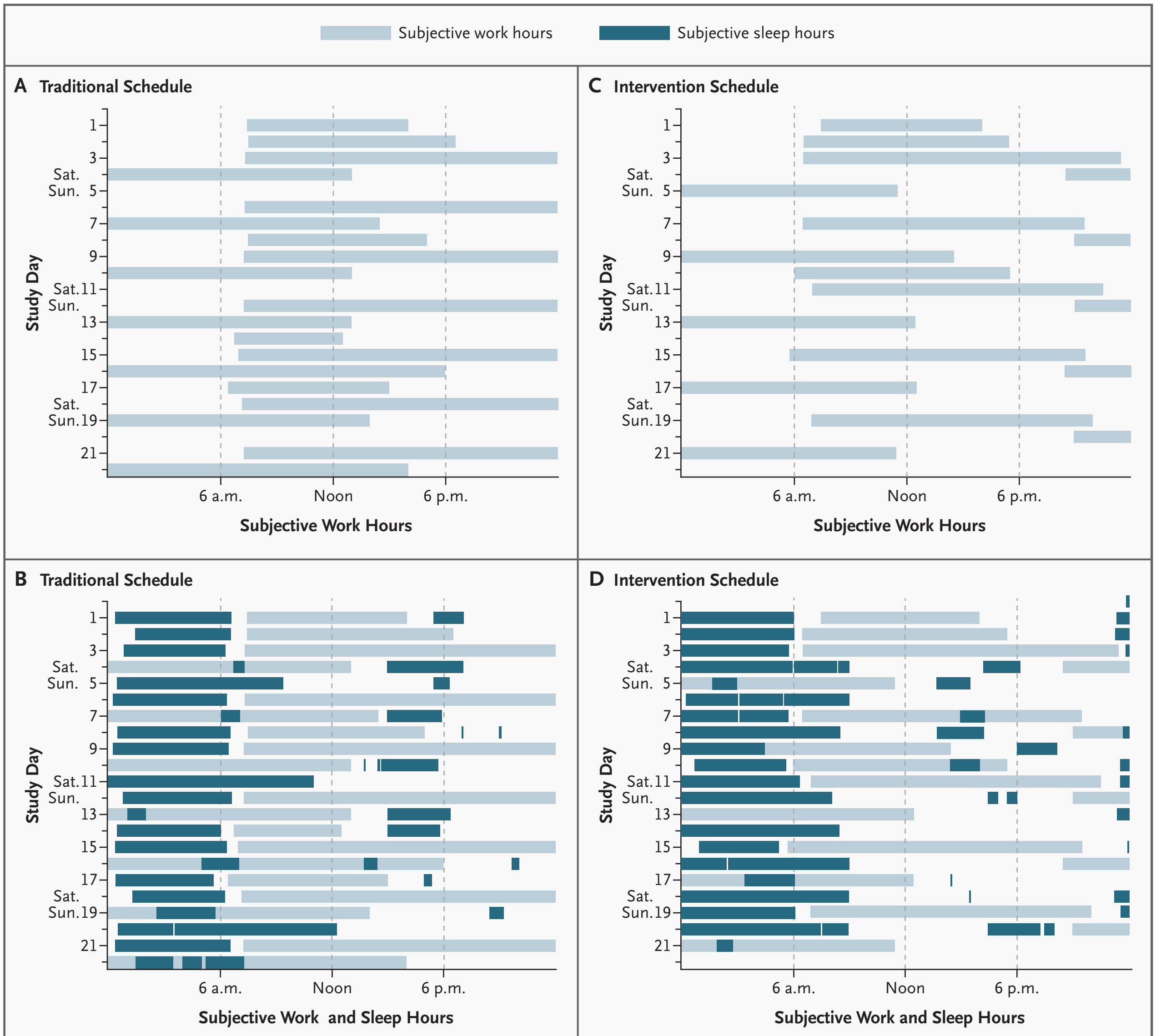


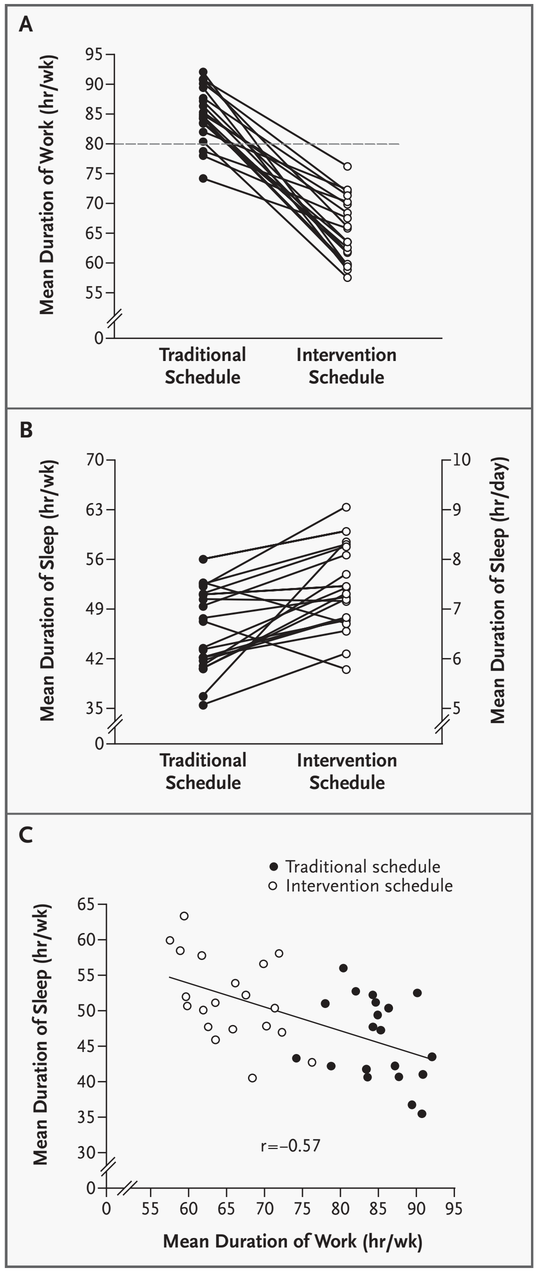
Figure 2. The Pattern of Subjective Work Hours and Subjective Hours of Sleep Reported by a Single Intern Working in an ICU during the Traditional Schedule (Panels A and B) and the Intervention Schedule (Panels C and D).

Sequential study days are shown on the ordinate of each panel, with weekend days included for reference, and clock time is shown on the abscissa. Both work rotations started on a Wednesday (day 1) and ended on a Tuesday (day 21) unless the last work shift was scheduled to be overnight (e.g., days 21 through 22 in Panel A). This intern worked an average of 83.4 hours per week during the traditional schedule, as compared with 62.6 hours per week during the intervention schedule. In Panels B and D the subjective sleep times are superimposed over work hours, including the hours the intern spent asleep while at the hospital (e.g., approximately 6 a.m. on days 4, 7, and 16 in Panel B). This intern slept 41.8 hours per week during the traditional schedule and 47.8 hours per week during the intervention schedule.

worked more than 80 hours per week during the traditional schedule, whereas all interns worked less than 80 hours per week during the intervention schedule (Fig. 3A). The average difference in work hours was 19.5 hours per week (range, 8.4 to 32.4), or 69.2 hours per rotation (range, 26.3 to 107.3). There was no correlation between an individual intern's work hours during the pre-ICU ambulatory clinic rotation and his or her subsequent ICU rotation (r=0.20, P=0.44 during the traditional schedule; r=−0.20, P=0.43 during the intervention schedule) or between an individual intern's

Figure 3. Subjective Mean Hours of Work per Week (Panel A), Duration of Sleep (Panel B), and the Relationship between the Duration of Work and the Duration of Sleep (Panel C) for 20 Interns during the Traditional Schedule and the Intervention Schedule.

All subjects worked less during the intervention schedule than during the traditional schedule (mean decrease, 19.5 hours per week) (Panel A). All but three subjects worked more than 80 hours per week during the traditional schedule, whereas the maximal number of hours worked during the intervention schedule was 76.3 hours. All but three subjects slept more during the intervention schedule, with the group averaging 5.8 hours more sleep per week (Panel B). The duration of work and the duration of sleep were inversely correlated (r=–0.57, P<0.001) (Panel C) during the traditional and intervention schedules, with the best-fit regression predicting a 19.2-minute loss of sleep per week for every additional hour of work per week.



two ICU rotations (r=0.05, P=0.85). Additional results are provided in Table 1 of the Supplementary Appendix.

During the traditional rotation, over half of work shifts (133 of 223, or 60 percent) were extended (more than 24 hours) and 84 percent of work hours (4255 of 5036) occurred during these shifts (Fig. 4A) — with 21 percent of these work hours logged after more than 24 hours of continuous duty. The intervention schedule had no extended work shifts (Fig. 4B), and 96 percent of work hours occurred within the 16 hours scheduled, in contrast to the traditional schedule, in which only 58 percent of work hours occurred within the first 16 hours on duty.

DURATION OF SLEEP

Interns slept an average of 45.9±5.9 hours per week (6.6±0.8 hours per day) during the traditional schedule, 5.8 fewer hours per week than during the intervention schedule (mean, 51.7±6.0 hours of sleep per week, or 7.4±0.9 hours per day; P<0.001). All but three interns slept more during the intervention schedule than during the traditional schedule (Fig. 3B).

DURATION OF WORK AND SLEEP

The weekly durations of sleep and work were significantly inversely correlated (r=–0.57, P<0.001), with a predicted loss of 19.2 minutes of sleep per week for each additional hour of work per week (Fig. 3C). During the traditional schedule, 31 percent of work hours were preceded by 4 or fewer hours of sleep in the preceding 24 hours and 19 percent of work hours were preceded by 2 or fewer hours of sleep in the previous 24 hours, as compared with 13 percent and 6 percent, respectively, during the intervention schedule (P<0.001 for both comparisons) (Fig. 4C). The percentage of work hours preceded by more than 8 hours of sleep in the prior 24 hours was 17 percent during the traditional schedule and 33 percent during the intervention schedule (P<0.001) (Fig. 4C). Interns reported

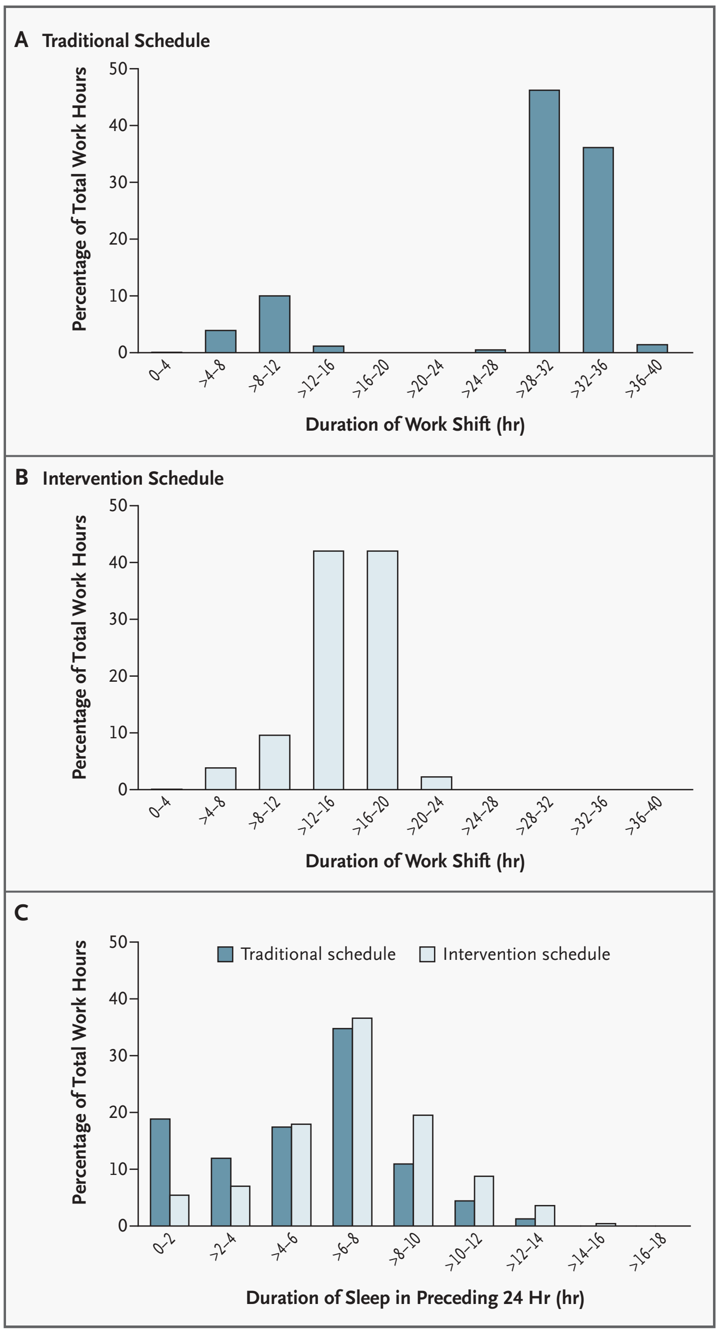


Figure 4. Proportion of Total Work Hours Plotted against the Duration of the Shift during the Traditional Schedule (Panel A) and the Intervention Schedule (Panel B) and the Percentage of Total Work Hours That Occurred after Various Amounts of Sleep in the Preceding 24 Hours (Panel C).

During the traditional schedule, the majority of work hours (84 percent) were during extended work shifts (more than 24 hours) (Panel A), whereas there were no work hours during extended shifts on the intervention schedule (Panel B). Panel C shows the distribution of work hours relative to the duration of sleep in the prior 24 hours for the traditional and intervention schedules. A greater proportion of work hours during the traditional schedule than during the intervention schedule (48 percent vs. 31 percent) were preceded by 6 or fewer hours of sleep in the preceding 24 hours, whereas twice as many work hours were preceded by more than 8 hours of sleep in the preceding 24 hours during the intervention schedule as during the traditional schedule (33 percent vs. 17 percent).

taking a prophylactic nap before night call during the intervention schedule on 69.9±30.8 percent of occasions.

On average, interns slept for 1.76±1.04 hours between 9 p.m. and 8 a.m. during the traditional schedule, significantly longer than they slept while working the corresponding hours during the intervention schedule (1.29±0.90 hours per shift, P=0.02).

ATTENTIONAL FAILURES

Attentional failures occurred at more than double the rate during the night (from 11 p.m. to 7 a.m.) on the traditional schedule as compared with the intervention schedule (P=0.02) (Fig. 5) and 1.5 times the rate during the day (7 a.m. to 10 p.m.) (P=0.07).

DISCUSSION

The elimination of extended work shifts had a significant effect on the number of hours worked by interns, the duration of sleep, and the rate of attentional failures. Eighty-four percent of the work hours on the traditional schedule occurred during extended work shifts (24 hours or more), as compared with 0 percent on the intervention schedule. The traditional schedule had three times as many shifts that were prefaced by fewer than 2 hours of sleep in the preceding 24 hours and more than twice as many attentional failures during night work as did the intervention schedule.

Daily reports, validated by simultaneous independent objective assessments, captured the high degree of variability in work hours and sleep across rotations with greater precision than did residents' estimations of work hours, sometimes covering an entire year or longer, used in previous studies.[12,13,15,16,22] For example, work hours during the pre-ICU clinic rotation averaged 40 hours per week but increased to 85 hours per week during the three-week traditional ICU schedule. The resulting four-week average of 74 hours per week, calculated as specified by the ACGME,[1] means that interns' schedules in high-intensity settings can far exceed the weekly work-hour limits of "no more than 80 hours in *any* week" and "no more than 12 hours of continuous duty" specified by the Association of American Medical Colleges.[23]

The average of 85 hours of work per week during the traditional schedule represented half of the 168 hours available in a week (every other shift on the schedule averaged 32 hours, despite this being termed a "Q3," or "every third night," call schedule) and did not include other work-related activities, such as commuting or studying. With such a large proportion of the available hours used for work, it is not surprising that the amount of time interns spent sleeping was directly related to the duration of work, with approximately one third of the newly available free time on the intervention used for sleep, an increase of nearly an hour per day. Moreover, as compared with their patterns of sleep during the traditional schedule, interns worked half as many shifts during the intervention schedule after having had 4 or fewer hours of sleep in the prior 24 hours and twice as many shifts after having had more than 8 hours of sleep in the preceding day. They also slept significantly less during night work during the intervention schedule. These results demonstrate that interns working on the intervention schedule were less sleep-deprived at work and were more often able to sleep longer during nonwork hours to counteract in part the cumulative and acute performance- and health-related adverse effects of sleep deprivation.[24-28]

The acute and chronic sleep deprivation inherent in the traditional schedule[14] caused a significant increase in attentional failures in interns working at night. The robustness of this result, which was evident in 13 of the 20 interns, is striking, considering the fact that caffeine use, compliance with the protocol, and individual differences in the need for sleep among subjects could not be controlled in this field study. The presence of slow-rolling eye movements during wakefulness is indicative of profound fatigue in both occupational settings[29] and laboratory settings[21] and parallels subjective sleepiness, theta activity on electroencephalography, and impaired neurobehavioral performance[21,29] similar to those observed among subjects in studies of acute and chronic partial sleep deprivation[24,25] and in previous studies of residents.[18,30-33] Slow eye movements are correlated with performance failures on the psychomotor vigilance task[21] and are reduced by treatments that counteract fatigue and thus improve neurobehavioral performance.[34-36] The increased incidence of attentional failures during night work among interns during the traditional as compared with the intervention schedule may impede their ability to care for patients and their education.[27,37] It is noteworthy that interns took prophylactic naps before two thirds of the overnight shifts during the intervention schedule, thereby preemptively attenuating the deleterious effects on alertness and neurobehavioral performance of continuous wakefulness and blunting the circadian performance nadir.[38] Although the relative contribution of these and other factors to the observed improvement cannot be determined from our findings, we believe it unlikely that simply decreasing the number of hours worked in a week without incorporating the underlying principles of sleep physiology would yield a similar increase in sleep or reduction in attentional

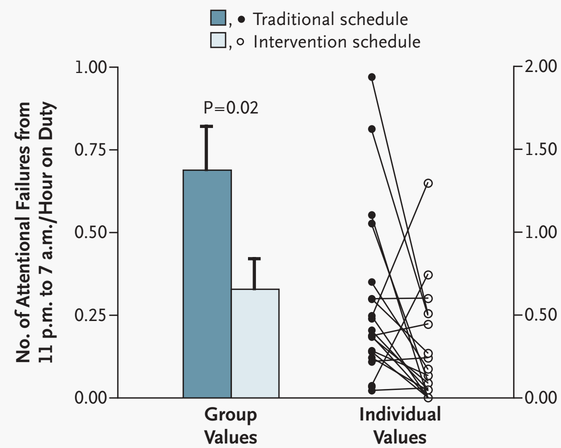


Figure 5. **Mean (+SE) Number of Attentional Failures among the 20 Interns as a Group and Individually while Working Overnight (11 p.m. to 7 a.m.) during the Traditional Schedule and the Intervention Schedule.**

The number of attentional failures was determined by the presence of at least one electrooculography-derived slow eye movement while the subject was awake and at work. The rate of attentional failures among interns who were working overnight (from 11 p.m. to 7 a.m.) during the intervention schedule (0.33 per hour, or 2.6 attentional failures per intern overnight) was less than half that during the corresponding times on the traditional schedule (0.69 per hour, or 5.5 attentional failures per intern overnight; P=0.02), and a trend (P=0.07) toward a reduction in attentional failures during day and evening call (7 a.m. to 10 p.m.) was also apparent (data not shown). Thirteen of the 20 interns had a decrease in the number of slow eye movements during overnight work on the intervention schedule as compared with the traditional schedule.

failures. For example, changing the frequency of extended work shifts from every other shift to every third shift would be unlikely to cause a similar reduction in attentional failures despite effecting a similar reduction in weekly work hours, because interns would still be required to work extended shifts.

Superimposed on the population effects are interindividual variations in the detrimental effects of sleep restriction. Nearly a quarter of the population,[39] including night-shift workers[40] and residents,[30] is particularly sensitive to sleep loss. This sizable and unidentified proportion of the population may be particularly vulnerable to the effects of extended work shifts and chronic sleep restriction imposed during residency training, possibly unwittingly placing themselves and their patients at markedly increased risk for fatigue-related errors.

The intervention schedule had limitations. Despite the fact that the extended work shift was split in half, most work shifts remained long enough to induce significant decrements in neurobehavioral performance owing to sleep deprivation[21,24] and still exceeded the limits imposed by many other safety-sensitive industries, such as transportation and nuclear power, on the number of consecutive hours of work. Moreover, the interns often had to rise between 4 a.m. and 6 a.m., the time of maximal sleep propensity and efficiency in this age group,[41] to review their patients' progress before morning rounds. Since nearly a third of their work hours (31 percent) were thus preceded by 6 or fewer hours of sleep in the preceding 24 hours, they continued to carry a substantial sleep debt, accounting for the high residual rate of attentional failures on both schedules, even during the day.[22] Furthermore, during both the traditional and the intervention schedule, reported work hours often exceeded both the scheduled weekly hours and the number of consecutive work hours scheduled, owing to the interns' obligation to ensure the continued care of their patients after their own shift was over. Our data on actual work hours reveal that the maximal number of scheduled work hours must be much lower to allow for this inevitability.

Our study provides objectively validated data on work hours, sleep, and attentional failures among medical trainees in situ and quantifies the effects of eliminating extended work shifts on these measures. Our findings may apply not only to residents working in critical care units but also to those on other rotations and specialties and to more senior residents, attending physicians, nurses, and others. Future studies should further evaluate the effects of current working practices on physicians and objectively measure the effect of interventions designed to improve physicians' health and patients' safety.

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When Policy Meets Physiology

The Challenge of Reducing Resident Work Hours

Steven W. Lockley, PhD; Christopher P. Landrigan, MD, MPH; Laura K. Barger, PhD; and Charles A. Czeisler, PhD, MD

Considerable controversy exists regarding optimal work hours for physicians and surgeons in training. In a series of studies, we assessed the effect of extended work hours on resident sleep and health as well as patient safety. In a validated nationwide survey, we found that residents who had worked 24 hours or longer were 2.3 times more likely to have a motor vehicle crash following that shift than when they worked < 24 hours, and that the monthly risk of a crash increased by 16.2% after each extended duration shift . We also found in a randomized trial that interns working a traditional on-call schedule slept 5.8 hours less per week, had twice as many attentional failures on duty overnight, and made 36% more serious medical errors and nearly six times more serious diagnostic errors than when working on a schedule that limited continuous duty to 16 hours. While numerous opinions have been published opposing reductions in extended work hours due to concerns regarding continuity of patient care, reduced educational opportunities, and traditionally-defined professionalism, there are remarkably few objective data in support of continuing to schedule medical trainees to work shifts > 24 hours. An evidence-based approach is needed to minimize the well-documented risk that current work hour practices confer on resident health and patient safety while optimizing education and continuity of care.

For The Harvard Work Hours Health and Safety Group
From the Division of Sleep Medicine, Brigham and Women's Hospital, Boston, MA; Division of Sleep Medicine, Harvard Medical School, Boston, MA.
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Correspondence to: Steven W. Lockley, PhD, Division of Sleep Medicine, Department of Medicine, Brigham and Women's Hospital, Harvard Medical School, 221 Longwood Avenue, Boston, MA 02115. Phone: 617-732-4977; Fax: 801-729-9929; E-mail: slockley@hms.harvard.edu.
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Considerable controversy exists regarding the optimal work hours of physicians and surgeons in training. It has long been suspected that extended work hours negatively affect medical[33,34,87] and surgical[37] performance, and are possibly damaging to resident health and well-being.[32,63,70,73,75] Consequently, there have been several sporadic, largely unsuccessful attempts to limit physicians' work hours, often in response to high profile adverse events thought to be related to long work hours.[68] More recently, guidelines set forth by the Accreditation Council for Graduate Medical Education (ACGME) in the US have reignited this debate and have brought the medical and surgical professions to what is considered by some to be a defining and allegedly disastrous moment in their history.[29]

In 2003, the ACGME mandated a maximum 80-hour work week, restricted continuous on-call shifts to 30 hours and insisted that residents had one day off per week.[1] Closer inspection of these regulations, however, reveals subtleties that dilute their impact and, in fact, largely permit a continuation of the status quo in most hospitals. For example, the weekly work hour limit is averaged over four weeks, thereby allowing several weeks in excess of 80 hours. An additional 8 hours per week, or 32 hours/4 weeks, can be requested in many specialties, allowing a maximum of 352 hours of work per four weeks. Similarly, days off are also averaged over four weeks and the regulations therefore permit residents to work for 24 consecutive days without a day off, as long as this is followed by four consecutive days off. Moreover, continuous on-call duty hours can be routinely extended past 24 hours with an additional 6 hours allowed for teaching and continuity of care; this "30-hour" limit (24 + 6) is used daily in most medical centers. Altogether, while these limits have attempted to eliminate extreme extended duration work shifts of 32 or more hours that occasionally occurred before their implementation, the ACGME has avoided a paradigm shift in the traditional scheduling of medical residents. Many residency programs have therefore largely been able to maintain their pre-existing resident on-call schedules with minimal modifications.[55] Notable exceptions are those surgical training programs which routinely required residents to work 100 or more hours per week[8]; such programs have had a greater challenge meeting these limits.[48]

In this paper, we review the physiological principles underlying fatigue, and a series of studies by the Harvard Work Hours Health and Safety Group quantifying the negative effects of extended duration work shifts on resident health and patient safety. We found that residents who had worked 24 hours or longer were 2.3 times more likely to have a motor vehicle crash following that shift than when they worked < 24 hours, and that the risk of a crash increased by 16.2% per month after each extended duration shift. We also found in a randomized trial that interns working a traditional on-call schedule slept 5.8 hours less per week, had twice as many attentional failures on duty overnight, and made 36% more serious medical errors and six times more serious diagnostic errors than when working on a schedule that limited continuous duty to 16 hours. Furthermore, we review the need for additional objective research in this area to ensure that future policy developments are based on scientific evidence rather than subjective opinion.

Principles of Sleep Medicine Underlying Fatigue

It is beyond dispute that sleep deprivation adversely affects safety and performance. In many other safety-orientated industries, the deleterious effects of extended duty hours and working at night have been recognized and addressed. The public also readily understands the concept that fatigue increases and performance worsens with increasing hours awake. In fact, 86% of those who responded to a National Sleep Foundation survey reported that they would likely feel anxious about their safety if they learned their surgeon had been on duty > 24 hours, with 70% likely to ask for a different doctor and 60% assuming that the procedure was unlikely to go well.[60] During the past 30 years there have been considerable advances in the understanding of the neurobiology of sleep and the rhythmic processes underlying sleep patterns, and there now exist a multitude of studies quantifying the negative impact of sleep loss and shift work on short-term fatigue, performance, and learning,[24,76] and more recently on longer-term health and metabolic consequences.[4,49,74]

There are four major physiological determinants of alertness and performance: circadian phase, number of hours awake, nightly sleep duration, and sleep inertia. The detrimental effects of each of these four factors are exacerbated by the extended on-call shifts experienced by residents and, consequently, their performance is likely to be degraded (Fig 1). First, residents regularly work during the biological night when the endogenous drive for alertness is lowest. Second, extended on-call shifts demand long continuous episodes of wakefulness that induce fatigue. Third, residents are regularly exposed to chronic partial sleep deprivation for many months at a time as they repeatedly fail to gain adequate recovery sleep after extended shifts. Finally, residents who do manage to sleep for a few minutes when on-call are often asked to perform emergent actions immediately upon awakening when sleep inertia is maximal.

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

Fig 1. Physiological consequences of current resident schedules

Circadian rhythms

The daily 24-hour rhythm in alertness and performance is driven by an endogenous circadian pacemaker situated in the suprachiasmatic nuclei (SCN) of the hypothalamus, with the maximal drive for alertness emanating from the pacemaker during the biological day, and maximal drive for sleepiness during the biological night (Fig 2). The adverse effects of attempting to maintain wakefulness during the biological night have measurable consequences, as illustrated by the elevated rate of single-vehicle truck accidents at night compared to daytime accidents,[59] and the increase in work-related accidents by night-shift workers compared to day workers.[31] Furthermore, misalignment of the sleep-wake cycle and the circadian pacemaker greatly affects the quality and quantity of sleep attained and subsequently impairs recovery.[17,21] A sleep opportunity starting at 11pm will lead to more consolidated and extended sleep than the same opportunity at 11 am.

Number of hours awake

In laboratory and field studies conducted among medical and non-medical personnel, increased time awake has repeatedly been proven to lead to decreased alertness and poorer performance. Acute continuous sleep deprivation has a profound impact on fatigue and, under laboratory conditions, alertness and performance decline in a sigmoidal manner, at least over the first 50 hours of wakefulness.[44] Notably, impairment of performance has been equated to that associated with blood alcohol concentration[6,18] with cognitive performance after 19 hours of sustained wakefulness equivalent to a 0.05% blood level, and after 24 hours equal to approximately 0.10% blood alcohol concentration.[18] Under real-world conditions, it is well documented that the risk of fatigue-related fatal truck crashes increases with increased hours driving[20] and consequently federal regulations limit the number of consecutive hours that truckers can drive; there is a greater than 15-fold increase in the risk of a fatigue-related fatal crash after more than 13 hours awake compared to the first hour.[20]

The interaction of these circadian and homeostatic processes, quantified in laboratory studies,[22] is exacerbated during traditional resident schedules (Fig 3).[13] As described above, the circadian drive for sleep is maximal toward the end of the night (Fig 2) and, as also described above, increased time spent awake increases fatigue. A resident beginning their 30-hour extended duration shift beginning at 7:00 am will, during and after their night on-call, not only work through their circadian nadir but simultaneously will have been awake for 24 hours or more, vastly amplifying the risk of a fatigue-related lapse of attention during this critical zone of vulnerability (Fig 3).[13] Whereas federal regulations limit the number of consecutive hours that truck drivers can drive or pilots can fly to reduce this risk, postgraduate medical professionals are currently allowed to work, and to drive after their shifts, during this particularly susceptible time.

Chronic partial sleep deprivation

Under normal conditions, the sleep pressure accumulated during wakefulness is dissipated during sleep to the extent

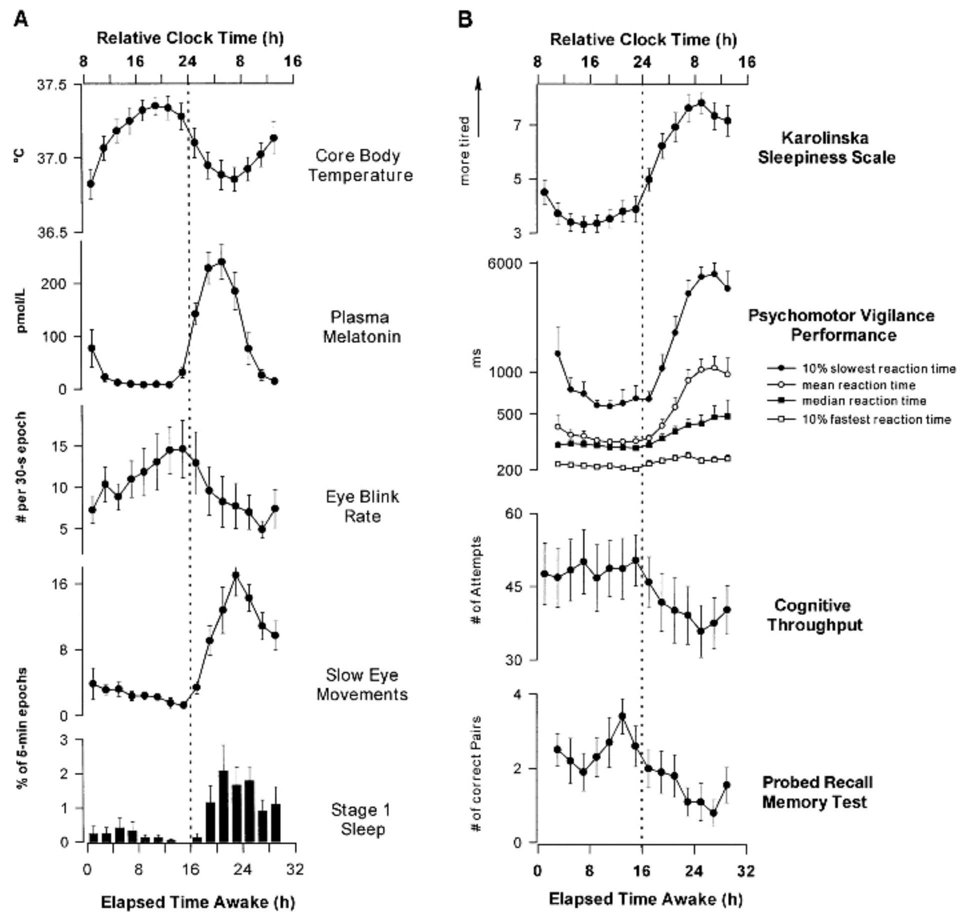

Fig 2A–B. Endogenous circadian rhythms in human physiology and subjective and objective correlates of alertness. Ten subjects were studied for up to 32 hours of continuous wakefulness after waking at their habitual time while supervised under constant conditions (posture, lighting, nutrient intake; see[12] for details). (A) The endogenous fall in core body temperature and rise in the sleep-promoting hormone melatonin in the late evening (upper panels) are accompanied by a simultaneous increase in polysomnographically-derived eye blink rate, slow rolling eye movements and frank Stage 1 sleep (lower panels), measures considered reliable physiological markers of fatigue. (B) Subjective ratings of sleepiness also increase at this time (upper panel), and psychomotor performance, cognitive throughput and short-term memory begins to deteriorate (lower panels). Subjective and objective measures of sleepiness are maximal, and performance is worst, during the early hours of the morning before gradually improving (although not to levels equivalent to 24 hours earlier) as the circadian drive for alertness increases again. Although average reaction times at the circadian low point average approximately 1 second, the slowest 10% of responses average nearly 6 seconds before the subject reacts to a visual stimulus (second panel down in column B) and, in a real-world environment, could represent a significant lapse of attention, for example while driving or performing surgery. Reproduced with permission from C Cajochen, SB Khalsa, JK Wyatt, CA Czeisler, D-J Dijk. EEG and ocular correlates of circadian melatonin phase and human performance decrements during sleep loss. *Am J Physiol.* 1999;277:R640–R649.

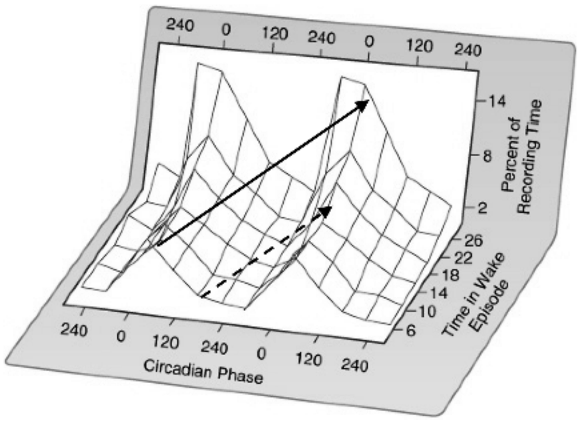

Fig 3. Interaction of circadian phase and duration of wakefulness on waking function. The rate of slow-rolling eye movements, a reliable marker of fatigue,[12,53] was measured during a specialized laboratory protocol designed to separate the circadian and homeostatic contribution to waking function.[13] Circadian phase (and relative time of day; 0º ≡ 6:00 am, 120º ≡ 2 pm, 240º ≡ 10:00 pm) is plotted on the x axis, increasing time awake on the y axis and the percent of electrooculogram recording time containing slow-rolling eye movements plotted on the z axis. There is a clear circadian rhythm in the rate of slow eye movements, with maximal fatigue in the early morning. There is also an increase in the rate of slow eye movements with increasing time awake. The interaction between these two processes is indicated by the two example trajectories shown, illustrating two potential resident shifts. The solid arrow indicates the evolution of fatigue of an individual waking at 6:00 am and working an extended duration work shift for the next 24 hours. Fatigue remains fairly stable for the first ~16–18 hours after which it rapidly increases as increased time awake coincides with the endogenous circadian decline in alertness to potentially dangerous levels. The dotted arrow shows fatigue for someone working overnight having had a sleep prior to starting the night shift. While fatigue also deteriorates with increased time awake, the later time of day at which the wake episode starts prevents the cumulative interaction between time awake and adverse circadian phase; even if the individuals remain awake all night, they never reach as high a level of fatigue during the early hours as the resident on duty continuously. Modified with permission from Czeisler CA, Buxton OM, Khalsa SBS. The human circadian timing system and sleep-wake regulation. In: Kryger MH, Roth T, Dement WC, eds. *Principles and Practices of Sleep Medicine,* 4th ed. Philadelphia, PA: W.B. Saunders Company; 2005:375–394.

that alertness is restored to near-maximal levels upon awakening, largely through homeostatic regulation of slow-wave (stage 3/4) sleep.[10] Several lines of evidence suggest that young adults would sleep ~8.4–8.6 hours per night if given sufficient opportunity,[67,85] far more sleep than is obtained by similar-aged residents.[8,53,73] Repeated failure to obtain sufficient sleep to fully recover from the previous wake episode has a cumulative detrimental effect on alertness and performance that increases linearly with sleep loss (Fig 4).[77] After less than two weeks with only 6 hours in bed per night, performance levels are equivalent to those observed after 24 hours of acute sleep deprivation (Fig 4).[77] At four hours in bed per night, it takes only seven days to reach that level and after two weeks, performance is equivalent to 48 hours without sleep. Current resident schedules thus often lead to chronic partial sleep deprivation.[73] F4

Sleep inertia

The fourth fatigue-related factor affecting performance is the phenomenon of sleep inertia. Regardless of the timing or duration of sleep, alertness and performance are impaired upon waking. The "grogginess" experienced after waking up does dissipate rapidly; although the effects of sleep inertia are most severe in the first 15–30 minutes after awakening, it may take as long as 1–2 hours to realize a fully alert state.[45] Unfortunately, the first few minutes are precisely the time during which residents must make critical decisions when awakening in response to an emergent page, greatly increasing the risk of a fatigue-related error.[71]

While the fundamental principles underlying sleep and fatigue have primarily been examined under laboratory conditions, there are many complementary examples of the same processes affecting resident performance, health and well-being.[30,35,65,79] As long as 30 years ago it was recognized that highly sleep-deprived physicians made more errors[33] and performed surgery at an inferior level[37] compared to better rested ones. More recently, simulated surgical performance was found to take longer and be of poorer quality and efficiency after a 17 hour overnight call than prior to the call.[39] Not all studies appear to be consistent, however. For example, a recent examination of cardiac surgery outcomes in the previous decade showed no differences in operative efficiency, morbidity or mortality for operations performed by residents retrospectively designated as sleep-deprived or non-sleep-deprived.[26] Unfortunately, this study did not use validated instruments to determine sleep deprivation or work hours and, while categorizing surgeons into sleep-deprived and non-sleep-deprived groups based on the timing of cases may appear to be reasonable, this approach fails to recognize the major role that chronic sleep deprivation plays in determining fatigue and which was likely to be high in both groups. Furthermore, the study was not sufficiently powered to detect a difference between the sleep-deprived and non-sleep deprived groups due to the relatively low error and mortality rates described. Such confounds underscore the need for prospective research using validated methods to determine the contribution of fatigue to medical and surgical performance. Collectively, however, the weight of

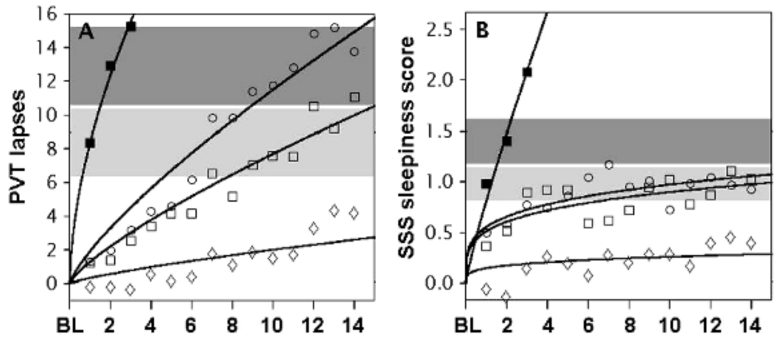

Fig 4. Effect of different amounts of acute and chronic partial sleep deprivation on alertness and performance.[77] The daily averages from tests performed every two hours (7:30–23:30 h) for the number of lapses on the Psychomotor Vigilance Task (PVT) (panel A) and subjective alertness (Stanford Sleepiness Scale, SSS) (panel B) are shown for subjects undergoing 88 hours of sleep deprivation (■; n = 13 M; 27.3 ± 4.6 yrs), or given 8 hours (◇; n = 9, 7 M; 24.1 ± 2.2 yrs), 6 hours (□; n = 13, 10 M; 30.1 ± 4.5 yrs) or 4 hours (○; n = 13, 12 M; 27.7 ± 5.4 yrs) time in bed per night for 14 days. Performance and alertness were maintained at baseline levels in those with 8 hours sleep opportunity per night in bed. Performance deteriorated in both the 6- and 4-hour sleep groups such that after 14 days, the 6-hour sleep group performed at an equivalent level to those kept awake for 24 hours continuously, and the 4-hour group was performing at the same level as someone kept awake for three whole days (panel A). Subjective sleepiness ratings, however, did not deteriorate in parallel with performance and both the 6- and 4-hour sleep groups reporting maximal sleepiness approximately equivalent to 24 hours of acute sleep deprivation. These results indicate that residents who have less than 8 hours sleep per night are likely to experience deterioration in their performance due to chronic partial sleep deprivation not represented by their own perception of how sleepy they are. Reproduced with permission from HP Van Dongen, G Maislin, JM Mullington, DF Dinges. The cumulative cost of additional wakefulness: dose-response effects on neurobehavioral functions and sleep physiology from chronic sleep restriction and total sleep deprivation. *Sleep.* 2003;26:117–126.

current evidence strongly suggests that resident on-call schedules cause fatigue and impair performance.[30,35,65,79]

A potentially important area of research applicable to medical and surgical resident education is the emerging role of sleep on learning, particularly motor learning, and memory.[76] A major concern of limiting resident work hours is the perceived reduction in educational opportunities.[55] Although the raison d'etre of residents is to receive graduate education, it can be argued that residents provide an inexpensive labor source, the advantages of which are multiplied by permitting excessive work hours. Current resident schedules provide many experiential opportunities, but are not necessarily designed to optimize learning during these experiences. It is hard to learn anything when sleeping through grand rounds post-call, and even more active learning experiences (eg, time in the operating room) are likely to be of lower educational value when residents are sleep-deprived. The role of sleep on residents' learning and consolidation of memory has recently shed light on the educational risks of sleep deprivation.[25] Of particular relevance to surgical residents are a series of papers showing that visual discrimination, motor learning and insight are dependent on adequate sleep following the initial learning opportunity.[76,81–83] Failure to sleep the night after learning a task, or having insufficient duration of a particular sleep stage, may impair residents' ability to consolidate learning about certain procedures and subsequently make improvements.[41,83] Although not all tasks exhibit this phenomenon, the potential adjunct role for sleep to facilitate learning in residents, or act as a barrier if sleep is inadequate, demands further investigation.

Harvard Work Hours Health and Safety Group

In 2002, the Harvard Work Hours Health and Safety Group embarked on a series of studies to contribute objective data to the debate concerning resident work hours. We aimed to test the hypotheses that extended work hours would have a negative effect on residents' sleep, performance and health, and patient safety. The first results were recently published[9,51,53] and the major findings are reviewed herein.

Nationwide survey of sleep, work hours and motor vehicle crashes

In the residency year prior to publication of the ACGME guidelines on duty hours, we conducted a prospective nationwide survey of 2737 PGY-1 residents (53% female, mean age ± SD = 28.0 ± 3.9 yrs).[9] Medical residents represented 79% of the cohort, 11% were in surgical programs and 10% were in other or non-specified specialties; 85% were US medical school graduates. Using a web-based survey tool, volunteers completed a total of 17,003 monthly reports between June 2002 and May 2003 about their sleep, work hours and extended duration work shifts, motor vehicle crashes and near-miss incidents, and self-reported attentional failures while driving, among 60 other questions. Volunteers from those who were matched to a residency by the National Resident Matching Program or who were graduates of US medical schools were invited to participate by e-mail.

We employed a series of validation procedures to ensure data collected through this survey methodology were accurate. Firstly, a random selection of 7% of participants completed daily work hour and sleep diaries for at least 3 of the 4 weeks requested, a method which we had previously shown correlated highly (r ≥ 0.98) with work hour reports from continuous observation and polysomnographically-determined sleep, respectively.[53] The number of work hours reported on the survey per month (mean ± SD = 249.8 ± 75.3 h) correlated with the daily work hour diaries (244.0 ± 69.3 h) (r = 0.76, p > 0.001, n = 192) and the number of extended shifts reported by the two methods (3.6 ± 3.3 and 3.5 ± 2.8, respectively) (r = 0.94, p < 0.001, n = 40).[9]

Secondly, we requested additional documentation in support of all reported motor vehicle crashes. A police report, an insurance claim, a repair record or photograph of the damaged vehicle, a medical record or a written description of the crash was obtained for 82% of all reported crashes.

PGY-1 residents reported being in the hospital for 70.7 ± 26.0 hours per week, and asleep for 3.2 ± 4.2 hours of that time, and averaged 6.5 ± 4.0 days off per month (Fig 5). The frequency of extended duration work shifts (> 24 h) was 3.9 ± 3.4 per month and the mean duration of each extended duration work shift was 32.0 ± 0.7 hours. More than 200 monthly surveys reported shifts exceeding 40 hours, and working after more than 40 hours without sleep was reported more than 1000 times, representing a substantial proportion of the shifts. Most of the extended shifts (86%) had no 'night-float' coverage and the mean maximal hours of continuous wakefulness reported was 25.3 ± 8.3 hours. Provision of a night-float had little impact, as we have also previously observed,[72] and residents with night-float coverage slept only slightly (but significantly) longer on-call (3.2 ± 1.6 hours) than those without coverage (2.6 ± 1.7 hours),

A total of 320 motor vehicle crashes were reported and 40% occurred on the commute from work. Of the 320 crashes, 133 were considered serious (as defined by requiring an Emergency Room visit, causing > $1000 in damages, and/or filing a police report). Using a within-person case-crossover design, we assessed the number and proportion of crashes and near-miss incidents that occurred following an extended duration work shift compared to those following a non-extended shift for each subject. The Mantel-Haenszel odds ratio (OR ± 95% confidence limit) for a crash on the commute after an extended shift was 2.3 (1.6–3.3) (p < 0.001) and 5.9 (5.4–6.3) for a near-miss (p < 0.001). A prospective Poisson regression analysis of the association between the mean number of scheduled extended duration work shifts per month and the subsequent occurrence of crashes demonstrated a linear relationship; each extended duration work shift that was scheduled per month increased the rate of any crash by an additional 9.1% (3.4–14.7%) over baseline, and the risk of a crash on the commute from work by 16.2% (7.8–24.7%). This means that residents working for a month on a traditional "Q3" schedule with 10 extended duration work shifts > 24 hours had a 162% increased risk of a crash on the commute from work in that month. Volunteers also reported a 2–3-fold increase in the likelihood of falling asleep while driving or while stopped in traffic, as the increasing number of extended duration shifts worked each month increased, as compared to months without extended shifts.[9]

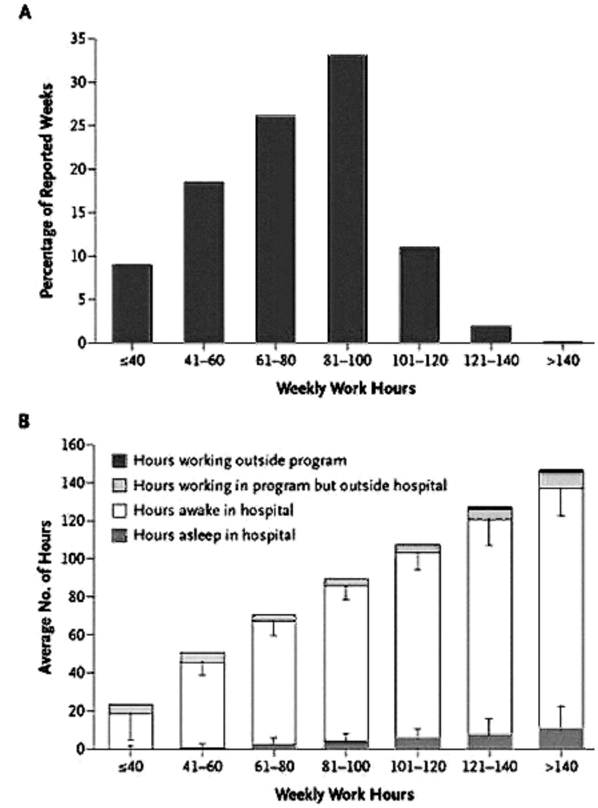

Fig 5A–B. Resident work hours and activity distribution. (A) The distribution of weekly work hours in 2,737 PGY-1 residents nationwide in 2002–2003 is shown. Residents worked more 80 hours per week 40% of the time, including more than 10% with 100+ hours per week. (B) The proportion of hours spent awake and asleep in the hospital are relatively stable regardless of the number of hours worked per week; the vast majority of the reported hours were spent awake in the hospital, even when residents worked 120 hours or more. The very long work hours presumably reflect near-continuous call or the practice of 'power weekends' (> 48 hours continuous work) in order to obtain time off later. Reproduced with permission from LK Barger, BE Cade, NT Ayas, JW Cronin, B Rosner, FE Speizer, CA Czeisler. Extended work shifts and the risk of motor vehicle crashes among interns. *New Engl J Med.* 2005; 352:125–134.

Effect of eliminating extended work hours on residents' sleep and fatigue and the incidence of serious medical errors

Coincident with the nationwide survey, we also conducted a prospective, randomized study to test the hypotheses that implementation of a resident work schedule that limited consecutive duty to 16 hours would increase their sleep, reduce fatigue, and reduce the rate of serious medical errors as compared to the same residents working on the traditional 'on-call' schedule which routinely included scheduled shifts > 30 hours.[51,53] Twenty PGY-1 residents were studied during a three-week rotation in both the Medical Intensive Care Unit (MICU) and Cardiac Care Unit (CCU) between July 2002 and June 2003. Using a within-subjects cross-over design, they were studied while working a traditional on-call schedule in a three-person team in one unit, and the intervention schedule in a four-person team in the other unit (Fig 6).

The subjects were asked to complete a daily sleep and work hours diary, and underwent ambulatory polysomnography (PSG) recordings continuously for 3–4 days a week. Reported work hours were highly correlated with work hour logs recorded independently by study staff ($r = 0.98$, $p < 0.001$) and subjective sleep duration was correlated with the objective PSG data ($r = 0.94$, $p < 0.001$). Attentional failures, an objective marker of fatigue,[12] were assessed independently from the rate of electrooculogram-derived slow eye movements (SEM) that occurred while residents were awake and on duty overnight.[53] The relative impact of the two schedules on patient safety was assessed using a multifaceted approach including direct continuous observation of the PGY-1 residents by six physician observers, regular chart reviews by two highly-trained nurses, voluntary reports, and the use of computerized event-detection monitoring data. Events were classified independently by two physicians blinded to the study condition as to their seriousness and preventability using predetermined definitions ($\kappa = 0.80$–0.90).[51]

The intervention schedule reduced ($p < 0.001$) weekly work hours by nearly 20 hours per week from 84.9 ± 4.7 hours to 65.4 ± 5.4 hours and totally eliminated extended work shifts > 24 hours in duration that constituted 60% of

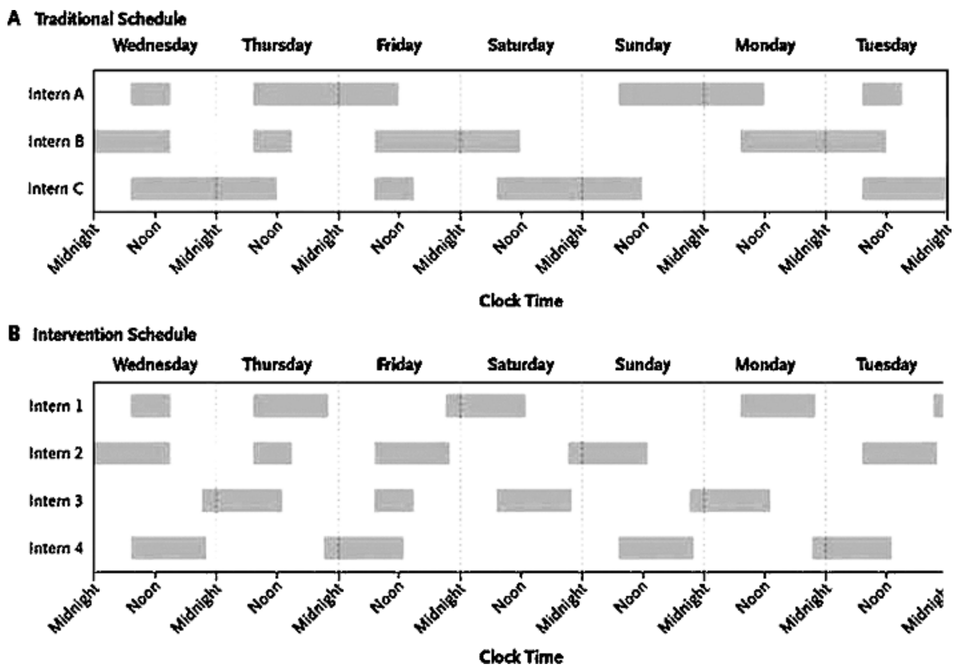

Fig 6A–B. Traditional and intervention work hours schedule for PGY-1 resident teams. Scheduled work hours for the entire PGY-1 resident team for one week are shown by the shaded bars. (A) The continuous coverage pattern of the three-resident team on the traditional on-call schedule is shown. Residents rotated sequentially through a 'swing' shift from 07:00–15:00 h on Day 1 (eg, Intern A, Wednesday) followed by an extended duration work shift from 07:00 h on Day 2 to the afternoon (~13:00) of Day 3 (Thursday to Friday for Intern A). Residents staffed weekly ambulatory clinics when clinics coincided with the swing day or 'post-call' (Day 3), and had a day off when the swing day occurred Saturday–Monday. While the average scheduled hours totaled ~81–83 hours depending on clinic assignment, actual weekly work hours were slightly more (84.9 ± 4.7 h, range 74.2–92.1 h, n = 20). (B) The four-day rotating coverage pattern for the four PGY-1 residents required for the intervention schedule is shown, which consisted of an identical swing day (Day 1; Intern 1 Wednesday), followed by a day-call shift (7:00–22:00 h; Intern 1 Thursday), before returning on Day 3 for the night-call (21:00–13:00 h; Intern 1 Friday night through to Saturday afternoon). A one-hour hand-off was scheduled between the day- and night-call (21:00–22:00 h). Residents staffed clinics when they occurred on a swing day only and had a day off when the swing day fell on Saturday–Tuesday. The maximum scheduled shift duration was 16 hours and scheduled work hours ranged from ~60–63 hours/week; actual work hours were (65.4 ± 5.4 h, range 57.6–76.3 h, n = 20). Two weeks prior to each study rotation, subjects worked primarily on an ambulatory clinic rotation (~40 hours/week). Reproduced with permission from CP Landrigan, JM Rothschild, JW Cronin, R Kaushal, E Burdick, JT Katz, CM Lilly, PH Stone, SW Lockley, DW Bates, CA Czeisler. Effect of reducing interns' work hours on serious medical errors in intensive care units. *New Engl J Med.* 2004;351:1838–1848. © 2004 Massachusetts Medical Society. All rights reserved.

traditional shifts. While working on the intervention schedule, residents also slept more ($p < 0.001$) on average (7.4 ± 0.9 hours/day), compared to when they worked on the traditional schedule (6.6 ± 0.8 hours/day) and exhibited less ($p < 0.02$) than half the rate of attentional failures while on duty overnight (0.33/hour versus 0.69/hour). During the intervention schedule, subjects were also encouraged to take a nap before beginning their 'night-call' (Fig 6) and they did so on 70% of occasions. There was a reciprocal relationship ($r = -0.57$) between sleep and work hours, such that residents had ~20 minutes more sleep per week for each hour that their work week was F7 reduced ($p < 0.001$) (Fig 7). The distribution of sleep relative to work hours was also altered ($p < 0.001$) with a smaller proportion of work hours performed with less than 4 hours sleep in the preceding 24 hours on the intervention F8 as compared to the traditional schedule (Fig 8).

During the traditional schedule, PGY-1 residents made 35.9% more ($p < 0.001$) serious medical errors than when they worked the intervention schedule (136.0 versus 100.1/1000 patient days). They made 27.8% more intercepted serious errors on the traditional as compared to the intervention schedule (70.3 versus 55.0/1000 patient days, $p = 0.02$), and 56.6% non-intercepted serious errors (44.8 versus 28.6/1000 patient days, $p < 0.001$). The increased number of PGY-1 errors on the traditional schedule led to more ($p < 0.001$) errors overall on the units during the traditional schedule as compared to the intervention, with 22.0% (193.2 versus 158.4) more serious medical errors overall. When categorized according to type of error, PGY-1 residents made 20.8% more serious medication errors ($p = 0.03$) and 5.6-fold more serious diagnostic errors ($p < 0.001$) when working on the traditional schedule, rates that were also reflected unit-wide (17.1% increase in medication errors ($p = 0.03$) and 96.4% more diagnostic errors ($p < 0.001$).[51]

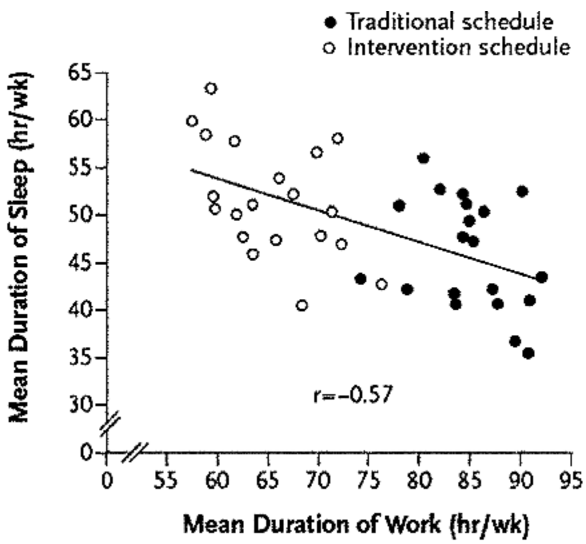

Fig 7. Relationship between weekly work and sleep hours. Seventeen out of 20 residents slept more on the intervention schedule as compared to the traditional one although all residents worked fewer hours on the intervention. As seen above, a reciprocal relationship was observed when average weekly sleep and work hours were correlated for the traditional and intervention schedules combined. The regression analysis predicted an increase of 19.2 minutes sleep per week for each single work hour reduction. Reproduced with permission from SW Lockley, JW Cronin, EE Evans, BE Cade, CJ Lee, CP Landrigan, JM Rothschild, JT Katz, CM Lilly, PH Stone, D Aeschbach, CA Czeisler. Effect of reducing interns' weekly work hours on sleep and attentional failures. *New Engl J Med.* 2004;351:1829–1837.

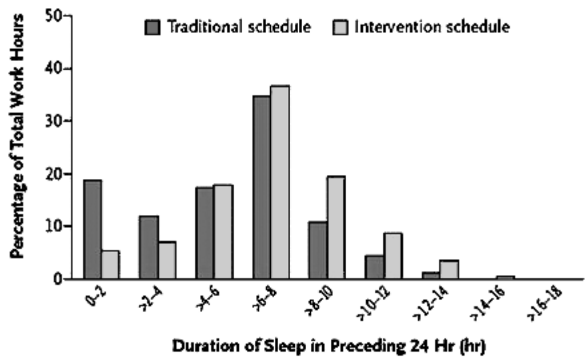

Fig 8. Distribution of sleep in relation to duty hours. Figure 8 shows the distribution in the amount of sleep in the 24 hours prior to each work hour for the traditional and intervention schedules. A greater proportion of work hours were preceded by more sleep during the intervention compared to the traditional schedule represented by the relative shift to the right of the distribution for the intervention schedule. A smaller proportion of work hours were preceded by 4 hours of sleep or less during the intervention (13%) compared to the traditional schedule (31%), and a greater proportion of work hours followed 8 hours of more sleep in the prior 24 hours (33% versus 11%, respectively). Reproduced with permission from SW Lockley, JW Cronin, EE Evans, BE Cade, CJ Lee, CP Landrigan, JM Rothschild, JT Katz, CM Lilly, PH Stone, D Aeschbach, CA Czeisler. Effect of reducing interns' weekly work hours on sleep and attentional failures. *New Engl J Med.* 2004; 351:1829–1837.

DISCUSSION

Collectively, the findings to date from the Harvard Work Hours Health and Safety Group strongly demonstrate the risk to both residents and patients of continuing to permit extended duration work shifts of 24 hours or more. When working extended duration shifts, residents are at a higher risk of lapses of vigilance and committing serious medical errors, and are more than twice as likely to crash their cars while driving home than when they do not work these shifts. Restricting residents to 16 hours of scheduled continuous duty increases sleep duration outside work, improves attentiveness on duty overnight, and reduces the rate of medical errors. The improvements observed in the intervention study were found despite the addition of a fourth resident to the team and an increase in the number of hand-offs between physicians, as also observed elsewhere,[55] suggesting that the perceived risk of changing continuity of care is less than the risk of error due to sleep deprivation. There was also no evidence in our study that more senior staff undertook an increased burden of care as a result of reduction in junior residents' hours, as has been suggested,[15,48,86] as there were no differences in the total number of medication orders or tests interpreted by PGY-1 residents between the schedules, and the PGY-1s performed significantly more procedures per patient-day ($p < 0.001$) during the intervention schedule than when they worked the traditional one.

In considering the design of new work schedules, it is important to keep in mind the biological principles underlying fatigue: fundamentally, all sleep hours and all wake hours are not equal. A simple reduction in work hours may achieve an administrative goal but may not optimize the time at which sleep opportunities are available. Poorly designed schedules that reduce work may inadvertently reduce sleep and increase fatigue, and subsequently increase the risk of medical errors and crashes. While the focus is often on weekly work hour limits and the permissible frequency of extended duration work shifts, eliminating these extended duration shifts outright is likely to have a much greater impact of resident health and patient safety than attempting to achieve an arbitrary work-hour limit of 80 hours per week.[50] We purposely designed our intervention with these principles in mind. Key considerations included avoiding consecutive night-calls in order to minimize chronic sleep deprivation; allowing nearly 24 hours off after night-calls to enable sufficient recovery from acute sleep deprivation; reducing night-call duration to minimize sleeping on-shift and thereby reduce the risk of sleep inertia; allowing time for a long recovery sleep after the day-call to reduce chronic sleep deprivation; and, notably, enabling and encouraging residents to take a nap before coming onto night-call, thereby interrupting the build-up of homeostatic sleep pressure before they come onto a shift and blunting the severity of the circadian performance nadir overnight. An additional consideration that was not optimal in this study, however, was the effort to formalize the sign-out process, particularly during the evening sign-out. There was a great deal of variability in how each team managed the content and quality of the sign-out and, subsequently, those residents who were called upon to present at rounds were not always fully aware of the patients' history. We feel that developing a system of formal rounds in the afternoon or evening, supervised by senior residents or the attending physician,[3] would greatly improve the communication within the team and the perception that continuity of care was adequate, as well as providing more frequent educational opportunities for the residents. The potential for error inherent in this suboptimal hand-off, however, was insufficient to negate the significant improvement in serious error rates gained by the elimination of extended duration work shifts.

Another important consideration in planning resident schedules is the fact that residents, as a result of their sense of professionalism, will often want to work longer than scheduled.[52] Although in our intervention study the maximum scheduled shift duration was 16 hours, 40% of the shifts actually lasted between 16–20 hours.[53] Assuming that this level of resident professionalism holds true across specialties and systems, it may be preferable to schedule residents to work less than the maximum number of hours legally allowed, as many will undoubtedly work longer than scheduled; we therefore suggest that scheduled work hours be less than the proscribed limits.

The introduction of 'night-floats' has been a common strategy to reduce the work hours of on-call residents,[48,52,54] despite the increase in hand-offs, lack of continuity when residents are brought in from other services, and the perceived reduction in educational opportunities for the resident being covered. Although we observed a slight increase in the amount of sleep obtained by those residents who had night float coverage compared to those without it in the survey (36 minutes per shift), this approach is unlikely to be a robust solution to address work hour limits. Previously, we measured the amount of sleep obtained in residents on-call with and without four hours of night-float coverage[72] and found that those with coverage did not sleep significantly more than those without coverage, as residents were reportedly using their protected time for sleep to catch up on paperwork and other tasks.[72] Our current data suggest that spending more hours at the hospital does not allow a greater proportion of time to sleep (Fig 5).[9] A reduction in the absolute number of work hours, however, can be an effective way to increase sleep duration if the schedule is designed to facilitate sleep. In our intervention study, about one-third of all time made available by reduced work hours was used for sleep,[53] contrary to others' expectations,[62] but in line with typical sleep-wake behavior (Fig 7).

Following the introduction of the ACGME guidelines, there have been many editorials and surveys purportedly addressing the impact of the regulations on medical and surgical residency programs[19,30,38,40,43,46–48,54,88] and many have reported a negative response.[11,15,29,36,52,56,64,80,84,86] It is difficult to interpret subjective reports that lack validated measures of work hours, sleep and fatigue, especially given that the 2003 regulations did little to change the practices of many residency programs where work weeks longer than 80 hours and extended duration work shifts are still reportedly common.[52,55,84] Although the ACGME has reported a high rate of compliance with the duty hour standards,[2] several preliminary studies have suggested that true rates of compliance may be substantially lower.[5,16,69] Lack of compliance with the ACGME regulations may underlie the failure of several studies to detect any impact of work hour regulations on clinical performance,[7,58,61,66] especially as reductions in work hours or changes in fatigue were not objectively confirmed. It may also call into question the appropriateness of the ACGME being both the body to which programs report, and which provides program accreditation. Further multi-center studies of true rates of ACGME compliance across specialties are needed.

The reduction of work hours has raised legitimate concerns regarding continuity of patient care, reduced educational opportunities, and the tradition of professionalism.[29,56,78] What is lacking, however, are objective data addressing solutions to these concerns. The vast majority of recent reports consist of opinion or surveys of residents or program directors, but remarkably few contain experimental data collected using rigorous study designs or validated instruments for measuring medical error rates or quality of care. While opinion surveys provide interesting points of debate, they are not sufficient to address the issues regarding resident work hour reduction. Subjective data may be particularly hazardous when quantifying sleepiness given the disconnect between actual performance and subjective ratings when chronically sleep deprived (Fig 4).[77] The guiding operational principle in this endeavor should be that outcome-based evidence must direct policy towards development of the best practice. Researchers need to conduct well-designed trials that provide objective data from which evidence-based decisions can be made regarding how best to reform resident work hours while guarding against the risks to patient care and resident education outlined above. Residency programs routinely make evidence-based decisions in clinical practice and even in selecting trainees[23] but have appeared reluctant to rely on such data to develop safe resident work hour schedules that are optimal for both training and patient care. The challenge to the medical and surgical professions is to replace conjecture with evidence and take a proactive role in finding workable solutions to eliminate extended shifts. Several progressive institutions have taken up this challenge and successfully adopted work hour reductions across their residency programs, instituting maximum shifts of 12 to 14 hours,[3,14,42] or employing physicians' assistants to redistribute some of the workload,[56] which suggests that the required changes can be achieved. Moreover, it should be noted that, while US programs struggle to achieve 80-hour work weeks, European countries are implementing 56-hour work week limits. Although the European solution remains a work in progress,[57] it suggests that substantially greater reductions in consecutive and total weekly work hours are possible to achieve in high quality health care systems.

At the 2005 ABJS/AOA Carl T. Brighton Workshop on Orthopaedic Education, an attendee likened the ACGME work hour guidelines to reducing the speed limit from 55 mph to 35 mph—an initiative that would no doubt make the roads safer but may be considered excessive and impractical (Dempsey S. Springfield, MD, 12 Nov 2005, oral communication). Given the fact that the legal work limits in other high risk industries in the United States are set between 8 and 12 consecutive hours,[27,28] a more appropriate analogy may be that the current regulations reduce the residents' speed limit from 150 mph to 100 mph, still allowing them to travel twice as fast as others are legally permitted. This situation is unsafe and while extended duration work shifts persist, they will continue to place both residents' and patients' health and safety at risk.

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Extended Work Shifts and the Risk of Motor Vehicle Crashes among Interns

Laura K. Barger, Ph.D., Brian E. Cade, M.S., Najib T. Ayas, M.D., M.P.H., John W. Cronin, M.D., Bernard Rosner, Ph.D., Frank E. Speizer, M.D., and Charles A. Czeisler, Ph.D., M.D., for the Harvard Work Hours, Health, and Safety Group

ABSTRACT

BACKGROUND

Long work hours and work shifts of an extended duration (≥24 hours) remain a hallmark of medical education in the United States. Yet their effect on health and safety has not been evaluated with the use of validated measures.

METHODS

We conducted a prospective nationwide, Web-based survey in which 2737 residents in their first postgraduate year (interns) completed 17,003 monthly reports that provided detailed information about work hours, work shifts of an extended duration, documented motor vehicle crashes, near-miss incidents, and incidents involving involuntary sleeping.

RESULTS

The odds ratios for reporting a motor vehicle crash and for reporting a near-miss incident after an extended work shift, as compared with a shift that was not of extended duration, were 2.3 (95 percent confidence interval, 1.6 to 3.3) and 5.9 (95 percent confidence interval, 5.4 to 6.3), respectively. In a prospective analysis, every extended work shift that was scheduled in a month increased the monthly risk of a motor vehicle crash by 9.1 percent (95 percent confidence interval, 3.4 to 14.7 percent) and increased the monthly risk of a crash during the commute from work by 16.2 percent (95 percent confidence interval, 7.8 to 24.7 percent). In months in which interns worked five or more extended shifts, the risk that they would fall asleep while driving or while stopped in traffic was significantly increased (odds ratios, 2.39 [95 percent confidence interval, 2.31 to 2.46] and 3.69 [95 percent confidence interval, 3.60 to 3.77], respectively).

CONCLUSIONS

Extended-duration work shifts, which are currently sanctioned by the Accreditation Council for Graduate Medical Education, pose safety hazards for interns. These results have implications for medical residency programs, which routinely schedule physicians to work more than 24 consecutive hours.

From the Division of Sleep Medicine (L.K.B., B.E.C., N.T.A., J.W.C., C.A.C.) and the Channing Laboratory (B.R., F.E.S.), Department of Medicine, Brigham and Women's Hospital; and the Division of Sleep Medicine, Harvard Medical School (L.K.B., N.T.A., J.W.C., C.A.C.) — both in Boston; and the Department of Medicine, University of British Columbia; and the Center for Clinical Epidemiology and Evaluation, Vancouver Coastal Health Research Institute — both in Vancouver, B.C., Canada (N.T.A.). Address reprint requests to Dr. Czeisler at the Division of Sleep Medicine, Department of Medicine, Brigham and Women's Hospital, Harvard Medical School, 221 Longwood Ave., Boston, MA 02115, or at caczeisler@hms.harvard.edu.

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Residents in their first postgraduate year (interns) in the United States frequently work shifts of an extended duration (≥24 hours), a practice that results in long workweeks.[1,2] Both the number and the distribution of work hours can affect sleep, productivity, and safety.[3] The risk of fatigue-related crashes, a leading cause of truck crashes that have been fatal to the driver in the United States,[4,5] increases markedly as a function of truckers' consecutive driving hours.[6] Despite long-standing concerns regarding the effects of work hours on performance and safety among postgraduate physicians,[7-10] prior studies have not directly associated safety outcomes with such a specific characteristic of their work schedule.

To address this issue, we administered a monthly Web-based questionnaire to interns nationwide to investigate the association between validated work hours, extended work shifts, and driving safety. Assessment of driving safely included documented motor vehicle crashes, near-miss incidents, incidents involving falling asleep while driving, and incidents involving falling asleep while stopped in traffic.

METHODS

DATA COLLECTION

In April 2002, advertisements announcing the Harvard Work Hours, Health, and Safety study and offering the chance of a monetary incentive for participation were sent by e-mail to people who were matched to a residency by the National Resident Matching Program and to graduates of U.S. medical schools. The advertisement that was used is contained in the Supplementary Appendix (available with the full text of this article at www.nejm.org). Thereafter, responses to detailed questions regarding work hours, shifts of extended duration (≥24 hours), motor vehicle crashes, near-miss incidents (near-miss motor vehicle crashes in which property damage or bodily harm was narrowly avoided), and incidents of involuntary sleeping were collected monthly through May 2003, when responses regarding the overall first postgraduate year were also collected. Although this report addresses only data regarding extended shifts, motor vehicle crashes, and near-miss incidents, the questions regarding these exposure and outcome variables were distributed among 60 other questions on the monthly surveys. The Human Research Committee of Brigham and Women's Hospital and Partners HealthCare approved all the study procedures, and all the participants provided electronic written informed consent.

VALIDATION OF WORK HOURS

A random subgroup of participants (7 percent) completed daily work diaries. We validated these diaries in a separate study in which direct observation was used for continuous monitoring of work hours. A very high correlation was found between work hours (r=0.98) and shifts of extended duration (r=1.0) as reported by observers and as recorded in the diaries.[11] This work-diary subgroup recorded their work hours for at least 21 out of 28 days and completed the corresponding monthly survey. Pearson's product-moment correlation was used to determine the association between the daily average number of work hours and the number of extended-duration work shifts that were reported in the diary and in the monthly survey.

DOCUMENTATION PROCESS FOR CRASHES

Participants who reported a motor vehicle crash were requested to provide documentation of the crash. A police report, an insurance claim, an auto-repair record, a medical record, a photograph of the damaged vehicle, or a written description of the crash was accepted as documentation. For participants who did not complete the year-end survey, no additional crashes were identified, either through a search of the Social Security Death Index or through inquiries to the interns' designated emergency contacts.

STATISTICAL ANALYSIS

We used two independent techniques to quantify exposure and to assess relative risk. First, the subgroup of crashes and near-miss incidents that occurred on the commute from work was analyzed with the use of a within-person case-crossover design. For each participant, we assessed the number and proportion of crashes and near-miss incidents that had occurred after an extended work shift, as compared with a shift that was not extended. The Mantel–Haenszel test (with each subject as a separate stratum) was used to calculate the odds ratio for crashes and near-miss incidents that occurred after an extended work shift as compared with a nonextended shift.[12] Second, to address potential reporting bias (because both the crashes and the number of extended shifts were reported in each monthly survey), we also prospectively assessed whether the mean monthly number of scheduled extended shifts (collected on the baseline survey) was associated with the subsequent occurrence of motor vehicle crashes as reported on the monthly surveys. We then used Poisson regression analysis that was adjusted for age and sex to determine whether the mean monthly number of scheduled extended shifts was associated with the occurrence of crashes. For each participant, the time at risk for the Poisson regression was considered to be the number of monthly surveys that each participant completed.

A case-crossover analysis was used to determine whether the number of extended shifts that interns worked per month was associated with incidents of falling asleep while driving or while stopped in traffic. The Mantel–Haenszel test was used to calculate odds ratios. The case-crossover study design eliminated the need to account for potential confounders, such as differences in age, sex, commuting time or distance, or medical specialty, since participants served as their own controls.[13] All data are reported as means ±SD. All odds ratios are reported with 95 percent confidence intervals; all P values are two-sided. Additional information about the methods used is provided in the Supplementary Appendix.

RESULTS

A total of 3429 interns volunteered to participate in the study. Of those, 2737 (80 percent) completed the baseline survey and were thus deemed the study cohort. Each month, an average of 1548±376 surveys were completed. Ninety-three percent of the study cohort completed at least one monthly survey and were eligible for the analysis of crashes and near-miss incidents; 82 percent completed at least two monthly surveys and were thus eligible to be included in all analyses (Fig. 1). We collected a total of 19,740 surveys, including 2737 baseline surveys and 17,003 monthly surveys.

DEMOGRAPHIC DATA

The demographic characteristics of the study participants were similar to those of all interns matched through the National Resident Matching Program in 2002. Of the participants, 53 percent were female, with a mean age of 28.0±3.9 years; 79 percent were in medical specialties, 11 percent in surgical specialties, and 10 percent in other or nonspecified specialties; and 85 percent were graduates of U.S. medical schools. Among all interns in 2002, 41 percent were female, with a mean age of 30.2 years; 88 percent were in medical specialties and 12 percent in surgical specialties; and 74 percent were graduates of U.S. medical schools. Sixty-nine percent of the study participants commuted by car, and their average weekly commute was 91.6±96.2 miles, with 4.4±3.4 hours spent each week commuting.

VALIDATION

Pearson's correlation coefficient for the number of hours reported on the monthly surveys (249.8±75.3 hours) versus the actual number of hours worked, as indicated by daily work diaries completed by a subgroup of 192 participants (244.0±69.3 hours), was 0.76 ($P<0.001$). Likewise, the number of extended work shifts reported on the monthly surveys (3.6±3.3) was highly correlated with the number of extended work shifts reported in the daily diaries completed by 40 participants (3.5±2.8; $r=0.94$, $P<0.001$) (Fig. 1).

WORK HOURS

Interns averaged 70.7±26.0 hours in the hospital weekly; they were awake 67.4±24.4 of those hours and asleep 3.2±4.2 hours (Fig. 2). They reported that they spent an additional 3.9±5.0 hours per week working or studying outside the hospital, classroom, or workplace related to their program and that they spent 0.1±1.6 hours per week working at a job outside their program. Interns averaged 6.5±4.0 days off per month, including weekends, holidays, and allocated time off.

EXTENDED WORK SHIFTS

The mean monthly number of extended work shifts that were reported was 3.9±3.4, with an average duration of 32.0±3.7 hours. The mean number of scheduled monthly shifts of extended duration correlated significantly with the mean number of extended shifts reported on the monthly surveys for participants who completed all 12 surveys ($r=0.71$, $P<0.001$). On 86 percent of monthly surveys, participants reported having worked extended shifts without any night-float coverage (the assignment of another physician to take calls for the on-call participant during an overnight shift for a period of time so that the participant could rest). On only 7 percent of the surveys did they report having had night-float coverage on all extended shifts, and on another 7 percent of the surveys, they reported having had some night-float coverage. Of those report-

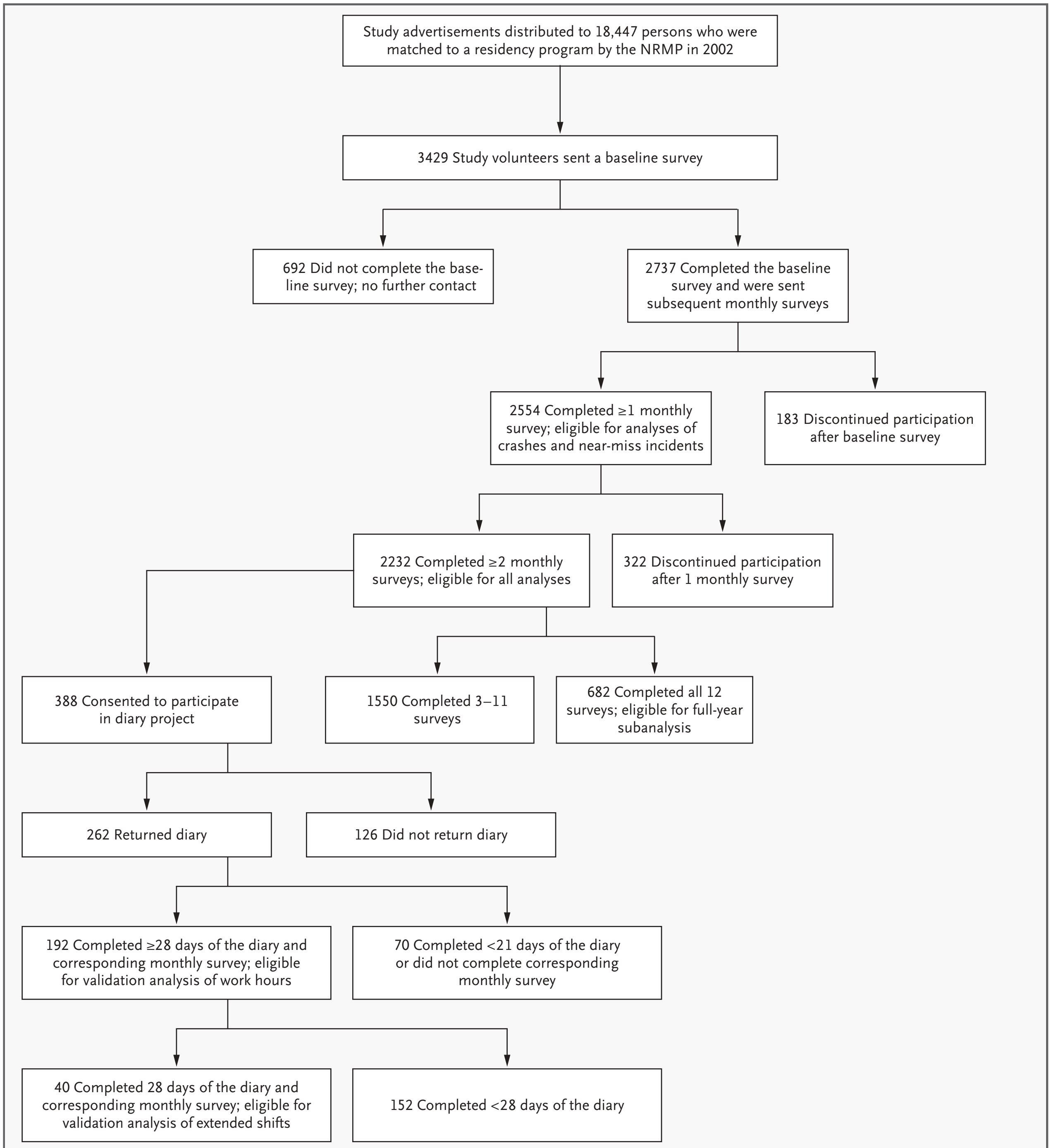

Figure 1. Flow Chart of Participation in the Study.
Although the primary means of advertisement and entrance into the study was through the National Resident Matching Program (NRMP), advertisements were also sent out to U.S. medical school graduates. Therefore, participants in the survey may have included those who arranged their internships outside of the NRMP.

ing night-float coverage, the average number of hours of night-float coverage per extended shift was 7.3±3.3 hours. The average number of sleep hours per extended shift for those with night-float coverage was significantly greater than the number for those without night-float coverage (3.2±1.6 hours vs. 2.6±1.7 hours; t=21.3; P<0.001). The number of sleep hours during extended shifts is shown in Figure 3.

The largest number of continuous hours that interns reported that they were physically at work averaged 27.6±10.5 hours (Fig. 4A). Although a quarter of the interns reported that their longest shift did not exceed 16 hours, the modal length of the longest shift worked for the remaining three quarters of the interns was 33 to 36 hours. The largest number of hours that interns remained continuously awake averaged 25.3±8.3 hours, with a subgroup remaining continuously awake much longer (Fig. 4D), indicating that extended work shifts of 48 to 84 hours still occurred in some residency programs, presumably on weekends.

MOTOR VEHICLE CRASHES

A total of 320 motor vehicle crashes were reported, including 133 that were consequential (i.e., crashes leading to treatment in an emergency department, property damage of $1,000 or greater, the filing of a police report, or a combination of these factors); 131 of the 320 crashes occurred on the commute from work. Documentation was obtained for 82 percent of all crashes. The risk of either a crash or a near-miss incident was significantly greater if the intern was commuting from work after an extended shift than it was after a nonextended shift. The Mantel–Haenszel odds ratio was 2.3 (95 percent confidence interval, 1.6 to 3.3) for motor vehicle crashes (χ^2=21.4, with 1 df; P<0.001) and 5.9 (95 percent confidence interval, 5.4 to 6.3) for near-miss incidents (χ^2=2419.5, with 1 df; P<0.001) (Table 1). To address possible reporting bias, we calculated these ratios for the 682 interns who completed all 12 monthly surveys, and the results were similar: 44 crashes during the commute from work (odds ratio, 2.5; 95 percent confidence interval, 1.4 to 4.7) and 663 near-miss incidents (odds ratio, 5.5; 95 percent confidence interval, 4.8 to 6.3). Crashes that occurred after extended shifts and those that occurred after nonextended shifts followed similar temporal patterns for both the time of day and the day of the week (Fig. 1 of the Supplementary Appendix).

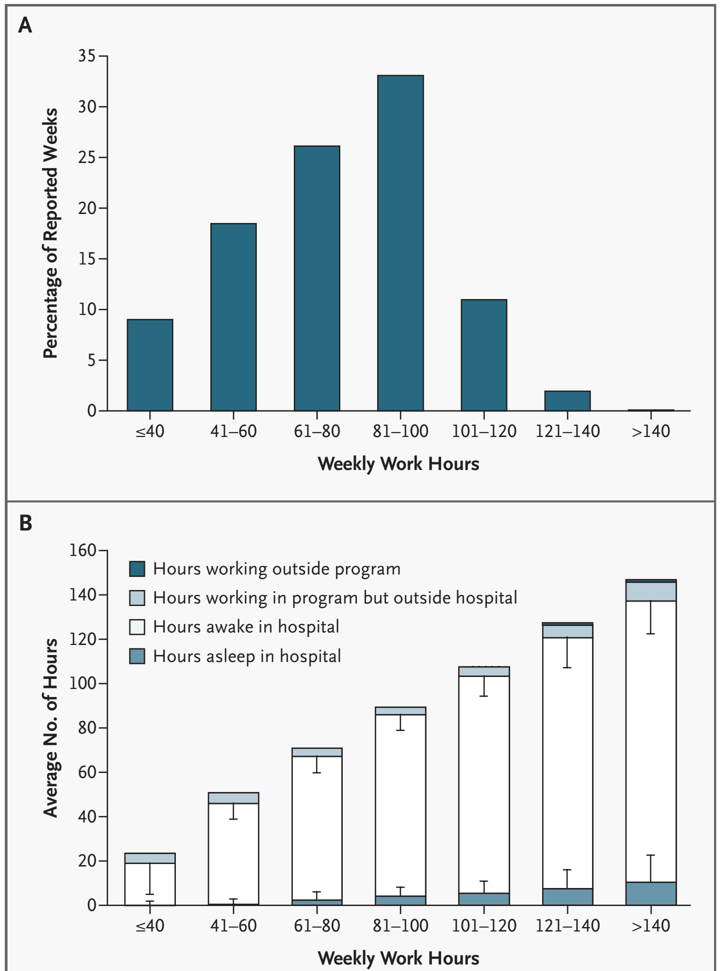

Figure 2. Weekly Hours That Interns Worked as a Percentage of Reported Weeks.
A total of 17,003 person-months of data were collected from a nationwide sample during 2002–2003. The distribution of the percentages of reported weeks with a given range of work hours is shown in Panel A. Panel B shows the average number of hours that interns spent asleep in the hospital, awake in the hospital, studying or working in relation to their program but outside the hospital, and working outside of the program. T bars indicate standard deviations. Interns reported spending an average of 193.4±88.8 of their waking hours in the hospital each month participating in direct patient care (e.g., examining patients; writing progress notes; interpreting diagnostic tests, radiographic studies, and pathological specimens; and consulting with other physicians), 43.3±47.0 hours in duties not directly related to patient care (e.g., completing other paperwork and scheduling tests), 23.5±20.1 hours in structured learning sessions (including classes, laboratories, and grand rounds), and 7.3±16.4 hours teaching students or house staff.

Every extended shift that was scheduled per month increased the monthly rate of any motor vehicle crash by 9.1 percent (95 percent confidence interval, 3.4 to 14.7 percent) and increased the monthly rate of a crash on the commute from work by 16.2 percent (95 percent confidence interval, 7.8 to 24.7

Figure 3. Hours That Interns Slept during Extended Shifts as a Percentage of Monthly Surveys.

percent). The odds ratios for falling asleep while driving or while stopped in traffic increased significantly as the number of extended shifts worked per month increased (Table 2).

DISCUSSION

We found that the odds that interns will have a documented motor vehicle crash on the commute after an extended work shift were more than double the odds after a nonextended shift. Near-miss incidents were more than five times as likely to occur after an extended work shift as they were after a nonextended shift. These findings, which are of particular concern because motor vehicle crashes are the leading cause of death in this age group,[14] are consistent with the findings that sleep deprivation degrades performance[5,15,16] and that the number of fatigue-related crashes increases in proportion to the time spent on task.[6] Given the percentage of interns in our study who commuted by car (69 percent), these data suggest that implementation of a work schedule for interns without any extended shifts[11] could prevent a substantial number of crashes.

We also found, with the use of a validated survey instrument, that in the 2002–2003 academic year, 46.2 percent of the weeks that interns worked averaged more than 80 work hours, and 11.0 percent of the weeks they worked averaged more than 100 work hours. These findings are consistent with earlier studies of self-reported work hours.[1] Overall, interns reported that they were awake during 96.1 percent of their hours in the hospital. Contrary to conventional wisdom, interns whose weekly work hours exceeded the equivalent of three full-time jobs (i.e., >120 hours per week) slept just as small a percentage of their time in the hospital as did interns working the most common weekly work hours (81 to 100 hours per week).

These findings reveal that the schedule of present-day resident physicians in the United States is far different from that of resident physicians 60 years ago who lived, worked, and slept in the hospital in order to follow the evolution of the illnesses of patients who were hospitalized for extended periods.[17] Currently, interns work extended shifts with minimal sleep in the hospital while caring for patients who are hospitalized during the most acute phase of their illness. Yet interns are still anachronistically described as being "on call" during these extended shifts, even though they are working 96 percent of the time. In today's climate of pressure to reduce the length of patients' hospital stays, 85.6 percent of monthly surveys indicated that interns slept four hours or less while working on extended shifts.

Given that there are 168 hours in a week, the opportunity for sleep is severely limited among interns who are working more than 100 hours per week. Their ability to sleep for the recommended eight hours per night becomes physically impossible and inevitably leads to progressively more severe chronic sleep restriction, with its attendant consequences.[15-18]

Most interns in our study routinely worked more than 30 consecutive hours, a schedule that involved at least one night of acute sleep deprivation. It is remarkable that there were 275 reports from interns who worked more than 40 continuous hours, a shift that necessarily involved the intrusion of acute sleep deprivation into a second consecutive night. Given the 1400 person-years of data collected, extrapolation of these results to the wider population of 102,577 person-years worked by residents in U.S. hospitals in 2002–2003[19] suggests that physicians in training worked approximately 20,000 extended shifts that exceeded 40 consecutive hours while caring for patients. Of note, extrapolation from our data suggests that 10 percent of these shifts may have exceeded 64 continuous hours in duration, indicating potential intrusion of acute sleep deprivation into a third consecutive night on a single work shift.

Our study has a number of limitations. First, even

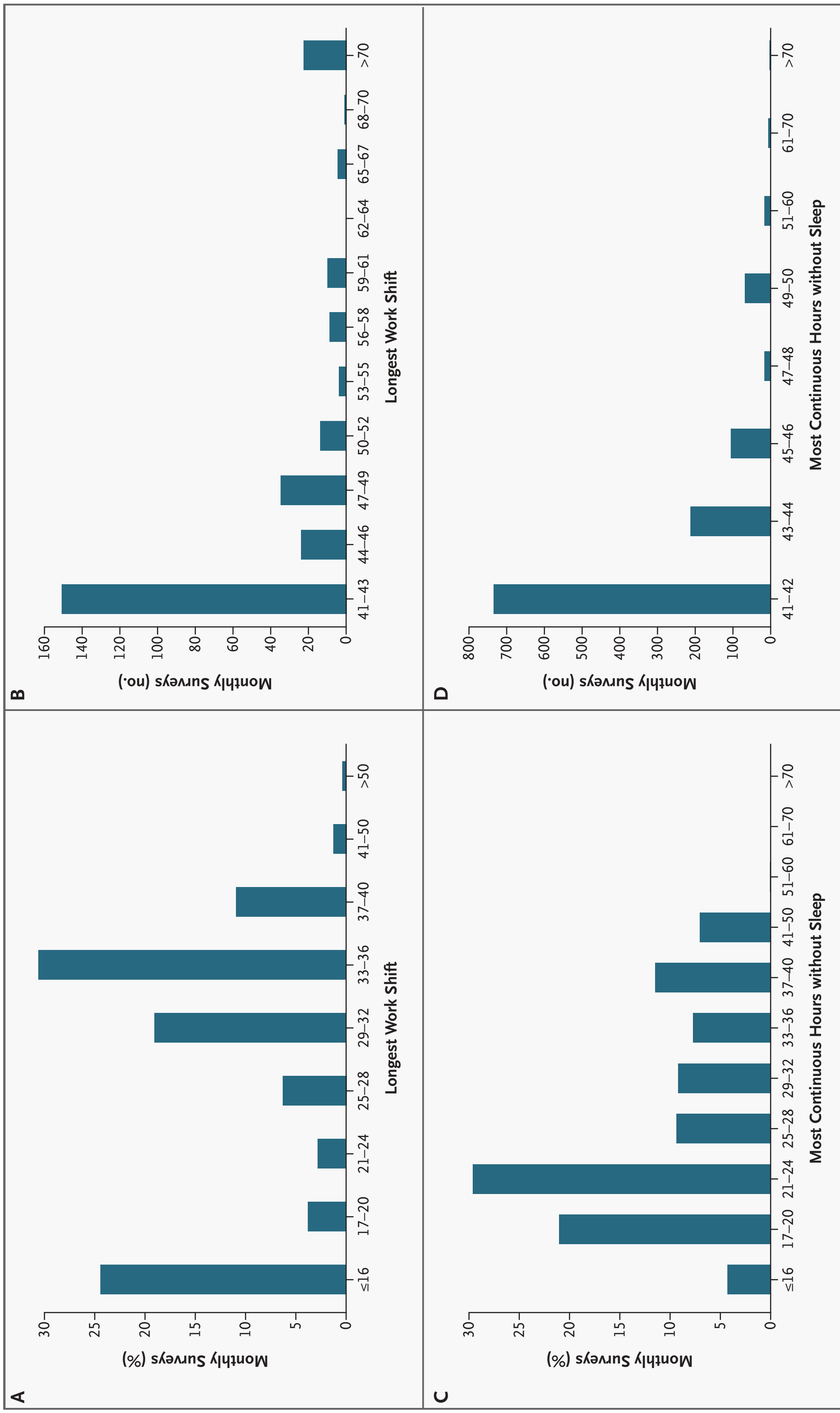

Figure 4. Longest Reported Shifts at Work.

The longest shifts reported by participants are shown in Panel A. Panel B shows the number of surveys in which participants reported shifts that exceeded 40 hours. The greatest number of hours without sleep as a percentage of monthly reports is shown in Panel C. Panel D shows the number of surveys in which participants reported more than 40 continuous hours without sleep. Although the majority of interns worked extended shifts of 30 to 39 hours, some reported working much longer hours — presumably reflecting the long-standing practice, in some programs, of working a "power weekend" (≥48 continuous work hours) in order to obtain one weekend off.

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

* A within-person case-crossover analysis was used to assess the risks of motor vehicle crashes and near-miss incidents among interns during commutes after extended shifts as compared with nonextended shifts. A two-by-two table was constructed for each intern who reported either a crash or a near-miss incident, consisting of the number of crashes or near-miss incidents after an extended shift, the number of crashes or near-miss incidents after a nonextended shift, the number of extended shifts that did not precede a crash or a near-miss incident, and the number of nonextended shifts that did not precede a crash or a near-miss incident. CI denotes confidence interval.

though we had a response rate of 80 percent from interns who volunteered to participate, those who did may not be representative. However, the distributions of age and residency-program type of our participants were comparable to those in the entire National Resident Matching Program. Notably, participants were not apprised of the study hypotheses, and the questions regarding our primary variables of exposure (work shifts of extended duration) and outcome (motor vehicle crashes) were validated and documented, respectively, and distributed among numerous other questions. As such, we believe that it is highly improbable that the participants — even those with a specific interest in the work hours of residents — could have deliberately affected the specific data regarding crash and near-miss rates that we report here. Second, the case-crossover analysis cannot account for the contribution of within-person factors that may have been covariates with exposure status. For example, interns probably had higher average blood levels of caffeine during their commutes after extended shifts as compared with commutes after nonextended shifts — a factor that may have had an effect on our results.[20] However, even if extended shifts were to elicit behavior that affected risk, this elicited behavior would not obviate the potential causal relationship between exposure to extended shifts and motor vehicle crashes. Third, our prospective analysis may have been confounded by uncontrolled covariates, although the results of that analysis were consistent with the results of our case-crossover analysis, which was free of such confounders because each participant served as his or her own control. Fourth, by collecting data on a monthly basis, we attempted to reduce, but could not eliminate, the effect of recall bias. Fifth, reporting bias could have confounded the results of our case-crossover analysis if participants preferentially completed monthly surveys after having had a motor vehicle crash. However, the prospective analysis, which was relatively free of this type of reporting bias, yielded similar results. Furthermore, case-crossover analysis of the subgroup of participants who completed all the surveys yielded an odds ratio of 2.5 (95 percent confidence interval, 1.4 to 4.7) for having a motor vehicle crash after working an extended shift (as compared with a nonextended shift) that was similar to that of the entire study population (odds ratio, 2.3; 95 percent confidence interval, 1.6 to 3.3). Overall, the convergence of our crash results with the use of two independent methods of exposure-data collection strongly supports our conclusion that an increased risk of crashes and near-miss incidents is associated with working extended shifts.

The increased rate of actual motor vehicle crashes and near-miss incidents during interns' commutes after extended work shifts that we have documented has legal implications, since drivers in both the United States[21,22] and Great Britain[23] have already been convicted of vehicular homicide for driving when impaired by sleepiness. Furthermore, the state of New Jersey has recently amended its vehicular-homicide statute to add to the definition of reckless driving "driving after having been without sleep for a period in excess of 24 consecutive hours," a revision that explicitly subjects drivers in that state to a conviction of criminal homicide under such circumstances.[24] Similar legislation is pending in New York, Massachusetts, and Michigan. Moreover, appeals courts in two states have ruled that an employer's responsibility for fatigue-related crashes can continue even after an employee has left work, similar in concept to the liability incurred by people who serve alcohol to drivers who are subsequently involved in alcohol-related mo-

Table 2. Odds Ratios for Falling Asleep while Driving or while Stopped in Traffic, According to the Monthly Number of Extended Work Shifts.*

Question	0 Extended Work Shifts				1–4 Extended Work Shifts				≥5 Extended Work Shifts			
	No. of Person-Months	No. of Person-Months with Positive Response	Rate of Positive Response	Odds Ratio	No. of Person-Months	No. of Person-Months with Positive Response	Rate of Positive Response	Odds Ratio (95% CI)	No. of Person-Months	No. of Person-Months with Positive Response	Rate of Positive Response	Odds Ratio (95% CI)
Did you nod off or fall asleep while driving?	3035	199	0.066	1.00	3068	286	0.093	1.82 (1.73–1.93)	6933	872	0.126	2.39 (2.31–2.46)
Did you nod off or fall asleep while stopped in traffic?	3039	311	0.102	1.00	3078	508	0.165	1.74 (1.68–1.81)	6944	1608	0.232	3.69 (3.60–3.77)

* Data are from interns' monthly reports on extended shifts. The number of person-months varies because nonresponses were eliminated from the analysis. Rates represent the proportion of months in which participants reported one or more incidents of nodding off or falling asleep, regardless of how many incidents were reported. CI denotes confidence interval.

tor vehicle crashes.[25,26] The Department of Surgery at the University of Michigan has taken the initiative to address this concern by offering round-trip taxicab vouchers to surgical residents on request (Mulholland M: personal communication). However, the impairment of judgment about one's own ability to perform after sleep deprivation[15] could limit the use of such transportation vouchers by residents, even when they are available.

In 2005, the current work-hour guidelines of the Accreditation Council for Graduate Medical Education still allow interns in the United States to work 30 consecutive hours every other shift. This practice has recently been prohibited by the European Union, which stipulates a "minimum daily rest period of 11 consecutive hours per 24-hour period" (thereby limiting the duration of shifts for all physicians to 13 hours), although the regulation includes some exceptions and a controversial opt-out provision.[27] Our data indicate that scheduling physicians to work such extended shifts, which our group has recently shown to increase the risk of failures of attention[11] and serious medical errors,[28] poses a serious and preventable safety hazard for them and other motorists. These results have important implications for scheduling practices in medical-residency programs.

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ORIGINAL CONTRIBUTION

Neurobehavioral Performance of Residents After Heavy Night Call vs After Alcohol Ingestion

J. Todd Arnedt, PhD
Judith Owens, MD, MPH
Megan Crouch, BA
Jessica Stahl, BA
Mary A. Carskadon, PhD

Context Concern exists about the effect of extended resident work hours; however, no study has evaluated training-related performance impairments against an accepted standard of functional impairment.

Objectives To compare post-call performance during a heavy call rotation (every fourth or fifth night) to performance with a blood alcohol concentration of 0.04 to 0.05 g% (per 100 mL of blood) during a light call rotation, and to evaluate the association between self-assessed and actual performance.

Design, Setting, and Participants A prospective 2-session within-subject study of 34 pediatric residents (18 women and 16 men; mean age, 28.7 years) in an academic medical center conducted between October 2001 and August 2003, who were tested under 4 conditions: light call, light call with alcohol, heavy call, and heavy call with placebo.

Interventions Residents attended a test session during the final week of a light call rotation (non–post-call) and during the final week of a heavy call rotation (post-call). At each session, they underwent a 60-minute test battery (light and heavy call conditions), ingested either alcohol (light call with alcohol condition) or placebo (heavy call with placebo condition), and repeated the test battery. Performance self-evaluations followed each test.

Main Outcome Measures Sustained attention, vigilance, and simulated driving performance measures; and self-report sleepiness, performance, and effort measures.

Results Participants achieved the target blood alcohol concentration. Compared with light call, heavy call reaction times were 7% slower (242.5 vs 225.9 milliseconds, $P<.001$); commission errors were 40% higher (38.2% vs 27.2%, $P<.001$); and lane variability (7.0 vs 5.5 ft, $P<.001$) and speed variability (4.1 vs 2.4 mph, $P<.001$) on the driving simulator were 27% and 71% greater, respectively. Speed variability was 29% greater in heavy call with placebo than light call with alcohol (4.2 vs 3.2 mph, $P=.01$), and reaction time, lapses, omission errors, and off-roads were not different. Correlation between self-assessed and actual performance under heavy call was significant for commission errors ($r=-0.45$, $P=.01$), lane variability ($r=-0.76$, $P<.001$), and speed variability ($r=-0.71$, $P<.001$), but not for reaction time.

Conclusions Post-call performance impairment during a heavy call rotation is comparable with impairment associated with a 0.04 to 0.05 g% blood alcohol concentration during a light call rotation, as measured by sustained attention, vigilance, and simulated driving tasks. Residents' ability to judge this impairment may be limited and task-specific.

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WORK-RELATED SLEEP LOSS and fatigue in medical training has become a source of increasing concern.[1-4] Although some studies demonstrate post-call performance deficits,[5-8] other studies do not.[9-12] These mixed findings have been attributed to methodological limitations,[13,14] such as low power, absence of objective sleep measurement, outcome measures insensitive to sleepiness or lacking ecological validity (having little relevance to real-world demands), absence of control for circadian factors or stimulant use (caffeine), and questionable rested control groups (>4 hours of sleep).[10] The serious consequences of resident sleep loss have been demonstrated in an intervention study that found that interns obtained 5.8 hours less sleep, had 50% more attentional failures, and committed 22% more serious errors on critical care units while working a traditional schedule compared with a schedule of reduced hours.[15,16]

On self-report measures, residents express concern about occupational and interpersonal difficulties stemming from sleep loss.[1,2,17-19] Of particular concern,

For editorial comment see p 1104.

Author Affiliations are listed at the end of this article.
Corresponding Author: J. Todd Arnedt, PhD, Sleep and Chronophysiology Laboratory, Department of Psychiatry, University of Michigan, 2101 Commonwealth Blvd, Suite D, Ann Arbor, MI 48105 (tarnedt@med.umich.edu).

self-reported lifetime rates of motor vehicle near-misses and crashes among residents[20] are 2.5 and 3 times those of nonresident drivers, respectively.[21] One survey found that compared with faculty members over the previous 3 years, more pediatric house officers reported falling asleep behind the wheel (49% vs 13%) and having motor vehicle crashes (20% vs 11%) during residency.[22] A prospective study found that for every extended work shift, the monthly risk of a motor vehicle crash increased by 9.1%.[23] Despite the heightened risk, only 2 small studies have examined resident driving impairment experimentally. Both found impairment of simulated driving post-call, but neither provided objective on-call sleep duration[24,25] and 1 study used a driving task lacking face validity.[24]

One approach to measuring the magnitude of performance deficits associated with sleep loss is to compare performance following sleep loss and alcohol consumption. Dawson and Reid[26] found that impairment on a tracking task after 17 hours of wakefulness was equivalent to a blood alcohol concentration (BAC) of 0.05 g% (per 100 mL of blood) in a sample of nonresidents. These findings have been replicated with other tasks, including simulated driving, in samples of nonresident university students and truck drivers.[27-29] Alcohol serves as a useful index for comparison because it impairs performance, even at lower BACs,[30-34] and legal limits of intoxication have been established. At 0.05 g% BAC (3-4 standard drinks), alcohol increases self-confidence; decreases inhibitions; diminishes attention, judgment, and control[35]; and leads to hazardous driving.[36]

Our primary goal was to compare post-call performance during a heavy call rotation to non–post-call performance during a light call rotation with a BAC of 0.04 to 0.05 g%, using tests of sustained attention, vigilance, and simulated driving. To maximize rested and sleepy states, residents were tested during the final week of light and heavy call rotations. A prospective within-subject 2-session design was used to enhance feasibility and generalizability, reduce attrition, and experimentally control for time of testing, alcohol expectancy, beverage consumption, and test fatigue for our comparison of primary interest. A second goal was to evaluate the association between self-assessed and actual performance call-related sleep loss and alcohol ingestion.

METHODS

Participants

Participants were recruited from the Brown University Pediatrics residency program, Providence, RI. Interested residents were screened for the following exclusion criteria: aged older than 40 years; sleep disorder diagnosis; chronic medical condition; current psychiatric illness; current use of medication known to affect the sleep/wake cycle or daytime alertness, or that is a contraindication for alcohol ingestion; no or minimal prior alcohol exposure, defined as responding "never drink alcohol" or "never" to the question "How often do you have 2-4 drinks in one occasion at least once in a while"[37]; current or prior treatment for alcohol or substance abuse; and positive urine pregnancy screen.

Of the 115 residents potentially eligible for participation between October 2001 and August 2003, 43 (37%) responded to e-mail solicitations and were screened for eligibility. Six were excluded (2 were older than 40 years, 1 had a sleep disorder, 2 were taking medication, and 1 never consumed alcohol) and 2 declined. One enrolled participant completed only 1 test session. The final sample included 16 men and 18 women (mean [SD] age, 28.7 [2.7] years); 14 were interns, 15 were second-year residents, and 5 were third-year residents. Participants and nonparticipants or dropouts ($n=81$) did not differ by age ($P=.74$), sex ($P=.21$), or residency type (pediatric, medicine/pediatrics, triple board; $P=.94$). Participants were told that the purpose of the study was to compare performance following call-related sleep loss and following alcohol, but they were not told the primary study hypothesis. Participants provided written informed consent and received US $200 upon successful completion of each test session. The study was approved by the institutional review boards at Rhode Island Hospital and Brown University, Providence, RI, and the University of Michigan, Ann Arbor.

Study Design

Our study was a prospective 2-session within-subject study with 4 conditions: light call, light call with alcohol, heavy call, and heavy call with placebo. Light call and light call with alcohol occurred consecutively during a single session and followed a non-call night during the final week of a 4-week light call rotation. Heavy call and heavy call with placebo were completed post-call after 4 weeks of a heavy call rotation. We did not use a no-call condition as a control to maximize the generalizability of our findings by including actual rotations that are present in the training program. We did not include a light call with placebo condition because our primary comparison of interest was between the heavy call with placebo and light call with alcohol conditions, and a third testing session would likely have had a high attrition rate.

Light and Heavy Call Rotations

Light call rotations (behavioral, elective, or selective) were 4-week daytime clinic rotations averaging 44 hours per week, along with sick-call, which requires night call only if the on-call resident becomes ill. Heavy call rotations (neonatal intensive care, pediatric intensive care, or wards) averaged 90 hours per week (80 hours per week after July 2003) and mandated call every fourth or fifth night (34-36 consecutive hours per overnight call). Residents were allowed to work outside the authorized training program (moonlight) only with written permission from the residency director.

Study Protocol

One week before the first session, participants attended a 90-minute orientation during which all participants practiced the tests and received a daily sleep/activity diary and wrist activity monitor (Actiwatch 64, Mini Mitter Company Inc, Bend, Ore). For 7 days before each test session, participants maintained the diary, self-selected their sleep schedules, and had activity levels continuously monitored. Sleep parameters were estimated using sleep analysis software. We adapted scoring procedures from Acebo et al.[38] Nocturnal sleep (from 2100 to 0900 hours) was analyzed separately from daytime sleep (from 0901 to 2059).

On the test day, participants were not allowed to nap, ingest caffeine after noon, or to ingest food or drink other than water within 4 hours of testing, verified by self-report before each test session.[39] Twenty-two residents were tested first during heavy call; the mean (SD) intersession interval was 106 (82) days.

Participants arrived at 1500 hours for the light call and heavy call sessions. After completing self-report sleepiness measures, participants performed a 60-minute battery that included the Psychomotor Vigilance Test (Ambulatory Monitoring Inc, Ardsley, NY),[40] the Continuous Performance Test,[41] and a simulated driving task (DriveSim, York Computer Technologies, Kingston, Ontario). The sleepiness measures were repeated every 30 minutes. After each test, participants completed self-assessments of performance and effort.

Following the light call condition testing, participants consumed alcohol (light call with alcohol condition). The alcohol dose was 0.6 g/kg for men and 0.55 g/kg for women, to produce equivalent peak BACs of 0.05 g%.[42] The alcoholic beverage consisted of a commercial brand of chilled 80-proof vodka mixed with tonic water in a 1:5 ratio and one-fourth lime. Following the heavy call condition testing, participants consumed placebo (heavy call with placebo condition). The placebo was an equal volume of chilled tonic water and one-fourth lime. The total volume was distributed among three 12-oz cups and consumed at an equal rate over 30 minutes. To enhance the appearance that participants were receiving alcohol in both conditions, the drinks were mixed in plain view, alcohol and tonic were decanted from vodka bottles, and beverages were served with fresh lime. Participants repeated the battery 20 minutes postingestion. Breath samples were analyzed before and after tests using a handheld breathalyzer (AlcoSensor IV, Intoximeters Inc, St Louis, Mo).

After each session, participants rated their certainty of having received alcohol on a 0 (certain did not receive) to 100 (certain did receive) scale. For the light call with alcohol sessions, 63.6% of the participants were completely certain they had received alcohol; for the heavy call with placebo sessions, 67.6% of the participants were completely certain that they had received placebo. Four participants in the heavy call with placebo group were at least 25% certain of receiving alcohol.

Participants in the heavy call conditions were excused and driven home by a significant other or by taxi. Participants in the light call conditions either remained in the laboratory under supervision until their BAC dropped below 0.02 g% or they signed a release and were driven home by a significant other or by taxi.

Outcome Measures

Stanford Sleepiness Scale. The Stanford Sleepiness Scale[43] is a 7-item scale that requires participants to rate their current sleepiness from 1 (feeling active and vital, wide awake) to 7 (almost in reverie, sleep onset soon, lost struggle to remain awake).

Visual Analog Scale. The visual analog scale comprised the questions, "How alert do you feel?", "How sleepy do you feel?", and "Overall, how do you feel?" Participants marked a 100-mm line, with anchors "very little/very bad" to "very much/very good." The distance from the left edge of the scale to the participant mark was the score (range, 0-100). Higher scores indicated greater levels of alertness, sleepiness, and overall functioning. Scores on the alertness and overall functioning scales have been inverted for consistency.

Psychomotor Vigilance Task. The Psychomotor Vigilance Task[40] is a 10-minute visual sustained-attention test that is sensitive to sleepiness[44,45] and alcohol.[34] Participants pressed a button on the handheld unit in response to numbers scrolling on the liquid crystal display screen with a 2- to 10-second interstimulus interval. Dependent variables were median reaction time and frequency of lapse (reaction time >500 milliseconds). Higher scores indicated worse performance.

Continuous Performance Test. The Continous Performance Test[41] is a 14-minute computer vigilance task, previously used with residents,[46,47] which requires participants to respond to any alphabetic letter except "x/X." Stimuli are displayed for 250 milliseconds with interstimulus intervals of 1, 2, and 4 seconds. Dependent variables included errors of commission (%) and omission (%). Higher scores indicated worse performance.

Simulated Driving Task. The simulated driving task is a 30-minute task, sensitive to sleepiness and alcohol,[48,49] which runs on a computer with software (DriveSim 3.00, York Computer Technologies), peripheral steering wheel, accelerator, and brake. The task presents a driver's orientation of a 2-lane highway with lane markings, speed signs, and small trees along the roadside. Other vehicles appear periodically but participants ignore them. Instructions are to stay in the center of the right lane and follow a fixed speed limit (60 miles per hour) while driving on the straight road. "Wind" periodically and randomly pushes the simulated vehicle right, left, or not at all. Traveling off the road elicits a beep and the car is automatically placed back on the road. Dependent variables were lane variability (SD of the vehicle center from the center of the right lane measured in feet), speed variability (SD of the difference in the vehicle speed from the posted speed measured in miles per hour), and "off-roads" (number of times the vehicle left the road). Higher scores indicated worse performance.

Posttest Self-assessments. Dependent variables were performance and effort ratings. Performance was assessed on a 7-point Likert scale response to the statement "I feel my performance during this test was . . . ", anchored with 1 = extremely good, 4 = fair, and 7 = extremely poor. Effort was assessed on a 4-point Likert scale response to the statement "The effort I had to expend to achieve this level of performance was . . . ", anchored with 1 = very little effort and 4 = an extreme effort.

Data Analyses

Variables that deviated significantly from normality were transformed for parametric analyses or dichotomized (lapses, omissions, off-roads) and analyzed using nonparametric McNemar tests. Data are reported as mean (SE) unless otherwise indicated, with significance level set at $P = .05$.

Continuous performance and subjective measures were analyzed with training year (interns vs second-year residents and third-year residents) by condition (light call, light call with alcohol, heavy call, or heavy call with placebo) mixed repeated measures analysis of variance. Main effects were followed by pairwise comparisons between light call and each of the other 3 experimental conditions (light call with alcohol, heavy call, and heavy call with placebo) and between light call with alcohol and heavy call with placebo. Because of our nonrandomized design, we secondarily examined order effects by separately analyzing performance in participants whose first session occurred during light call (n = 12). Test-dependent variables for light call with alcohol, heavy call, and heavy call with placebo were compared with posttest self-assessments using Spearman rank order correlations. Analyses were conducted using SPSS version 12.0 for Windows (SPSS Inc, Chicago, Ill).

RESULTS

Call Schedules

Residents were on-call more frequently during the heavy than light call rotation (mean [SE], 7.3 [0.3] vs 1.4 [0.3] nights; $P < .001$). One resident reported moonlighting 6 days before light call testing; no moonlighting occurred during heavy call.

Actigraphy

Actigraphy results for the 7 days and the 24 hours before testing are shown in TABLE 1. For the 7 days preceding each test session, the mean nocturnal sleep period (the elapsed time between sleep onset and sleep offset as scored by the actigraphy software) was 7 hours 32 minutes during light call compared with 6 hours 17 minutes during heavy call ($P < .001$). There were similar results comparing light call and heavy call with respect to total sleep time and the cumulative sleep duration for the week.

For the 24 hours preceding each test session, there was significantly more sleep during light call than heavy call as measured by nocturnal sleep period (7 hours 24 minutes vs 3 hours 56 minutes, respectively; $P < .001$), total sleep time (6 hours 37 minutes vs 3 hours 2 minutes, respectively; $P < .001$), and the cumulative sleep duration (6 hours 48 minutes vs 3 hours 8 minutes, respectively; $P < .001$). Nocturnal sleep was also more efficient during light call than heavy call (89.4% vs 82.3%, $P = .02$), but there were no rotation differences in diurnal sleep.

Blood Alcohol Concentrations

Blood alcohol concentrations were 0.0 g% before all sessions and after light call, heavy call, and heavy call with placebo. Mean (SE) peak BACs in the light call with alcohol assessment were 0.046 g% (0.002 g%) before the Psychomotor Vigilance Test and 0.041 g%

Table 1. Actigraphically Determined Sleep Parameters for the 7 Days Before and the 24 Hours Before the Light Call and Heavy Call Test Sessions*

	7 Days Before Testing			24 Hours Before Testing		
Actigraph Parameter	Light Call (n = 30)	Heavy Call (n = 31)	P Value†	Light Call (n = 30)	Heavy Call (n = 32)	P Value†
Daily nocturnal sleep‡						
Sleep-onset time	23:52 (0:08)	00:23 (0:09)	.01	23:57 (0:12)	02:33 (0:21)	<.001
Sleep-offset time	07:24 (0:08)	06:40 (0:05)	<.001	7:21 (0:12)	06:29 (0:16)	.07
Sleep period	7:32 (0:09)	6:17 (0:10)	<.001	7:24 (0:17)	3:56 (0:19)	<.001
Total sleep time	6:38 (0:10)	5:20 (0:09)	<.001	6:37 (0:16)	3:02 (0:16)§	<.001
Sleep efficiency, %	88.2 (0.8)	85.2 (1.0)	.24	89.4 (1.0)	82.3 (2.8)	.02
Daily diurnal sleep‖						
No. of diurnal sleep episodes	0.6 (0.1)	0.8 (0.1)	.21	0.4 (0.2)	0.2 (0.1)	.77
Duration of diurnal sleep	0:13 (0:03)	0:22 (0:03)	.08	0:11 (0:05)	0:06 (0:03)	.54
Total cumulative sleep before testing	48:03 (1:23)	39:55 (1:00)	<.001	6:48 (0:17)	3:08 (0:16)§	<.001

*Results are hours:minutes mean (SE) unless otherwise specified.
†Light call vs heavy call comparisons based on paired *t* tests.
‡Nocturnal sleep defined as the major sleep bout between 2100 and 0900 hours. Sleep period is the elapsed time in hours:minutes from sleep-onset time to sleep-offset time as scored by Actiware-Sleep algorithm; it includes both sleep and wake episodes during this period. Total sleep time includes only sleep as scored by the software, within the sleep period. Sleep efficiency is the percentage of sleep period spent asleep as scored by Actiware-Sleep algorithm [(total sleep time/sleep period) × 100].
§These variables were computed on 33 residents because 1 resident had actigraphically defined 0 hour of sleep the night before testing.
‖Defined as episodes of 15 minutes to 180 minutes between 0901 and 2059 hours.

(0.002 g%) after the Psychomotor Vigilance Test; 0.041 g% (0.002 g%) before the Continuous Performance Test and 0.040 g% (0.001 g%) after the Continuous Performance Test; and 0.040 g% (0.001 g%) before the simulated driving task and 0.037 g% (0.002 g%) after the simulated driving task.

Self-reported Sleepiness

The Stanford Sleepiness Scale and visual analog scale ratings are summarized in TABLE 2. There were no main effects or interactions involving training year. The Stanford Sleepiness Scale ratings were higher in heavy call with placebo (mean, 4.5), light call with alcohol (mean, 3.3), and heavy call (mean, 4.6) vs light call (mean, 2.3; $P<.001$ for all comparisons). On the visual analog scale, the main effect of condition was significant for all subscales: alertness (light call: mean, 31.6; light call with alcohol: mean, 45.3; heavy call: mean, 68.4; heavy call with placebo: mean, 59.5; $P<.001$); sleepiness (light call: mean, 33.0; light call with alcohol: mean, 38.2; heavy call: mean, 77.9; heavy call with placebo: mean, 74.7; $P<.001$); and overall (light call: mean, 25.7; light call with alcohol: mean, 26.5; heavy call: mean, 53.5; heavy call with placebo: mean, 51.3; $P<.001$). Post hoc comparisons indicated that alertness, sleepiness, and overall ratings were higher (worse) in heavy call with placebo compared with light call with alcohol ($P<.001$) and in both heavy call and heavy call with placebo relative to light call ($P<.001$).

Actual and Self-assessed Performance

Results for actual and self-assessed performance are shown by condition in TABLE 3 and TABLE 4, respectively.

Psychomotor Vigilance Task. There were no main effects or interactions involving training year. Median reaction time for light call was 225.9 milliseconds, with reaction times 7% to 10% slower in light call with alcohol (248.4 milliseconds, $P<.001$), heavy call (242.5 milliseconds, $P=.001$), and heavy call with placebo (242.3 milliseconds, $P<.001$), and there was no difference between light call with alcohol and heavy call with placebo ($P=.19$). Lapses occurred more often in heavy call with placebo than with light call, but were not significantly differ-

Table 2. Stanford Sleepiness Scale and Visual Analog Scale Ratings in the 4 Experimental Conditions*

Self-report Measure	Mean (SE)				P Value	
	Light Call	Light Call With Alcohol	Heavy Call	Heavy Call With Placebo	Condition Effect†	Light Call With Alcohol vs Heavy Call With Placebo‡
Stanford Sleepiness Scale (n = 23)	2.3 (0.2)	3.3 (0.2)	4.6 (0.2)	4.5 (0.2)	<.001	<.001
Visual analog scale (n = 30)						
Alertness	31.6 (3.0)	45.3 (3.1)	68.4 (2.6)	59.5 (2.8)	<.001	<.001
Sleepiness	33.0 (3.5)	38.2 (4.1)	77.9 (2.1)	74.7 (1.8)	<.001	<.001
Overall	25.7 (2.7)	26.5 (2.6)	53.5 (3.1)	51.3 (2.7)	<.001	<.001

*Stanford Sleepiness Scale: 1-7 scale in which 1 = feeling active and vital, alert, or wide awake; 7 = almost in reverie, sleep onset soon, or lost struggle to remain awake. Visual analog scale: 0-100 scale in which higher scores indicate greater sleepiness, less alertness, and worse overall functioning.
†Based on training year (interns vs second-year residents and third-year residents) × condition (light call, light call with alcohol, heavy call, heavy call with placebo) mixed repeated measures analysis of variance. There were no significant training year × condition interactions.
‡Based on post hoc paired *t* tests.

Table 3. Performance Measures in the 4 Experimental Conditions

Performance Task	Light Call	Light Call With Alcohol	Heavy Call	Heavy Call With Placebo	P Value: Condition Effect*	P Value: Light Call With Alcohol vs Heavy Call With Placebo
Psychomotor Vigilance Task (n = 27)						
Median reaction time, mean (SE), ms	225.9 (4.0)	248.4 (7.0)	242.5 (6.1)	242.3 (5.0)	<.001	.19†
No. of lapses, median (range)	0 (0-3)	0 (0-13)	1 (0-9)	1 (0-7)	NA	.21‡
Continuous Performance Test (n = 33), %						
Commission errors, mean (SE)	27.2 (2.8)	46.5 (3.6)	38.2 (3.3)	40.6 (3.2)	<.001	.02†
Omission errors, median (range)	0.0 (0.0-26.8)	0.3 (0.0-3.3)	0.3 (0.0-59.3)	0.7 (0.0-33.2)	NA	.18‡
Simulated driving task (n = 34)						
Lane variability, mean (SE), ft	5.5 (0.2)	6.2 (0.2)	7.0 (0.4)	6.8 (0.3)	<.001	.06†
Speed variability, mean (SE), mph§	2.4 (0.3)	3.2 (0.5)	4.1 (0.5)	4.2 (0.4)	<.001	.01†
No. of off-road incidents, median (range)	0 (0-3)	1 (0-6)	1 (0-23)	1 (0-16)	NA	.55‡

Abbreviation: NA, not applicable.
*Based on training year (interns vs second-year residents and third-year residents) × condition (light call, light call with alcohol, heavy call, heavy call with placebo) mixed repeated measures analysis of variance. There were no significant training year × condition interactions.
†Based on post hoc paired *t* tests.
‡Based on paired McNemar tests.
§Analysis of variance conducted on transformed speed variability using the transformation log (x).

Table 4. Posttest Self-assessed Performance and Effort Ratings on the Performance Measures in the 4 Experimental Conditions*

Performance Task	Light Call	Light Call With Alcohol	Heavy Call	Heavy Call With Placebo	P Value†
Psychomotor Vigilance Task (n = 26)					
Performance	3.0 (0.1)	3.6 (0.2)	4.1 (0.2)	4.1 (0.2)	.73
Effort	1.8 (0.2)	2.4 (0.1)	2.5 (0.1)	2.5 (0.1)	>.99
Continuous Performance Test (n = 31)					
Performance	3.5 (0.2)	4.1 (0.2)	4.4 (0.3)	4.6 (0.2)	.21
Effort	2.2 (0.1)	2.2 (0.1)	2.8 (0.1)	2.9 (0.2)	.01
Simulated driving task (n = 34)					
Performance	2.8 (0.2)	3.4 (0.2)	4.7 (0.3)	4.3 (0.2)	.007
Effort	1.8 (0.1)	2.1 (0.1)	2.8 (0.2)	2.8 (0.1)	<.001

*Performance anchors: 1 = extremely good, 2 = very good, 3 = good, 4 = fair, 5 = poor, 6 = very poor, 7 = extremely poor. Effort anchors: 1 = very little, 2 = a moderate amount; 3 = quite a lot, 4 = an extreme amount.
†Light call with alcohol vs heavy call with placebo based on pairwise McNemar tests.

ent from light call with alcohol. There were no main effects or interactions involving condition in participants whose first session occurred during light call (n=9).

More participants rated their performance as poor, very poor, or extremely poor in heavy call (26.8%, P=.03) and heavy call with placebo (34.5%, P=.008) than with light call (3.8%). Self-assessments of poor or worse performance did not differ between heavy call with placebo and light call with alcohol (26.9%) or effort ratings of quite a lot or extreme (42.3% for light call with alcohol and 46.1% for heavy call with placebo).

Posttest performance ratings were associated with reaction time for light call with alcohol ($r=-0.65$, $P<.001$) but not for heavy call ($r=-0.18$, $P=.36$) or heavy call with placebo ($r=-0.01$, $P=.95$).

Continuous Performance Test. There were no performance differences by training year with this test. Compared with commission errors in light call (27.2%), there were 40% to 70% more commission errors in light call with alcohol (46.5%, $P<.001$), heavy call (38.2%, $P<.001$), and heavy call with placebo (40.6%, $P<.001$), and 15% more in light call with alcohol than heavy call with placebo ($P=.02$). Omission errors occurred more often with heavy call (median, 0.3%; $P=.01$) and heavy call with placebo (median, 0.7%; $P=.01$) than with light call (median, 0%), and heavy call with placebo did not differ from light call with alcohol (median, 0.3%; $P=.18$). For those residents who completed light call first (n=11), commission errors did not differ between light call with alcohol (48.8%) and heavy call with placebo (44.5%, $P=.37$), but in both conditions they were worse than light call (27.5% [SE, 4.3%]; $P<.001$ vs light call with alcohol, $P=.001$ vs heavy call with placebo).

Self-ratings of poor, very poor, or extremely poor performance were more common in heavy call (51.6%) than light call (12.9%, $P=.002$). There was no difference in the frequency of these performance ratings between heavy call with placebo (54.9%) and light call with alcohol (35.5%), but quite a lot and extreme effort ratings were more frequent in heavy call with placebo (64.5%) than light call with alcohol (32.3%, $P=.01$).

Performance ratings were associated with commission errors for light call with alcohol ($r=-0.61$, $P<.001$) and heavy call ($r=-0.45$, $P=.01$), but not for heavy call with placebo ($r=-0.25$, $P=.17$).

Simulated Driving Task. Performance was not significantly different by training year with the simulated driving task. Relative to light call lane variability (5.5 ft), lane variability was 13% to 27% higher in light call with alcohol (6.2 ft, $P=.002$), heavy call (7.0 ft, $P<.001$), and heavy call with placebo (6.8 ft, $P<.001$); light call with alcohol and heavy call with placebo did not significantly differ ($P=.06$). Speed variability was 29% greater in heavy call with placebo than light call with alcohol (4.2 vs 3.2 mph, $P=.01$) and was 34% to 75% higher in light call with alcohol ($P=.01$), heavy call with placebo ($P<.001$), and heavy call (4.1 mph, $P<.001$) compared with light call (2.4 mph). Off-roads occurred more frequently in heavy call (median, 1; $P=.02$) and heavy call with placebo (median, 1; $P=.049$) than light call (median, 0), and were not different between heavy call with placebo and light call with alcohol (median, 1). For those participants whose first session followed light call, heavy call with placebo performance was worse than light call with alcohol for lane variability and speed variability.

More than half of heavy call residents (58.8%) rated their simulated driving performance as poor or worse compared with only 5.9% of participants in the light call group ($P<.001$). These ratings were also more common in heavy call with placebo (44.1%) than light call with alcohol (11.7%, $P=.007$). Almost three quarters of participants in the heavy call with placebo group (73.6%) rated their effort as quite a lot or extreme compared with 17.6% for light call with alcohol ($P<.001$).

Performance ratings were associated with lane variability in heavy call ($r=-0.76$, $P<.001$) and heavy call with placebo ($r=-0.50$, $P=.003$), but not in light call with alcohol ($r=-0.32$, $P=.06$). Speed variability was associated with self-ratings in heavy call ($r=-0.71$, $P<.001$) and heavy call with placebo ($r=-0.51$, $P=.002$), but not in light call with alcohol ($r=-0.04$, $P=.85$).

COMMENT

Our primary findings were post-call performance decrements in attention, vigilance, and simulated driving following 4 weeks of heavy call compared with a light call rotation, similar to impairments associated with 0.04 to 0.05 g% BAC. Compared with light call, heavy call performance was characterized by slower and more variable reaction times and more commission errors on validated tests of sustained attention and vigilance. Heavy call residents were also less able to maintain a consistent lane position and speed, and ran off the road more often on a simulated driving task. Compared with alcohol ingestion, heavy call simulated driving speed variability was 30% higher, and reaction time, attention lapses, omission errors, and crashes were similar. These results were independent of training year and occurred despite self-ratings of greater effort in the heavy call with placebo group on 2 of the 3 tasks.

This is the first study to our knowledge to directly compare impairment related to heavy night call with that related to alcohol ingestion, an accepted standard of functional impairment. We selected performance tasks with known sensitivity to sleep loss and alcohol. Previous studies have demonstrated that both conditions individually increase reaction time, errors of omission, and errors of commission on neurobehavioral assays,[34,50,51] and that they induce simulated driving impairments, characterized by increased variability in driving performance and a greater tendency to drive off the road.[48,49,52] Together, sleep loss and alcohol produce at least additive impairments in driving performance.[48,53] The Continuous Performance Test and Psychomotor Vigilance Test findings from our study suggest that, consistent with nonresident[45,54,55] and other resident[16,56,57] studies, sustained attention and vigilance are particularly sensitive to training-related sleep loss. The observed post-call deficits likely result not only from acute sleep loss but also from the superimposed chronic partial sleep deprivation experienced during training.[13]

These laboratory tasks have not been validated against actual medical tasks. However, post-call deterioration has been found in simulated (laparoscopy)[58,59] and actual (perioperative complications)[60] medical procedures that require the skills inherent in these assessments. The driving simulator findings are particularly provocative. In the heavy call with placebo group, tracking and speed variability were, respectively, around 10% and 30% greater than the light call with alcohol group. These results must be interpreted cautiously because few controlled studies have compared simulated with actual driving,[61] and the strength of the relationship is likely simulator-specific. However, taken together with resident-reported increased motor vehicle crash rates,[23] it seems likely that resident driving skills are impaired post-call and contribute to increased injury risk.

Having demonstrated performance deficits, it is equally important to know whether residents recognize these deficits. We found significant associations between actual performance and self-assessed performance for the Continuous Performance Test and the simulated driving task but not the Psychomotor Vigilance Test. The associations on the 2 former tests (range, −0.45 to −0.76) are similar in magnitude to previous sleep deprivation studies,[62,63] but indicated only a limited ability of the residents to judge their impairment. The associations may have been highest on the simulated driving task because participants were better able to judge good driving rather than good reaction times. We additionally did not find systematic adaptation to chronic sleep loss effects with increasing training year despite self-reports of such adaptation.[4]

We controlled for methodological confounding variables present in previous studies[13] by requiring practice of the dependent measures, testing participants at the same time of day, objectively documenting sleep duration, including driving as a test with real-world relevance, and restricting medication, alcohol, and caffeine use. Robust call differences were found despite light call residents having a daily mean of only 6:38 and 6:37 of actigraphically defined sleep for the 7 days and the 24 hours before the test session. Greater differences might have been observed if participants maintained a consistent 8-hour sleep schedule during light call; however, our external validity is enhanced by having participants self-select sleep schedules. Additional studies are needed that include truly rested control conditions to determine if impairment is present even on light call rotations.

Our study had several limitations. First, the small sample size meant that our main comparisons of interest had low statistical power, and we did not perform an intention-to-treat analysis. However, we successfully detected simulated driving differences between the heavy call with placebo and light call with alcohol groups and we had a relatively large sample size for studies on residents using a within-subjects design. We did not randomize or counterbalance the order of test conditions and cannot discount the possibility of order effects on our findings. However, the tests we used have relatively small practice effects[41,64,65] and all participants practiced the outcome measures before the first test session. In addition, secondary analyses, although underpowered, showed a similar pattern of results.

There may have been a self-selection bias, such that participants may have wanted to demonstrate worse impairment after heavy call than after alcohol ingestion, and our attempts to blind participants to the presence or absence of alcohol were frequently unsuccessful. However, we believe that these results are valid because we did not communicate our specific hypotheses to the participants, we found consistently worse light call with alcohol than light call performance, and effort ratings were higher in heavy call with placebo than light call with alcohol. It is unlikely that participants could have titrated their light call with alcohol performance to be systematically worse than light call but not worse than heavy call with placebo, or that they used greater effort in heavy call with placebo if the goal was to show worse heavy call with placebo than light call with alcohol impairment. Intentional poor performance in heavy call with placebo would have been achieved by exerting minimal effort on the tasks.

Although the tests selected for our study were carefully chosen surrogates for skills that we hypothesized would be impaired by sleep loss in medical residents, we are unable to draw firm conclusions about the degree of training-related impairment associated with actual medical tasks or medical decision making. Our findings do suggest, however, that some of the constituent skills necessary to perform medical tasks are likely to be impaired post-call during a typical heavy call rotation. Finally, our results may not generalize to subspecialties other than pediatrics or to other residency programs with different light and heavy call rotation schedules.

In conclusion, our study demonstrates that resident performance impairment post-call after 4 weeks of heavy call is equivalent to or worse than the impairment observed at 0.04 to 0.05 g% BAC on tests of sustained attention, vigilance, and simulated driving. Moreover, residents' self-assessment of heavy call performance is limited and task-dependent. These findings have important clinical implications. Residents must be made aware of post-call performance impairment and the potential risk to personal and patient safety. There should be sleep loss, fatigue, and countermeasure education in residency programs. Because sleepy residents may have limited ability to recognize the degree to which they are impaired, residency programs should consider these risks when designing work schedules and develop risk management strategies for residents, such as considering alternative call schedules or providing post-call napping quarters. Additional studies should examine the impact of these operational and educational interventions on resident driving safety and on patient care and safety.

Author Affiliations: Department of Psychiatry and Human Behavior, Brown Medical School (Drs Arnedt, Owens, and Carskadon); Division of Ambulatory Pediatrics, Rhode Island Hospital (Dr Owens and Mss Crouch and Stahl); and Sleep and Chronobiology Research Laboratory, E. P. Bradley Hospital (Dr Carskadon), Providence, RI. Dr Arnedt is now with the Sleep and Chronophysiology Laboratory, Department of Psychiatry, University of Michigan, Ann Arbor.

Author Contributions: Dr Arnedt had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Arnedt, Owens, Carskadon.
Acquisition of data: Arnedt, Owens, Crouch, Stahl.
Analysis and interpretation of data: Arnedt, Owens, Crouch, Carskadon.
Drafting of the manuscript: Arnedt, Owens.
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THE GORDON WILSON LECTURE

WORK HOURS, SLEEP AND PATIENT SAFETY IN RESIDENCY TRAINING

CHARLES A. CZEISLER, PH.D., M.D.

BOSTON, MASSACHUSETTS

Case Presentation

In February, 2005, I was asked by the Department of Anesthesia at the Brigham and Women's Hospital in Boston to attend their Morbidity and Mortality Weekly Report rounds to discuss a fall-asleep motor vehicle crash that had occurred on February 20, 2005 in one of their trainees. The trainee was a 39-year-old white male who was in his fifth postgraduate year of training as an anesthesia fellow (Case A.F.). At about 3 pm on February 20, 2005, A.F. fell asleep at the wheel and collided with a stopped vehicle while he was en route home from a 7-hour work shift at the Brigham and Women's Hospital. There was no injury to the fellow, to the other driver or to her 5-year-old child—and hence there is no litigation involved—which is why I am able to present Case A.F. to you today. A.F. reported a similar incident four years earlier in which he had fallen asleep at the wheel while driving his car at high speed on an expressway during a commute home from a >30-hour extended duration work shift in his first postgraduate year of training. In that incident, A.F. was awoken by a rumble strip on the expressway and thereby avoided a potentially catastrophic motor vehicle crash. He said that he understood that the >30-hour shift had made him vulnerable to the fall-asleep incident while driving on the highway during his PGY1 year. However, he wondered why he experienced a fall-asleep crash during his PGY5 year, after working a much shorter, seven-

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From the Division of Sleep Medicine, Department of Medicine, Brigham and Women's Hospital and Division of Sleep Medicine, Harvard Medical School, Boston

Dr. Czeisler serves or has served as a paid consultant for Actilion, Avera Pharmaceuticals, Inc., Axon Sleep Research Laboratories, Cephalon, Hypnion, Lifetrac, Neurocrine, Sanofi-Aventis, Pfizer, Respironics, Takeda, Unilever and Vanda Pharmaceuticals; owns equity interest in Hypnion, Lifetrac and Vanda and has received clinical trial research contracts and investigator-initiated research grants from Cephalon and Pfizer. Dr. Czeisler's laboratory has received unrestricted research and education funds from Cephalon and he serves as the incumbent of an endowed professorship provided to Harvard University by Cephalon.

hour shift. To address this question, I initiated a series of steps comparable to those which might be undertaken by investigators (such as local or state police departments or the National Transportation Safety Board) evaluating if sleepiness or sleep deprivation were a probable contributing factor to a transportation accident.

Work-hour and Sleep-wake History

As a PGY-5 anesthesia fellow, A.F.'s work schedule required that he be "on call" from home for the intensive care unit for two out of every three weeks. He reported that his sleep habits were as follows: (1) during non-call/non-work nights (which occurred 6 times per month) his nightly sleep episode was from 10 pm to 6:30 am; (2) during non-call/work nights (which occurred 7–14 times per month) his nightly sleep episode was from 10 pm to 4:30 am; (3) during on-call/work nights (which occurred 7–21 times per month) his nightly sleep episode was from 10 pm to 4:30 am and he was awoken by 3–4 pages from the intensive care unit per night. Finally, A.F. noted that he and his wife were typically awoken once per night by one of their three young children for about 20 minutes per night.

Pharmacologic History

A.F. denied alcohol or hypnotic drug use prior to the crash. He admitted using caffeine, which he reportedly administered in the form of "three shots of espresso" each morning and which he said he "titrated to effects" during the remainder of the day (typically two more small cups of coffee). He reported that he avoided caffeine most afternoons, including the day of the crash, in order to avoid disturbing his subsequent night of sleep.

Hospital Paging Records

The times at which A.F. was paged were downloaded from the Brigham and Women's Hospital paging system records and are illustrated together with his reported sleep-wake times, as recollected by history, during the prior four nights, in Figure 1. On the night before the crash, A.F. was paged twice at the beginning of his sleep episode, then awoken by a page from the ICU again at about 1:30 am, then awoken by a page just before 2 am and then awoken by a page again at approximately 3 am before his final page during that sleep episode, which was at about 3:30 am. He arose at 4:30 am, showered, dressed and ate breakfast (including three shots of espresso) prior to commencing a 50-mile commute into the hospital at 5:45 am.

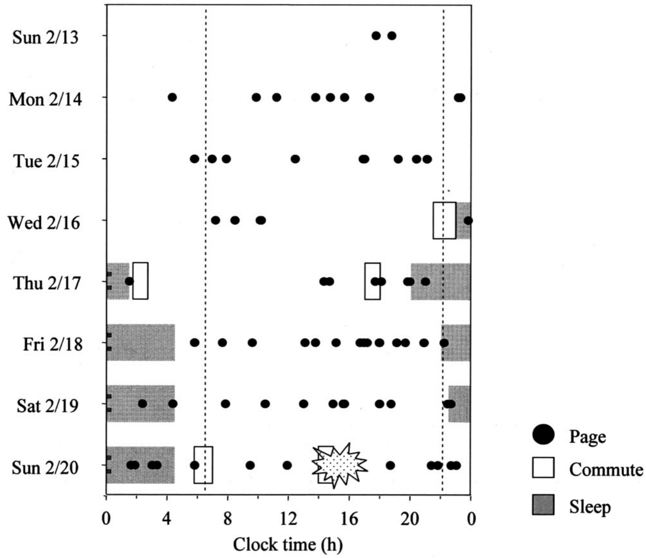

FIG. 1. The sleep-wake times, commute times and pages (from the Brigham and Women's Hospital paging records) of a PGY-5 Anesthesia Fellow leading up to motor vehicle crash.

Sleep Disorders Evaluation

A.F. was referred to Dr. David White, who then directed the Brigham and Women's Hospital Sleep Disorders Service, for an evaluation. He reported a history of loud snoring, particularly when sleep deprived and when sleeping on his back. He denied weight change, restless legs, history of sleep attacks or limb weakness with extreme emotion (cataplexy) or a history of difficulty falling asleep or staying asleep. His physical examination was unremarkable (Height: 6′3″; Weight: 180 lbs; BMI: 22.5). Dr. White ordered a polysomnographic recording, which revealed an hourly apnea/hypopnea index (AHI) of 20.5, with an AHI of 47 per hour when supine and 2 per hour when sleeping on his side. Oxygen desaturations to 86 percent were recorded during the apneic events. Dr. White diagnosed A.F. with positional sleep-related breathing disorder and behaviorally induced insufficient sleep syndrome.

In order to put the results of this evaluation into context, it is important to understand the physiology of sleep and wakefulness.

Background on Determinants of Alertness and Performance

Multiple factors influence the ability to sustain effective waking neurocognitive performance in young healthy individuals not taking medications. These include consecutive waking hours; nightly sleep duration; biological time of day (i.e., circadian phase); and the recency of the last sleep episode (i.e., sleep inertia). While the effects of these circadian and homeostatic sleep regulatory processes can be modified by environmental conditions, physical activity and pharmacological agents (i.e., stimulant and hypnotic agents), there is no countermeasure known that can consistently overcome the impact of adverse circadian phase and/or sleep deprivation on performance. The interaction of these regulatory processes can create an imposing biological force which can overpower an individual's ability to sustain alert wakefulness and remain attentive. This leads to impaired neurocognitive performance, including reduced memory consolidation, and deterioration of waking performance marked by increased rates of attentional failures (1). These consequences of misalignment of circadian phase and the wake-sleep schedule, cumulative sleep deprivation and lengthy prior wakefulness are particularly evident while attempting to sustain attention for a continuous duration of time (e.g., for 10–20 minutes or more) while performing a routine, highly over-learned task such as driving a motor vehicle.

The Sleep Homeostat

Without sleep, alertness and neurocognitive performance exhibit a steady deterioration attributable to sleep loss, onto which a rhythmic circadian variation is superimposed (2–18). Among individuals who win the struggle to remain awake, 24 hours of sleep deprivation has been shown to impair neurobehavioral performance to an extent that is comparable to a level of 0.10 percent blood alcohol content (19). In fact, the duration of time it takes to react to a visual stimulus (simple reaction time) averages three times longer after 24 hours of wakefulness than before an individual has stayed up all night (20) (Figure 2). Moreover, this is when the risk of attentional failures—in which the eyes begin rolling around in their sockets at the transition from wakefulness to sleep—is greatest. Within several days, chronic sleep restriction has been demonstrated to yield impairment in neurobehavioral performance and a risk of attentional failures that increased to a level comparable to that seen with acute total sleep deprivation (21,22). In fact, six hours of time in bed per night for a week or two brings the average young adult to the same level of impairment as 24 hours of wakefulness, whereas 4 hours of time in bed per night gets there in four to six days and induces a level of impairment comparable with 48 hours of wakefulness (i.e., two consecutive days and nights without sleep) after 10 days of restriction. As with alcohol intoxication, chron-

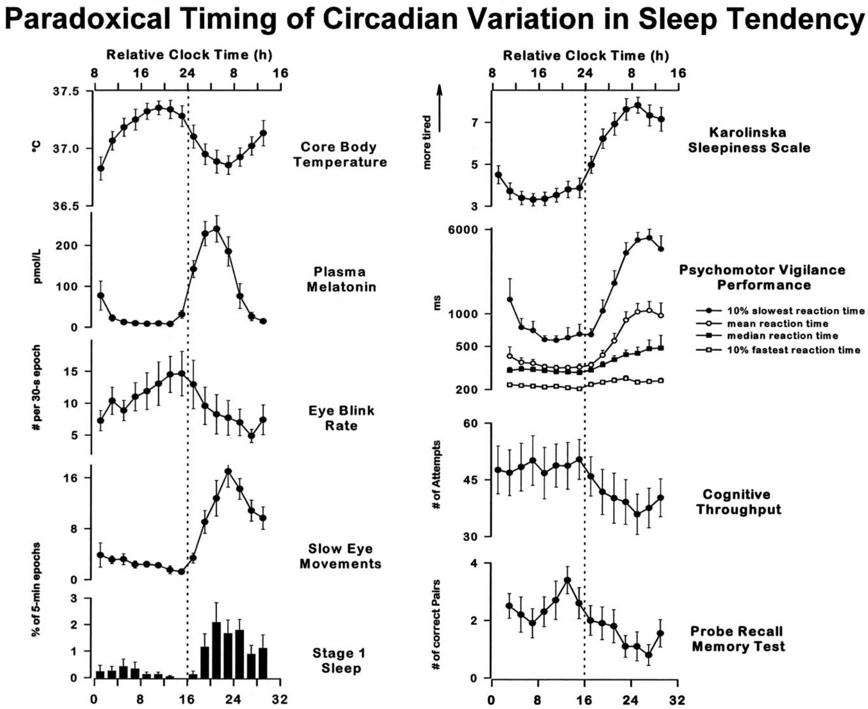

FIG. 2. Laft-hand column: Time courses of core body temperature, endogenous plasma melatonin, mean eye blink rate per 30-s epoch during Karolinska drowsiness test (KDT), incidence of slow eye movements (SEMs, percentage of 30-s epochs containing at least 1 SEM/5-min interval), and incidence of stage 1 sleep (% of 30-s epochs containing at least 15 s of stage 1 sleep per 5-min interval) are shown, averaged across 10 subjects ± SE. Right-hand column: Time course of subjective sleepiness as assessed on Karolinska sleepiness scale (KSS; highest possible score = 9, lowest possible score = 1), psychomotor vigilance performance [mean, median, 10% slowest and fastest reaction times in ms (logarithmic scale)], cognitive performance (numbers of attempt in 4-min 2-digit addition task), and memory performance (number of correct word pairs in probed recall memory task) are shown averaged across 10 subjects ± SE. All data were binned in 2-h intervals and expressed with respect to elapsed time since scheduled waketime. Vertical reference line indicates subject's habitual bedtime. Reprinted with permission from Cajochen et al (20). Copyright 1999 American Physiological Society.

ically sleep-deprived individuals tend to underestimate the extent to which their performance is impaired, despite increasing impairment evident in objective recordings of the rate of lapses of attention (23). Objective measures of performance, including reaction time and memory, worsen. The effects of recurrent nights of sleep restriction are not overcome with a single night of sleep. Increasing sleep deprivation leads to an increased probability of experiencing lapses of attention, episodes of automatic behavior and/or falling asleep while attempting to remain awake. In a condition of chronic sleep deprivation, even when wakefulness is scheduled during an appropriate circadian phase, the probability of a sleep-related attentional failure or neurocognitive performance failure while waking is markedly increased (23,24). Moreover, repeated interruptions of sleep, such as is experienced by physicians when they are on call, degrade the restorative quality of sleep compared to an equal amount of consolidated sleep. This is thought to be a primary basis for the excessive daytime sleepiness associated with sleep disorder breathing, which induces many brief arousals during the night. Interestingly, just being on call disturbs sleep, even when the individual is not called (25,26). Dr. Marshall Wolf and I learned this firsthand when recording the sleep of interns in a study that we did with Dr. Gary Richardson and that Dr. Wolf presented to this group fifteen years ago (27). As shown in Figure 3, the sleep of this young intern was acutely disturbed while he was on call, with little deep slow wave sleep and many awakenings that were not accounted for by the two pages that were received. This intern remained awake for almost an hour after being awakened by a page the second time.

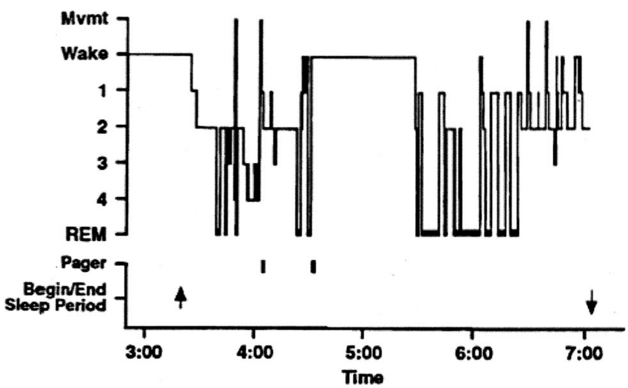

FIG. 3. Polysomnographic recording of sleep in an intern on call. The figure depicts the hypnogram and the effects of two pages during the night in an intern from the group not covered by a night float. "Pager" indicates an electronically recorded page was issued to the intern's beeper at the time indicated on the X-axis. "Begin/End sleep period" indicate the times recorded by the intern for these events in the diary. This record demonstrates the variable impact of pages during sleep. The first page, from one of the nursing stations, occurred at approximately 4.08 am. The page occurred while the intern was in stage 4 and produced only a brief movement without unambiguous awakening. Approximately 28 minutes later, the same nursing station paged again, this time awakening the intern from REM sleep. The intern subsequently remained awake for almost an hour despite no additional pager activity. Reprinted with permission from Richardson et al (26). Copyright 1996 Associated Professional Sleep Societies, LLC.

The impact on the brain of resulting insufficient sleep is only beginning to be appreciated. Positron Emission Tomography (PET) imaging has revealed that sleep deprivation is associated with decreased metabolism in the thalamus, the pre-frontal cortex and the parietal cortex (28). Metabolic studies have demonstrated that such sleep curtailment also has adverse effects on the metabolic and immune systems.

Sleep Attacks and Sleep Drunkenness

Individuals struggling to stay awake in the face of elevated sleep pressure—whether due to acute total sleep deprivation, chronic sleep restriction or repeated interruption of sleep (due to external interruptions or the presence of a sleep disorder)—are not always able to do so by the sheer force of will. Sleep deprivation greatly increases the risk that an individual will succumb to the increased sleep pressure when their brain initiates an involuntary transition from wakefulness to sleep. This transition is initiated by the ventrolateral preoptic (VLPO) area of the hypothalamus, which Saper et al. have identified as the brain's "sleep switch" (29). Another region of the hypothalamus, the suprachiasmatic nucleus (SCN), which serves as the central neural pacemaker of the circadian timing system, interacts with the VLPO such that there are two times of day at which such an involuntary transition from wakefulness to sleep is most probable: in the latter half of the night near the habitual wake time and in the mid-afternoon. Of course, once an individual has lost the struggle to stay awake and makes the transition from wakefulness to sleep, driving performance is much worse than that of a drunk driver, as the individual is unresponsive to the environment. Moreover, sometimes drowsy drivers linger in an intermediate state between sleep and wakefulness. The operator of a motor vehicle in this sleep-like condition—which probably represents a transitional state in which part of the brain is asleep while part of the brain remains awake—may maintain full pressure on the accelerator pedal and proceed for a considerable distance, even negotiating gradual turns, but fail to heed stop signals or respond appropriately to traffic conditions in a timely manner. This intermediate state, which has been termed "automatic behavior syndrome" or "sleep drunkenness" is characterized by retention of the ability to turn the steering wheel and to carry out rudimentary tasks and to provide semi-automatic responses to stimuli without appropriate cortical integration, often resulting in a complete loss of situational awareness and judgment (30). Some of you may have experienced this state when you suddenly realize that you have no idea how you went from point A to point B on the expressway—as if there were a missing segment in the video of life. One drowsy driver who steered his car toward an oncoming car and then tracked it as the other driver swerved to avoid him reported "waking up" from this state just in time to observe vividly through his windshield a terrified look on the face of the other driver only a moment before he killed her in a head-on collision (31). A similarly impaired NASA ground controller working in the Mission Control Room of the Johnson Space Center during the middle of the night shift sent a Space Shuttle careening into a spin while crew members were asleep when he repeatedly overrode automatically generated coordinates designed to keep the shuttle on track.

Circadian Rhythmicity

Circadian rhythms, i.e., biological rhythms oscillating with an approximate period of twenty-four hours (from the Latin words: *circa*—about and *dies*—a day), are present at all levels of biological complexity from unicellular organisms to humans. Circadian rhythms are endogenous (i.e., internally generated), self-sustaining oscillations; therefore, rhythmicity persists in the absence of periodic external time cues. In humans, many physiological processes, including the body temperature cycle, endocrine patterns, renal and cardiac function, subjective alertness, sleep-wake behavior and performance vary according to the time of day (4,20,32–37). The circadian contribution to variations in alertness and performance is generated by a light-sensitive circadian pacemaker that also drives the circadian rhythms of core body temperature, plasma cortisol and plasma melatonin (5,38–50). The endogenous circadian clock is a major determinant of the timing and internal architecture of sleep in humans (5,6). Spontaneous sleep duration, sleepiness, REM sleep propensity, and both the ability and the tendency to sleep vary markedly with circadian phase or biological time of day and interact with a homeostatic process to regulate sleep propensity and daytime alertness and neurocognitive performance (7–10,51–53). As noted above, deep within the brain, two bilaterally paired clusters of hypothalamic neurons comprising the SCN of the hypothalamus act as the central neural pacemaker for the generation and/or synchronization of circadian rhythms (54–60). This endogenous circadian pacemaker is a major determinant of daily variations in subjective alertness and cognitive performance (4,9,11,12,20,24,38). These and other studies have shown that there is a prominent circadian variation in objective and subjective measures of alertness, performance (psychomotor, vigilance, memory) and attention or ability to concentrate, with a nadir in the latter half of the usual sleep time, just before our usual wake time (Figure 2). Similarly, the peak drive for waking emanating from the hypothalamic circadian pacemaker occurs a couple of hours before our habitual bedtime. This paradoxical relationship between the output of the circadian pacemaker and the timing of the sleep-wake cycle is thought to help consolidate sleep and wakefulness in humans (8). Thus, under ordinary circumstances as the homeostatic drive for sleep increases throughout the 16-hour waking day, the circadian pacemaker sends out a stronger and stronger drive for waking during the latter half of the habitual waking day. Then, near the peak of the circadian drive for waking, about 1–2 hours before the habitual bedtime, the hormone melatonin is released. Activation of melatonin receptors on the surface of human SCN neurons suppresses the firing of those neurons. Since the SCN continues to oscillate with a near-24-hour period in the absence of SCN neuronal firing, this action of melatonin is thought to quiet the wake-promoting signal emanating from the SCN, thereby allowing us to fall asleep at our habitual hour. Similarly, the SCN sends out a strong drive promoting sleep in the latter half of the night, which helps to consolidate sleep once the pressure for deep slow-wave sleep is satiated in the first half of the night. The latter half of the night is richest in REM sleep, which has a very prominent circadian rhythm in its propensity. When one stays awake all night, in the latter half of the night near the habitual wake time, elevated homeostatic drive for sleep interacts with the circadian peak of sleep propensity to create a critical zone of vulnerability.

In the absence of periodic time cues, the period of the human circadian pacemaker is slightly longer than 24 hours (61,62). In order for the biological clock to coordinate its function with the timing of events in the external world that operates on a 24 hour schedule, daily information from the environment must therefore reach the circadian pacemaker. The circadian pacemaker is essentially reset by a small amount each day by this external stimulus in order to maintain synchrony with the 24-hour day (5,40,61).

Light is the principal environmental synchronizer of the mammalian SCN. The SCN is connected to specialized intrinsically photosensitive retinal ganglion cells containing the newly discovered photopigment melanopsin via a monosynaptic pathway called the retinohypothalamic tract (RHT), the presumed conduit by which information from the external light-dark cycle reaches the circadian clock. Properly timed exposure to light and darkness can rapidly shift the phase of the endogenous circadian pacemaker in humans (34,38–50,63,64). Both the magnitude and direction of the phase shifts induced by light are dependent on the timing, duration, intensity and wavelength of the light exposure (39,40,46–49,64–70). On average, light exposure occurring during the first half of the biological night resets the circadian clock to a later hour; light received in the latter half of the biological night resets the circadian clock to an earlier hour. Thus, the circadian pacemaker of an individual living on a conventional schedule of day work and night sleep is synchronized by the naturally occurring light- dark cycle to oscillate at the same period as the Earth's solar day, i.e., 24 hours.

Sleep Inertia

Fifty years ago, following a crash inquiry, scientists in the U. S. Air Force Laboratory discovered that performance is markedly degraded during the transition from wakefulness to sleep (71–83). The extent to which this phenomenon, now called sleep inertia, interferes with neurobehavioral performance is related to the depth of the prior sleep episode (78). Thus, agents that interfere with sleep, such as caffeine, can mute the effect of sleep inertia (84). Remarkably, as we recently reported, the adverse impact of sleep inertia on performance can far exceed the impact of total sleep deprivation (83) (Figure 4). Once residents are able to get to sleep, these house officers—who are often subjected to acute total sleep deprivation after days, weeks or months of chronic sleep restriction—often experience very deep sleep. When this occurs while residents are on call in the hospital, they may be required to make critical care decisions or perform life-saving medical

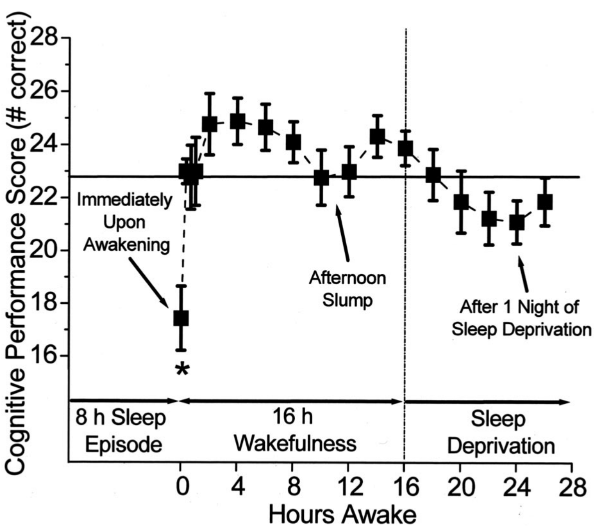

FIG. 4. Impact of sleep inertia on cognitive performance upon awakening compared with 24 hours without sleep. Reprinted with permission from Wertz et al. (83). Copyright 2006 American Medical Association.

procedures in an impaired state due to profound sleep inertia (15,83). Moreover, at times of night when they have the greatest patient care responsibilities due to the lack of on-site faculty supervision, resident physicians—who sleep on average just 2.6 hours while working 30-hour extended duration "on-call" shifts (85)—are likely to descend rapidly into deep stages 3 and 4 sleep during those two-hour naps, and then attempt to care for patients in an impaired confusional state—characterized by grogginess, disorientation in time or space, slowed mentation and slowed speech—immediately upon awakening.

There are a number of other factors that can have an impact on alertness and performance. These include the length of time on task, the level of environmental stimulation, the level of physical activity, posture, the level of task stimulation/novelty, and the use of pharmacologic agents with stimulant or hypnotic properties. Caffeine is the most widely used drug in the world. In fact, coffee beans are the second most widely traded commodity in the world, second only to oil. Caffeine administration can reduce the adverse impact of misalignment of circadian phase as well as increased homeostatic pressure on neurobehavioral performance (86). However, the dose and timing of administration is not always optimal. Specialty brand coffee, such as that available from retail outlets such as Starbucks and Dunkin' Donuts, contain 3–4 times as much caffeine per ounce as does home brewed coffee. Super-size (e.g., 24 ounce) servings can thus contain more than a gram of caffeine, as much caffeine as an entire 10-cup pot of home-brewed coffee. When taken in the morning, these large doses of caffeine are being administered when sleep pressure is lowest, with levels declining throughout the day. When taken in the evening, caffeine—which has a 6- to 9-hour half life—may interfere with recovery sleep. When used as a wake-promoting therapeutic, the minimum effective dose of caffeine should be taken at the optimal time to help sustain performance when adequate sleep cannot be obtained. However, neither caffeine nor other wake-promoting therapeutics are a substitute for sleep. In fact, in a study of fatal-to-the-driver truck crashes, the National Transportation Safety Board (NTSB) found that plasma caffeine levels were highest in drivers involved in fatigue-related crashes (87). The NTSB interpreted high plasma caffeine data from those drivers as indicating that the drivers were taking caffeine to try to combat their fatigue. Unfortunately, even high levels of caffeine were insufficient to save those drivers from the effects of fatigue, which the NTSB found to be the leading cause of fatal crashes in those trucker drivers, equal to the fraction of crashes caused by both drugs and alcohol combined (87).

Underlying Medical Condition and Age

A number of medical conditions and/or the medications used to treat those conditions are associated with increased sleep tendency, increased risk of lapses of attention and increased risk of sleep-related accidents (88). These include primary sleep disorders, such as narcolepsy and sleep apnea, as well as sleep disturbance secondary to a medical condition or its treatment. Obstructive sleep apnea patients, for example, with an apnea/hypopnea index greater than 10, have a 6-fold increase in risk of traffic accidents (89). Age decreases the risk of sleep-related lapses of attention at night; in fact, young people are at the greatest risk of the hazards of sleep loss (90). Thus, at first blush, one might hypothesize that senior staff rather than new trainees should be assigned to work marathon overnight shifts. However, before you hastily assign all extended duration night work to your chiefs of service, I would caution you to recognize that as we get older, it becomes more and more difficult to obtain the recovery sleep that is needed following sleep deprivation. In fact, even when sleep deprived, older people have a great deal of difficulty sleeping at an adverse circadian phase (10,16,91).

Graduate Medical Education and Sleep

Extended duration work shifts, like many other features of graduate medical education in the United States, were the product of the postgraduate medical education curriculum developed by William Steward Halsted, M.D. Professor Halsted, who was Surgeon-in-Chief at the Johns Hopkins Hospital, was internationally renowned for his innovations in medical education. He founded the surgical training program at the Johns Hopkins Hospital in the 1890s, which served as a model for postgraduate medical education. He required physicians-in-training to live in the hospital (they were quite literally residents) and discouraged them from marrying so that they could devote themselves to medicine (92). He required residents to be on a "q1" call schedule, i.e. they were on call 362 of 365 days per year. He taught devotion to the profession by example, working heroic hours with his trainees. Only recently was it revealed how he maintained this grueling sleep-deprived schedule. Professor Halsted was in fact addicted to cocaine, an addiction that was an unfortunate by-product of his pioneering work developing cocaine as a surgical anesthetic (93). He spent more than a year in a rehabilitation program at a Rhode Island hospital trying to shed his cocaine addiction prior to his appointment as the first Professor of Surgery at Johns Hopkins Medical School. However he only