

The Effects of Sleep Deprivation on Fire Fighters and EMS Responders



Final Report, June 2007





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Acknowledgments

This report was supported by a cooperative agreement between the International Association of Fire Chiefs (IAFC) and the United States Fire Administration (USFA), with assistance from the faculty of Oregon Health & Science University, to examine the issue of sleep deprivation and fire fighters and EMS responders. Throughout this work's preparation, we have collaborated with Victoria Lee, Program Manager for the IAFC, whose assistance has been instrumental in successfully completing the project. The information contained in this report has been reviewed by the members of the International Association of Fire Chiefs' Safety, Health and Survival Section; Emergency Medical Services Section and Volunteer and Combination Officers Section; and the National Volunteer Fire Council (NVFC). We also gratefully acknowledge the assistance of our colleagues Esther Moe, PhD, MPH, and Carol DeFrancesco, MA, RD.





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Preface

The U.S. fire service is full of some of the most passionate individuals any industry could ever have. Our passion, drive and determination are in many cases the drivers that cause us to take many of the courageous actions that have become legendary in our business. When others run to exit, we run to the entrance. What most would consider lost, we work to find. While others sleep, we often can't, don't or won't. Unfortunately, even the most impassioned, determined and courageous have human needs that don't cease during these expressions. Unfortunately for the fire service, our drive and desire, combined with a culture that says keep working until the job is done, can create situations where we don't take care of ourselves under the pretext of helping others. This tendency can extend to the amount of sleep that we get.

This study of the effects of sleep deprivation is important in a number of regards. Perhaps the most important fact is the realization that lack of adequate sleep for members of the fire service has the same effect on them as it does on other human beings. Humans don't perform at peak levels without adequate sleep. Like many other health and wellness issues, the amount of sleep one needs is highly variable and depends on several factors. Generally, a significant safety hazard is present when a person is sleep deprived.

One interesting offshoot of passion is emotion. Often, members of the fire service have immediate emotional reactions to subjects and issues, followed by the search for evidence to support that emotion. It is likely that this will be the case with a study of this type. Discussions about sleep adequacy can easily slip into discussions about shift schedules and work hours. Some will suggest that there is a correlation between shift schedules and sleep deprivation. The reality is there is correlation between the amount of sleep one gets and their overall level of performance. For those who are deprived, it really doesn't matter why they are deprived. One could just as easily be deprived from off duty activities as they could from on duty activities. Many of those who have already made their decision on this issue will likely skip this preface and go directly to the data that supports their assertions; however, if you are reading this, consider the fact that perhaps sleep deprivation is an issue that stands on its own.

Finally, it is refreshing to see a review of an issue that impacts the health and safety of the U.S. fire service addressed in such a comprehensive manner. The study provides another objective tool for strategic analysis of the fire service and our activities, particularly for the fire chief. It will be important for fire chiefs to look at this study from two perspectives. First, what can be done to minimize duty-related sleep deprivation? Of course, these discussions must be handled delicately because they do impact the working and operating conditions of the organization. Second, and perhaps most important, is how to determine when a member of the organization is sleep deprived. How do you handle it? Who will have which role in the evaluation process? These are just a few of the questions that this study can help a fire chief answer.

A handwritten signature in black ink, appearing to read "I. Daniels", followed by a horizontal line.

Chief I. David Daniels
IAFC Board of Directors, Safety, Health & Survival Section

A handwritten signature in black ink, appearing to read "James B. Harmes", followed by a horizontal line.

Chief James B. Harmes, CFO
IAFC President 2006-2007

Executive Summary

Social trends are toward a 24 hour a day, 7 days a week, 365 days a year culture, and as a nation, we are sleeping less and attempting to accomplish more during our waking hours. Nowhere are those trends more apparent than for fire fighters and EMS responders, who are charged with the immediate care of our 24/7 society.

However, humans have limits to their abilities. Adequate daily sleep is needed to perform optimally and be healthy. Sleep deprivation is linked with increased errors in tasks requiring alertness, vigilance and quick decision-making. Long work hours often are associated with chronic sleep loss, which may result in decreased ability to think clearly and feelings of depression, stress and irritability. Those effects are not reliably predicted by how fatigued an individual feels, as chronically sleep deprived people frequently do not perceive their lack of sleep as a problem. Chronic sleep loss also is associated with a general increase in health complaints and musculoskeletal problems, higher body weights, a greater risk of obstructive sleep apnea and heightened levels of cardiovascular disease and cancer.

However, although they may be associated with chronic sleep deprivation, longer duration work shifts and compressed work weeks may have advantages for certain professions, which can include fire fighters and EMS responders. The challenge is to achieve the benefits of a given work structure while minimizing the potential decrements in performance and cumulative adverse health effects that long work hours and acute and chronic sleep deprivation may have on workers.

We begin this report with background on the physiology of sleep, followed by a critical review of the immediate effects of fatigue and the health and performance consequences of chronic sleep deprivation. In Section 1, we outline the caveats and potential limitations when reviewing compiled research from varied settings. For many professions, including fire fighting and EMS, the unique characteristics and demands of a particular work setting make generalizations difficult. In presenting studies, we have included information about the group assessed and methodology to assist interpretation of those reports.

The transportation industry and more recently postgraduate medical training are settings where fatigue-related adverse events have mandated examination of work hours' effects, shift structure reform and attention to fatigue countermeasures. Sections 2 and 3 of this report present that information and highlight potential implications for fire fighters and EMS responders.

Section 4 is a review of information relating specifically to sleep deprivation and work hours among fire fighters and EMS responders. Again, study details are presented and compiled findings tabulated, which will allow readers to appropriately draw conclusions from observations in varied settings.

Section 5 presents science-based recommendations for individuals and organizations concerning managing work hours, including means to identify workers at greater risk from long hours, mitigating individual lifestyle actions and employer work-structure issues.

The Appendices in Section 6 include legal considerations and the authors' recommendations in the domains of education and potential future studies. By including these suggestions in the final Section, we underscore that these are the opinions of the authors.

As fire fighters and EMS responders continue to address the issue of sleep deprivation, it is important that they, their families, administrators and others with whom they work become educated about the performance and health effects of fatigue and assess their individual actions, job demands and work culture and structure. Involving all stakeholders (personnel and their families, management, representatives from labor organizations and national administrative bodies, and sometimes outside consultants) is critical to the success of any fatigue management program. The information in this report, presentation of its findings and the accompanying education DVD are resources for fire fighters and EMS responders in those efforts.

The fine letter by the IAFC's Chiefs Daniels and Harmes (page ii) articulates the importance of the topic for fire fighters and EMS responders, and they provide direction for this review's use.

In other settings, highly publicized fatigue-related adverse events have necessitated reform. The authors congratulate the organizations funding this work for anticipating the continued need to juxtapose the work demands and job structures of fire fighters and EMS responders and the excellence in performance that typifies those professions. We believe that as the poet said, limits in human abilities must be acknowledged, and adjusting to dynamic work influences is critical for continuing to exceed existing high performance standards, while maintaining the health and well being of fire fighters and EMS responders.

**My candle burns at both ends,
It will not last the night.**

Edna St. Vincent Millay

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Section 1: Effects of Long Work Hours and Sleep Deprivation

1.1 Introduction

Interest in sleep can be traced back to the earliest civilizations, and only love and human conflict have received more attention from poets and other writers (Dement, 2000). In the last 50 years, better understanding of sleep has resulted in a new medical specialty of *sleep medicine*, and almost 100 different sleep disorders have been described.

We have come to appreciate how important healthy sleeping habits are to well being. Sleep or lack of it, impacts humans' abilities and both psychological and physiological health. Despite better recognition of sleep and its importance, as work hours in the U.S. have increased, the nation's sleep habits have worsened.

Longer work hours and departures from the typical '9 to 5' work day mean disruption of sleep and the body's normal day-night schedule. In this report, we review the effects of sleep deprivation for emergency services personnel, and as background, we begin with a discussion of normal sleep physiology and daily biological rhythms.

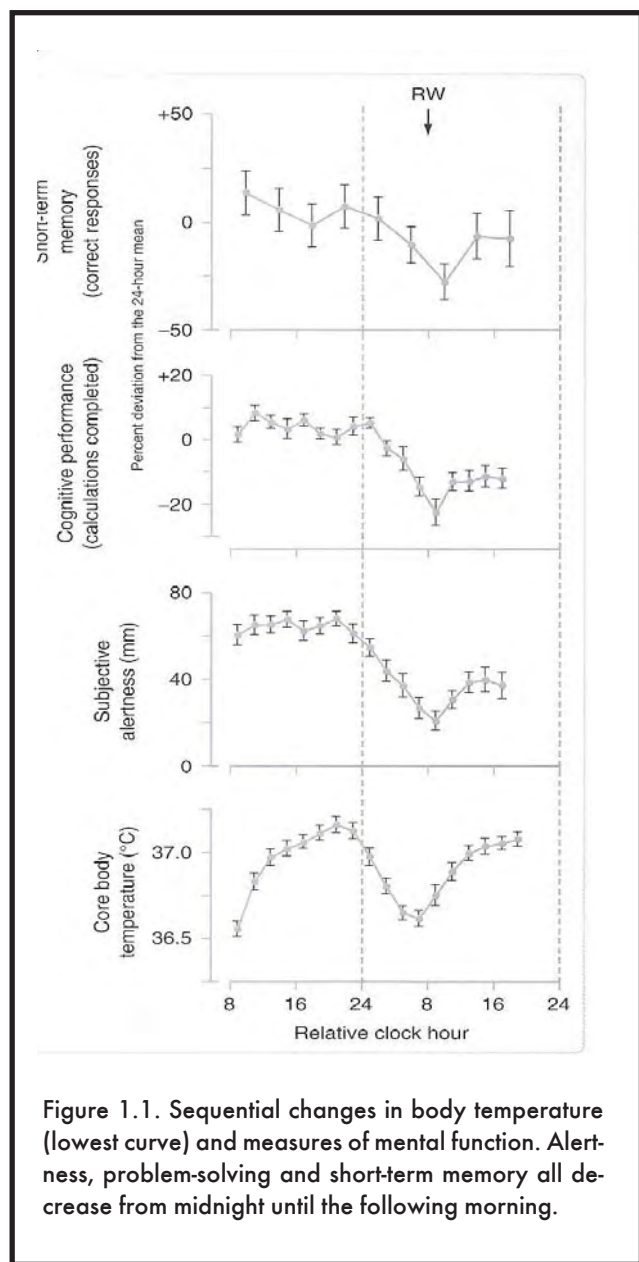
The hours worked annually by U.S. employees have risen steadily over the past several decades and surpass that of Japan and most of Western Europe. Coincident with longer work hours, the time slept each night has decreased. In 1910 the average sleep time was 9 hours, which had decreased to 7.5 hours in 1975 and currently is 6.8 hours per night for American adults. More than one-third of adults get less than the recommended 7.5 to 8 hours of sleep each night (National Sleep Foundation, 2005).

1.2 Normal Sleep and Circadian Rhythms

The need for regular sleep is superimposed on our daily day-night cycle or circadian rhythm, from the Latin *circa* meaning 'about' and *dies* meaning 'day.' Although there is agreement that sleep and chronobiology (the study of biologic rhythms) are closely linked, the two fields developed independently. Understanding each is important for interpreting studies of the effects of differing work hours on health. Humans are by nature diurnal (day orientated) as opposed to nocturnal (night orientated) beings, meaning that our physiological functions are geared towards daytime activity and nighttime rest.

The average adult requires from 6 to 10 hours of sleep each day. Because of humans' circadian rhythm and preference for nighttime sleep, all sleeping and waking hours are not equal. When assessing the effects of a given daily schedule, both the number of hours slept and the time that they occurred must be considered.

Normal sleep is complex and composed of two different states: *non-rapid eye movement* (NREM) sleep and *rapid eye movement* (REM) sleep. Non-rapid eye movement sleep occurs as sleep begins. It, in turn, is composed of four stages, indicating progressively deeper sleep. Stage 1 is viewed as a shallow sleep during which an individual can be easily awakened. With the onset of stage 2 NREM sleep, the arousal threshold increases. Stages 3 and 4 of NREM sleep are defined by specific EEG patterns and collectively are referred to as deep sleep, delta sleep or slow-wave sleep.



These deeper stages of NREM sleep are when the heart rate slows, blood pressure and the metabolic rate are reduced and hormones responsible for normal function and tissue repair are secreted. By definition, delta brain waves account for 20 to 50 percent of activity during stage 3 and greater than 50 percent of brain wave activity during stage 4 of NREM sleep. Individuals are more difficult to awaken during these stages of deeper NREM sleep.

NREM sleep is followed by the state of rapid eye movement (REM) sleep, during which dreaming occurs, emotions are processed and both motor and cognitive memories are consolidated. REM sleep is important for learning and emotional well being. The brain wave pattern and physiological profile of REM sleep is similar to that seen in relaxed wakefulness (with eyes closed).

This sequence of progressively deeper NREM sleep followed by REM sleep repeats cyclically throughout the night at intervals of 90 to 100 minutes (from one REM period to the next). REM sleep episodes become longer as the night progresses, and the longest REM periods are found in the last third of the night. Overall NREM sleep accounts for approximately 75 percent, and REM sleep accounts for 25 percent of the total sleep time. This cycling and organization of the sleep stages constitute the *sleep architecture*.

A person's level of alertness upon awakening depends on their stage of sleep. In Stage 1 or 2 of NREM sleep, the person is more likely to wake up feeling alert and refreshed. If roused during REM sleep, people feel alert and more easily remember their dreams. But if awakened from Stage 3 or 4 of NREM sleep, the individual may experience *sleep inertia*, a state of grogginess and diminished performance experienced on waking from a deep sleep. Thus, when napping, shorter durations (less than an hour) or more than 90 minutes may be preferred, so that awakening does not occur during the deeper stages of NREM sleep.

Humans' sleep architecture is composed of two types of sleep. Non-rapid eye movement (NREM) sleep is most important for normal bodily functions' rest and repair, and dream or rapid eye movement (REM) sleep is needed for learning and mental health. Achieving adequate amounts of both is critical for health.

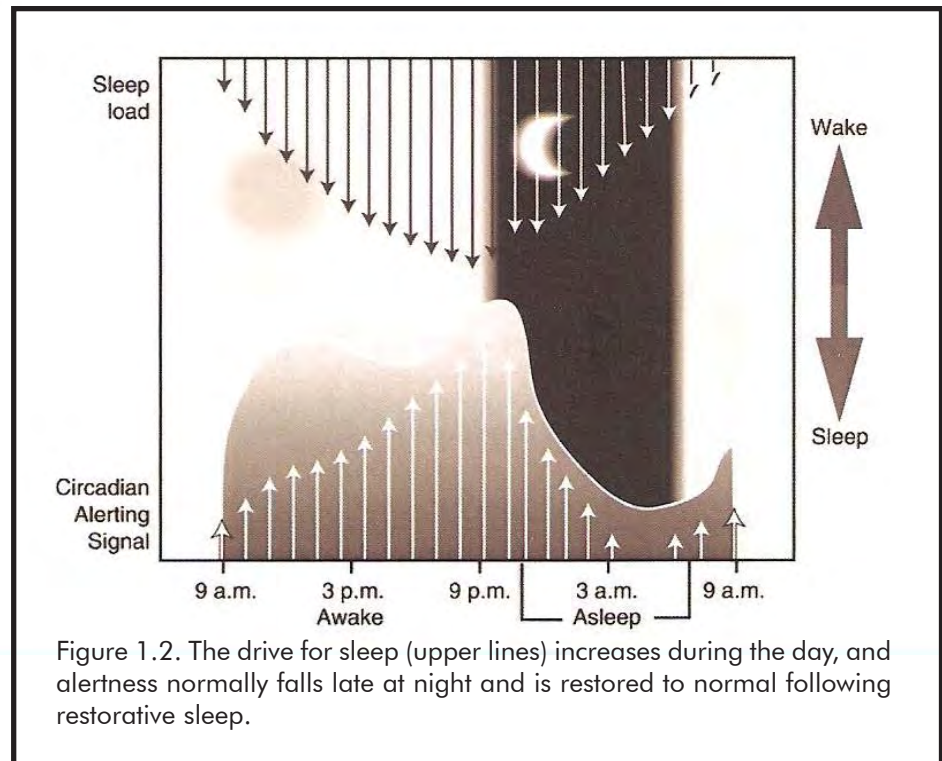
Because of our circadian rhythm, each day our bodies cycle through a normal progression of states. The most readily measured index of that daily progression is body temperature, shown in the lowest panel of Figure 1.1. The subjects' alertness is shown just above body temperature, and that remains fairly stable during the day, with a slight dip late in the afternoon. Then as midnight approaches alertness starts to decrease, falling progressively through the night. The subjects in the

figure did not sleep, and although their body temperature looks similar the second day, their alertness never returns to their baseline values. The top two panels show that more objective measures of mental function followed the same pattern as subjective alertness.

Figure 1.2 displays the alertness curve on the lower half and the drive for sleep on the top. The normal circadian pattern is for alertness during the day and a biological drive for sleep at night.

The 24 hour daily cycle is regulated by a circadian pacemaker situated in the brain's hypothalamus. This internal regulation is influenced by the external environment, and that cycle can be shifted, shortened/lengthened and reset (termed *entrainment*) by external cues, such as variation in sunlight and activity patterns. For example, information from the eyes is transmitted to the brain, and the hormone melatonin is secreted by the pineal gland, located at the base of the brain, during times of environmental darkness. Melatonin causes drowsiness, helps regulate diurnal sleep wake cycles and also influences several endocrine functions. Circadian rhythm accounts for the phenomenon of jet-lag. Because it is easier to adjust daily rhythms forward than backward, it is easier to travel east to west, than west to east.

Misalignment of the sleep time and the circadian daily pattern affects the quality and quantity of sleep attained (Dijk & Czeisler, 1995). A sleep that begins at 11 P.M. will lead to more consolidated and extended sleep than the same sleep opportunity at 11 A.M. When assessing a given work



The circadian disruption of jet lag can affect performance. It is not just a home field advantage that accounts for more wins at home. When the win-loss records of professional baseball teams over several years were studied, home teams won 63% of games if their opponents traveled west to east, but only 56% if they traveled east to west. It appeared that travel disrupted the biological clocks of visiting players and impaired their performances on the field.

pattern, both the effects on sleep and disruption in normal daily rhythms must be considered. Humans function optimally when they work in the day and sleep appropriately at night, and any prolonged deviation from that pattern potentially has adverse effects on performance and health.

A shift worker is any individual whose work pattern differs from a typical 8 AM to 5 PM work pattern. Approximately 20 percent of U.S. workers are shift workers.

1.3 General Effects of Sleep Derivation and Long Work Hours

1.3a Caveats When Interpreting Studies of Work Hours, Performance and Health

In general, studies that link sleep and work patterns with performance and health outcomes are cross-sectional, where a snapshot of findings at one time are used to compare individuals with one type of work and sleep habits with others having more traditional or 'healthy' patterns. However, other variables also may affect the findings. For example, individuals who work longer hours may do so because of financial pressures that drive them to work more hours. Similarly, individuals may select night shifts because of daytime demands. In addition, shifts may differ in ways other than just duration and time of day, such as the workload, supervision and the backup system. These factors also can make comparisons misleading. Thus, drawing conclusions concerning the effects of sleep deprivation and different work patterns can be problematic. The tabulated studies in Section 1.7 (pages 13 to 18), illustrate the difficulties in interpreting information concerning sleep deprivation, work hours, performance outcomes and health.

Two further examples illustrate the limitations when assessing the effects of specific work patterns. Job satisfaction is an important influence on how individuals react to a given schedule. Studies indicate that employees who are happy in their jobs and perceive the work structure as 'fair' are more willing to and feel better about working long hours (Hollman, 1980). On the other hand, workers also tend to minimize the stressors. Spelton, Barton and Folkard (1993) carried out a "reminiscence study" with retired police officers. The retired officers were asked about how they had felt while working at night, and the results clearly indicated that in retrospect, individuals perceived their situation as being far worse than they realized at the time. While satisfied workers may better tolerate longer work hours, it also is possible that some employees gradually habituate to their schedules and consequently underestimate their adverse impact.

Acute sleep deprivation is defined as less than 4 to 6 hours sleep in a 24 hour period (Belenky et al., 2003).

1.3b Definitions and General Effects

Longer work hours and sleep deprivation have been studied in the laboratory and during real-world observations of performance. For example, the National Highway Traffic Safety Administration estimates that drowsiness is the primary causal factor in more than 100,000 police-reported motor vehicle crashes each year, resulting in 76,000 injuries and 1500 deaths (Lyznicki et al., 1998). Those real world fatigue-related events sometimes are highly publicized. Major industrial disasters have occurred in the middle of the night, such the Chernobyl and Three Mile Island nuclear leaks, the chemical leak at Bhopal, India and the Exxon Valdez crash. Those events have been attributed to critical errors

More than one-third of U.S. adults get less than the recommended amount of sleep, and one-half report feeling significantly fatigued at least one day a week (National Sleep Foundation, 2005).

related, at least in part, to long work hours and sleepiness (Mitler, Carskadon & Czeisler, 1988; Wikipedia, 2007). However, disasters such as the Valdez are only the 'tip of the iceberg' when it comes to adverse effects from long work hours and sleep deprivation.

Acute sleep deprivation result from missing a single night's sleep. However, more common are reductions in sleeping time over many days. This more insidious chronic sleep deprivation occurs when individuals repeatedly do not get 'a good night's sleep,' which creates a *sleep deficit* or *debt*. Research indicates that decreasing sleep time by one hour a night for seven consecutive nights is equal to staying up for 24 hours straight once a week.

1.4 Psychological Effects

1.4a Measuring Vigilance and Sleepiness

To better study sleep deprivation, laboratory conditions and specific equipment have been designed to measure the effects of fatigue. One of most easily demonstrated effects of sleep deprivation is a decrement in alertness, as fatigued individuals experience brief periods of 'micro-sleep.' These momentary lapses are too brief to be noticed by the casual observer, but they create times when sleepy people are not attending to their environment, and they can be detected as a failure or a delay in responding to a stimulus.

The ability to maintain alertness and quickly and accurately perform skills is measured with the psychomotor vigilance task (PVT) (Dinges & Powell, 1985; Doran, Van Dongen & Dinges, 2001), which is a portable, easily usable reaction-time test (Figure 1.3). The equipment requires individuals to respond to a small, bright red light by pressing a response button. This action stops the stimulus counter and displays the reaction time in milliseconds for one second. The subject is instructed to respond as quickly as possible, but not to press the button too soon (which will cause a false start warning). The interval between stimuli varies randomly from 2 to 10 seconds, and the total test time is 10 minutes or a total of 90 reaction times. The PVT is designed so that it has only minor learning effects, a necessary prerequisite for any test of psychomotor vigilance (Van Dongen & Dinges, 2000).

Figure 1.3. Subject using apparatus to measure psychomotor vigilance.



Fatigue relates to a complex interaction of physiological, cognitive, and emotional factors. Fatigue results in slowed reactions, poor judgment, reduced cognitive processing of information, and an inability to continue performing a task or to carry it out at a high, sustained level of accuracy or safety. The pervasive problem of fatigue is due principally to one or more conditions including: lack of sleep; interrupted or poor quality of sleep (which denies opportunities for protracted deep sleeping periods); disrupted circadian work and rest cycles; and illnesses such as sleep apnea.

Table 1.1. The Epworth Sleepiness Scale

How likely you are to fall asleep or 'doze off' during these situations?

	would never doze off	slight chance of dozing off	moderate chance of dozing off	high chance of dozing off
1. Sitting and reading	0	1	2	3
2. Watching TV	0	1	2	3
3. Sitting and talking with someone	0	1	2	3
4. Passenger in a car for an hour	0	1	2	3
5. Lying down to rest in the afternoon	0	1	2	3
6. Sitting quietly after lunch	0	1	2	3
7. In a car stopped for a few minutes in traffic	0	1	2	3
8. Sitting inactive in a public place, like a meeting or classroom	0	1	2	3

Total number of points _____ (The total [0 to 24] is the Epworth score, and a value of 10 or higher indicates excessive sleepiness. From Johns MW. A new method for measuring daytime sleepiness: the Epworth sleepiness scale. *Sleep*. 1991;14(6):540-545.)

The PVT has been used in the laboratory and in field studies to precisely measure, at brief intervals (typically every two hours of wakefulness), the changes caused by sleep loss under different conditions. Although only ten minutes of testing provides reliable results, PVT sensitivity to changes in alertness can be increased by lengthening the test (e.g., 20 minutes). This manipulation can be useful when studying the assessment of interventions purporting to reduce sleepiness (e.g., various pharmacologic agents, naps, work-rest schedules) or when evaluating more subtle degrees of sleepiness.

In addition to measures of task performance, survey instruments are available to measure subjective 'sleepiness.' The most commonly used questionnaire is the Epworth Sleepiness Scale (Table 1.1) developed by Johns (1991). The Epworth Sleepiness Scale lists eight specific real-life situations, and the subject is asked to rate the likelihood of falling asleep during any of these activities. The total score can vary between 0 and 24, and values of 10 or greater indicate excessive daytime sleepiness.

Subjective fatigue differs from alertness and has many mental and physical dimensions, only one of which is the impact of sleep and circadian rhythm disruption. Subjective fatigue also has both acute and chronic aspects. One of the difficulties in assessing studies of work hours and their consequences is the variability in instruments used to assess study subjects' perceived fatigue levels (De Vries, Michielsen & Van Heck, 2003). Only recently have survey instruments been developed that are easy to administer and have robust psychometric properties of construct reliability and discriminant validity (Winwood et al., 2005 & 2006).

1.4b Alertness and Mental Performance

In Section 1.3a, we presented some of the reasons why other variables may confound studies of the effects of work hours and sleep loss on performance. Even under controlled conditions, when those other influences have been minimized, there are four major physiological determinants of 'alertness': 1) circadian phase, 2) number of hours awake, 3) chronic sleep loss effects and 4) sleep inertia.

The normal daily 24 hour rhythm results in alertness being greatest during the day, and conversely, the maximal drive for sleepiness is during biological night. Attempting to maintain alertness at night has measurable adverse consequences. When night and day shift workers are compared, even when taking into account the non-day workers' potential for reduced sleep overall, investigators have found an almost linear increase in accidents when comparing day, swing and night shift workers (Folkard, Lombardi & Tucker, 2005).

Being awake for prolonged periods, such as when working more than a typical eight hour shift, also impairs performance (Jewett, 1997). In fact, studies show that being awake for 18 hours produces impairment equal to a blood alcohol concentration (BAC) of 0.05, and deficits reach a BAC equivalent of 0.10 after 24 hours of wakefulness. Thus, a drowsy driver may be as dangerous as a drunk driver (Dawson & Reid, 1997; Falleti et al., 2003).

Those findings led to federal regulations limiting the number of consecutive hours that truckers can drive (see Section 3); 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 (Department of Transportation, 2000). Other occupations demonstrate similar time dependent errors, and the on-the-job accident rate increases during the later hours of longer shifts (Tucker, Smith, Macdonald & Folkard, 2000), so that 10 hour shifts were found to increase accident risk more than 10 percent, and 12 hour shifts increasing risk more than 25 percent.

Identifying the cause of a work-related accident after the fact is problematic, as the incident's occurrence causes a recall bias. Because of that, prospective investigations provide important information. In a study of more than 7000 Dutch employees from a variety of worksites, investigators found that occupational accidents were significantly more likely during shift work, especially during nights, and self-reported fatigue was a contributing factor (Swaen et al., 2004).

When a person has a full night's sleep, alertness is restored to near-normal levels upon awakening. Repeated failure to obtain sufficient sleep has a cumulative detrimental effect on alertness and performance that increases linearly with sleep loss (van Dongen et al., 2003). Workers beginning a series of night shifts generally sleep poorly following each of their night shifts, and the cumulative effect of lack of restorative sleep may explain the higher accident rate observed with each successive night shift worked, so that by the fourth night the risk is increased 36 percent above the first night (Folkard, Lombardi & Tucker, 2005).

Chronic sleep loss results in decreased ability to think clearly, handle complex mental tasks, form new memories and solve problems (Koslowsky & Babkoff, 1992; Durmer & Dinges, 2005; Stickgold, 2005; Rouch et al., 2005). That decrement is not reliably predicted by how 'sleepy' an individual feels; chronically sleep deprived people often are not aware of their cognitive deficits.

In addition to hours slept, time awake and disrupted day night schedules, the fourth factor affecting performance is the phenomenon of *sleep inertia* or the impairment in alertness immediately upon waking. The grogginess experienced is most severe in the first 30 minutes after awakening, and it varies with the stage of sleep, being greatest when aroused from a deep stage of NREM sleep. Although an individual may feel 'awake' after a few minute, studies indicate that it may take as long as two hours to be fully alert when awoken from a deep sleep (Jewett et al., 1999; Wertz et al., 2006).

1.4c Fatigue, Mood and Quality of Life

Chronic sleep loss can lead to feelings of depression, and the adverse effects on mood may be even greater than those on alertness and cognitive performance (Pilcher & Huffcutt, 1996; Sparks et al., 1997). Sleep has effects on brain receptors for serotonin and other neurotransmitters, which are related to mood and memory. In laboratory studies, only a few days of sleep restriction can alter these receptor levels, and a week of restorative sleep was required to reverse the changes (Roman et al., 2005).

The important interaction among mood, sleep and exposure to sunlight is illustrated by *seasonal affective disorder* (SAD) or winter depression. During short winter days, predisposed people experience SAD or a clinical depression, characterized by low mood and excessive fatigue. The disorder can be treated with typical serotonin re-uptake inhibitor antidepressants or exposure to high intensity light, simulating longer brighter days. SAD also illustrates the influence of individual variability on the reaction to environmental changes, as only approximately 10 percent of the population living in northern latitudes develops SAD (Lurie et al., 2006).

In addition to feelings of depression, sleep loss also leads to irritability and a sense of being 'stressed.' Those findings may add to the family disruption that can occur with long work hours and contribute to the observed adverse effects of shift work on social relationships (Poissonnet & Veron, 2000).

According to the International Classification of Sleep Disorders, *shift work sleep disorder* is considered a specific diagnosis because of the frequency with which shift workers suffer from sleep disturbances and excessive sleepiness (Beer, 2000). Compared to their '9 to 5' counterparts, shift workers are more likely to suffer from insomnia (61% vs. 47%) and excessive daytime sleepiness (30% vs. 18%). Shift workers also are more likely to drive while fatigued, and they are almost twice as likely to fall asleep at the wheel.

Recently, employers have recognized that health is more than the absence of injury and illness, and that worker well being and *presenteeism* may have a greater economic impact than the more traditionally indices of health care costs (Mills, 2005). For example, study of workers' mood resulted in recognition that feelings of depression greatly reduced employee productivity. To date, work hours and sleep deprivation have not been related to presenteeism or more global quality of life issues.

Shift work disorder is characterized by fatigue, functional impairment, difficulties initiating and maintaining sleep that are not readily remedied by behavioral measures and the exclusion of other disorders, such as obstructive sleep apnea and depression. It may occur in from 8 to 24 percent of night or rotating shift workers (Sherman & Strohl, 2004).

Long work hours and sleep deprivation may result in performance-related slowed reaction times and less alertness. They also can lead to a constant feeling of fatigue, irritability and a reduced sense of well being.

1.5 Physiological Effects

In general, long work hours and chronic sleep loss have been associated with adverse health consequences for most bodily systems (Knutsson, 2003; Sparks et al., 1997; Spurgeon, Harrington & Cooper, 1997; van der Hulst, 2003). Table 1.3 (page 14) summarizes studies assessing work hours and general health/overall mortality, and a consistent relationship between increasing work hours and more health complaints was observed across studies. More recent data from approximately 20,000 European workers from a broad range of occupations confirmed a clear direct correlation between the number of hours worked per week and health complaints (Raediker et al., 2006).

Caruso and colleagues (2004) performed a critical review of studies linking work hours and health outcomes. In their analysis, they separated shift work in general and shift work that involved more than 40 hours of work a week. When those latter criteria were met, findings consistently demonstrated lower perceived general well being and more health problems, along with an increased risk of occupational injuries.

Eight hours of sleep per night is recommended for adults, because that number is the average preferred duration among healthy adults, who do not have other demands limiting sleep. Longitudinal mortality studies and sleep seem to confirm that optimum duration. Mortality increases in men and women when they deviate from that amount. In long term studies, even controlling for other factors influencing life expectancy, sleeping less than that per night was associated with higher mortality (Heslop et al., 2002; Patelet et al., 2004).

1.5a Cardiovascular Disease

The evidence linking long working hours and adverse cardiovascular events is not yet definitive, but findings are concerning. Several lines of evidence indicate that long work hours (more than 50 to 60 hours each week) increase the incidence of, and risk factors for, heart disease and cardiovascular events. The potential mechanisms for this association include lack of normal cardiovascular rest during deep sleep, increased inflammation associated with sleep deprivation (see Section 1.5d) and the unhealthy lifestyles that accompany long work hours.

Comparisons are difficult, but some have suggested getting less than six hours of sleep per night increases heart disease risk comparable to that of smoking a pack of cigarettes a day (Akerstedt et al., 1984).

In a study of individuals admitted to U.S. hospital with myocardial infarction, more than half regularly worked more than 60 hours per week, compared with only one-quarter of a matched control group (Thiel, Parker & Bruce, 1973). As shown in Table 1.4, other studies have found a direct relationship between the risk of myocardial infarction and longer working hours, with a two-fold increase in risk associated with working more than 40 hours each week (Sokejima & Kagamimori, 1998; Lui et al., 2002). Most studies linking heart disease and long work hours have been among Japanese men. However, recent longitudinal assessment of U.S. nurses has confirmed that short sleep duration, even after adjusting for other risk factors, increased the risk of coronary heart disease by 50 percent, and interestingly, long sleep duration (more than 9 hours a night) also increased that risk (Ayas et al., 2003).

The stages of deep sleep are times when the heart rate and blood pressure are lowered, and important bodily repair functions may occur. Disruption in that sequence may predispose to hypertension. Daytime ambulatory blood pressure cuff measurements found that prolonged work hours were associated with an increase in blood pressure (Fialho et al., 2006). Large cross-sectional studies also support the relationship between loss of sleep and hypertension (Gangwisch et al., 2006). Along with high blood pressure, tobacco use is a major risk factor for heart disease, and lack of sleep has been associated with greater tobacco use (Caruso et al., 2004).

1.5b Digestive Disorders

Digestive enzymes are secreted in a cyclical fashion related to the normal daily rhythm, and the different daily patterns and unusual meal times of longer work hours and night shifts may disrupt that normal sleep physiology. Those alterations may relate to the up to six-fold increase in gastrointestinal disorders, such as peptic ulcers, indigestion, diarrhea and constipation, observed among those with sleep deprivation and night shift work (Reid et al., 1997; Orr & Chen, 2005).

1.5c Obesity, Diabetes and Obstructive Sleep Apnea

Strong mounting evidence links sleep loss with obesity and the hormonal changes that result in weight gain (Vorona, Winn & Babineau, 2005). Over the last 40 years, self-reported sleep duration in the U.S. has decreased by almost two hours, and that change coincides with a marked increase in the prevalence of obesity. Large longitudinal studies of the U.S. population have found that young adults (ages 30 to 50 years old) with sleep durations at of less than seven hours per night were more likely to gain weight and become obese than subjects with longer sleep durations (Gangwisch et al., 2005). Six large U.S. studies and investigations from six other countries have linked lack of sleep with obesity (Cizzi, Skarulis & Mignot, 2005).

Weight gain and obesity have strong genetic components, comparable to the inheritance of height. In recent years, researchers have recognized that obesity is a metabolic disorder, and they have identified the physiology explaining why people differ in their propensity to gain weight. In part, those are explained by differences in the hormone levels that regulate eating behavior and metabolic rate. Ghrelin is a hormone produced by stomach cells that stimulates the appetite, and its level increases before meals. It is considered the counterpart of the hormone leptin, produced by adipose tissue. Leptin levels directly relate to the amount of body fat, and higher levels lead to reduced eating and an increase in metabolic rate. Higher ghrelin levels stimulate appetite, as do lower levels of leptin.

Laboratory studies and observations in the field indicate that shorter sleep duration in young, healthy adults is associated with a hormonal pattern (decreased leptin and increased ghrelin levels) that stimulates hunger and promotes weight gain (Spiegel et al., 2004; Copinschi, 2005).

Weight gain and obesity are associated with development of type 2 diabetes (Speigel et al., 2005). Short sleep durations more than double the risk of developing diabetes (Yaggi, Araujo & McKinlay, 2006). A longitudinal study of Japanese workers documented that those not on day shifts had a significantly greater risk of developing diabetes over 10 years, even when controlling for body weight,

One of the strongest biological links is between chronic sleep deprivation and weight gain.

physical activity and other factors known to influence diabetes onset (Suwazono et al., 2006). Diabetes also is a major risk factor for development of heart disease.

Shift workers are at increased risk for *obstructive sleep apnea* (OSA). OSA is a common sleep disorder found in approximately five percent of the general population, but more than 10 percent of shift workers.

Obstructive sleep apnea (OSA) also is discussed in Section 2 (page 32) and in Section 5 (page 59).

OSA is associated with obesity, hypertension, diabetes and heart disease. Due to their disorder, those with OSA obstruct their airways during certain sleep stages and as a result, they are awakened from sleep, never achieving normal restorative sleep architecture. They suffer from chronic daytime fatigue and lowered alertness; without treatment, those with OSA have a six-fold increase in traffic crashes (Teran-Santos et al., 1999). Although the precise connection between sleep deprivation, shift work and OSA is not understood, the connection is so well recognized and the adverse effects on alertness potentially so injurious, that regulations are in place to screen all commercial motor vehicle operators for the disorder (Hartenbaum et al., 2006).

1.5d Immune System, Infection and Malignancies

Normal restorative sleep is needed for optimum functioning of the immune system, which supports the common wisdom that sleep deprivation increases susceptibility to infections (Mohren, Jansen & Kant, 2002). Research indicates that inadequate rest lowers levels of immunoglobulins needed to fight infections (Hui, Hua, Diandong & Hong, 2006).

Sleep deprivation appears to increase circulating blood factors that promote and indicate inflammation (Vgontzas et al., 2004), and higher levels of these inflammatory markers have been associated with an increased risk of cardiovascular disease. The finding that sleep loss may activate inflammatory processes is another potential link explaining the association of sleep deprivation and cardiovascular morbidity observed in epidemiologic studies (Meier-Ewert et al., 2004).

Identifying a link between work hours and malignancies is complicated by the many other factors relating to cancer risk, such as exposure to carcinogens. However, the U.S. nurses health study carefully has followed more than 80,000 women for more than 15 years. Nurses are the largest group of U.S. shift workers, and findings indicated that nurses working a rotating night shift of at least three nights per month for 15 or more years had an increase risk of colorectal cancer (Schernhammer et al., 2003). Also among women, the risk of breast cancer is increased among night shift workers (Megdal et al., 2005; Davis & Mirick, 2006). The large ongoing longitudinal studies of men have involved male physicians, who generally have not worked in shifts and whose job structures were more varied. As a result, the incidence of cancer among men working long hours has not been well studied.

One of the speculated mechanisms relating work hours to malignancies among women is disruption of normal circadian hormone levels. Gonadal hormone patterns among men also have a circadian rhythm, which could be impacted by long work hours and sleep deficits (Axelsson et al. 2005). In a cross-sectional study, men's testosterone levels appeared to be influenced by shift work, as those employees with sleep and fatigue problems had lower levels than workers without those problems (Knutsson, 2003).

1.6 Evidenced-based Reviews

Lack of sleep is associated with decreased alertness, impaired ability to think clearly and depression. Job performance may be adversely impacted by long work shifts and inadequate sleep.

Among physical problems related to long work hours and sleep loss, the evidence is most compelling for obesity and cardiovascular disease. However, because of the many confounding variables, it remains difficult to draw firm conclusions. In 2004, the National Institute for Occupational Safety and Health (NIOSH) of the Department of Health and Human Services commissioned a review of the scientific literature on sleep and health (Caruso et al., 2004). A team of researchers identified reports meeting certain validity criteria and performed critical analyses of more than 50 published studies examining the relationship between long working hours and medical illnesses, injuries, health behaviors and performance. They tabulated the study findings, and modified versions of those Tables are included in Section 1.7 (annotated Tables 1.3 to 1.7) and summarized in Table 1.2. The researchers did not address obesity, where the link to sleep deprivation is strong. In addition, no well done research has examined long work hours and quality of life issues. Conclusions from that review and another recent critical review of findings are presented in the text box on the next page.

In assessing the effects of sleep deprivation and shift work, individual differences in physiology, attitudes and other health behaviors are likely to be important in modifying the observed outcomes.

1.7 Summary and Evidence-based Review Tables (modified from Caruso et al., 2004)

- Adequate restorative sleep is needed to perform optimally and to be healthy. An individual's circadian rhythm also affects functional abilities and the quality of sleep obtained. Most adults require six to eight hours of sleep each day, with episodes of sufficient duration to achieve all the stages of sleep.
- Alertness decreases with sustained wakefulness, so that being awake for 24 hours produces impairment equivalent to a blood alcohol level of 0.10.
- Long work hours (shifts lasting more than 10 to 18 hours) have been clearly linked to time dependent errors in tasks requiring vigilance and focused alertness, as evidenced by an increase in motor vehicle crashes (see Section 2), errors among health care providers (see Section 3) and work-related injuries and accidents.
- Chronic sleep loss results in decreased ability to think clearly and handle complex tasks, a depressed mood and feels of stress and irritability. Those effects are not reliably predicted by how 'sleepy' an individual feels, as chronically sleep deprived people do not perceive their lack of sleep as the problem.
- Chronic sleep deprivation and long work hours are linked to a general increase in health complaints, obesity, obstructive sleep apnea, and possibly a heightened risk for cardiovascular disease. Potential associations also have been made with digestive disorders, increased risk of infections and a greater likelihood of malignancies.

Summary statements from two recent reviews of the health effects of shift work indicate the limitations in the available studies. Confounding variables and individual differences make drawing firm conclusions difficult.

Caruso and colleagues (2004) concluded 'research questions remain about the ways overtime and extended work shifts influence health and safety. Few studies have examined how the number of hours worked per week, shift work, shift length, the degree of control over one's work schedule, compensation for overtime, and other characteristics of work schedules interact and relate to health and safety. Few studies have examined how long working hours influence health and safety outcomes in older workers, women, persons with preexisting health problems, and workers with hazardous occupational exposures.'

The review for the Department of Transportation published in the Federal Register (2005) stated that 'the general consensus in the shift work research community therefore is that while certain work schedules may result in health problems, there are few epidemiological studies of shift workers, and more empirical data is needed.'

Table 1.2. Summary Tabulated Studies on Work Hours and Health Outcomes

Additional Details In:	Outcome(s) Assessed	Study Findings about Outcomes' Relationship to Long Work Hours
Table 1.3	health complaints and perceived health	4 of 5 showed relationship
Table 1.3	sick time	1 study found greater overtime was associated with less sick time
Table 1.3	mortality	1 study found greater overtime related to increased death rate
Table 1.4	hypertension	2 showed relationship, 1 showed reduction in risk and 1 found no relationship
Table 1.4	heart attacks	2 of 2 showed relationship
Table 1.5	type 2 diabetes	2 of 2 showed relationship
Table 1.5	obesity	2 of 2 showed relationship
Table 1.6	smoking and alcohol use	2 of 3 found relationship, and suggestion risks may be greater for women
Table 1.7	injuries and musculoskeletal complaints	5 of 5 showed relationship

Table 1.3. Studies Examining Work Hours, General Health Complaints and Overall Mortality

Author, Date	Subjects	Work Measures	Health Outcomes	Findings
Eithner & Grzywacz, 2001	2048 U.S. workers	one time questionnaire	health complaints	working > 45 hours per week increased complaints 25%
Siu & Donald, 1995	332 Japanese workers	one time interview, controlled for relationships with coworkers and supervisors	health complaints	overtime significantly correlated with more health complaints
van de Hulst & Geurts, 2001	535 Dutch male postal workers	one time questionnaire about work hours and work pressures and rewards	health complaints and burnout	overtime with low rewards increased health complaints and burnout
Worrall & Cooper, 1999	1312 English managers	one time questionnaire	self perceived health	two-thirds reported long work hours adversely impacted health
Mitchell & Williamson, 2000	27 Australian male electrical power station employees	data before and 10 months after schedule change from 8 to 12 hour shifts	health complaints and vigilance tests	overall more health complaints with 8 hour shift, and vigilance tests had more errors at end of a 12 hour shift
Voss et al., 2001	2628 Swedish male and female postal workers	one time questionnaire	sick time	> 50 hours overtime per year associated with less absences due to sickness
Nylen et al., 2001	20,632 Swedish workers	survey of overtime and extra work hours and death registry follow up	mortality	women and men working > 5 hours per week overtime had increased mortality (men at 5 years and women at 24 years of follow up)

Table 1.4. Studies Examining Work Hours, Hypertension and Myocardial Infarctions

Author, Date	Subjects	Work Measures	Health Outcomes	Findings
Hayashi et al., 1996	approximately 45 Japanese male white collar workers, ages 36 to 47	high versus low overtime workers	blood pressure	longer work hours associated with high blood pressure
Iwasaki et al., 1998	71 Japanese salesmen	one time survey and long hours defined as > 60 hours per week	blood pressure	longer work hours associated elevated blood pressure for men > 50 years old
Nakanishi et al., 2001	941 Japanese male white collar workers	interviewed about work habits	development of high blood pressure over 5 years follow up	longer work hours was associated with less risk of hypertension at follow up
Park et al., 2001	238 Korean male engineers	one time questionnaire	one time blood pressure on day of survey	no relation blood pressure and work hours
Sokejima & Kagamimori, 1998	195 Japanese males compared to 331 controls matched for age and job	self reported work hour survey, controlled for other cardiac risk factors	survivors of acute myocardial infarction (MI) (heart attack) identified from hospital records	longer work hours (> 9 per day) associated threefold increase in risk of MI
Liu et al., 2001	260 Japanese males compared to 445 matched controls	interviewed about work habits and controlled for other cardiac risk factors	all surviving individuals hospitalized with acute myocardial infarction (heart attack) during two years	working > 60 hours per week increased risk MI twofold above working < 40 hours per week

Table 1.5. Studies Examining Work Hours, Type 2 Diabetes and Obesity

Author, Date	Subjects	Work Measures	Health Outcomes	Findings
Kawakami et al., 1999	more than 2000 Japanese male workers	survey about work hours and shift structure, controlled for other variables known to be related to diabetes	type 2 diabetes	threefold increase in risk developing diabetes when working > 50 hours per week
Nakanishi et al., 2001	1266 Japanese male office workers	interview about work hours, controlled for other variables known to related to diabetes	type 2 diabetes	risk of diabetes increased in direct relationship to hours worked per day
Nakamura et al., 1998	248 Japanese male white collar workers	overtime from time clock measures, controlled for age and lifestyle habits	obesity	overtime significantly correlated with body weight (BMI [body mass index]) and waist circumference
Shields, 1999	randomly selected 3830 Canadian male and female workers	phone interview about work habits, controlled for relevant covariants	obesity	men working long hours doubled their risk of weight gain and excessive body weight

Large studies in the U.S. and elsewhere have linked lack of sleep with obesity (Cizzi, Skarulis & Mignot, 2005).

Table 1.6. Studies Examining Work Hours, Smoking and Alcohol Use

Author, Date	Subjects	Work Measures	Health Outcomes	Findings
Park et al., 2001	238 Korean male engineers	one time questionnaire	smoking and alcohol use	no relationship between hours and smoking or alcohol use
Shields, 1999	randomly selected 3830 Canadian male and female workers	phone interview about work habits, controlled for relevant covariants	smoking, alcohol use and exercise	for women, longer work hours increased alcohol use for both men and women, longer work hours were related to smoking exercise habits did not relate to work hours
Trinkoff & Storr, 1998	randomly selected 3917 U.S. nurses	one time questionnaire	smoking and alcohol use	risk for smoking increased with night shifts risk for alcohol increased with long work hours, overtime and night shifts

Table 1.7. Studies Examining Work Hours, Shift Length, Injuries and Musculoskeletal Complaints

Author, Date	Subjects	Work Measures	Health Outcomes	Findings
Lowery et al., 1998	approximately 32,000 U.S. male airport construction workers	payroll records and workers' compensation claims	injuries	greater injuries when > 20% of payroll expenses as overtime
Simpson & Severson, 2000	2247 workers from one U.S. hospital	work hours and injury records	injuries	working > 2000 hours per year increased risk of injury 75%
Bergqvist et al., 1995	260 Swedish visual display workers	one time questionnaire	musculoskeletal complaints	twice as many arm and hand problems in overtime workers
Frederiksson et al., 1999	484 Swedish workers from range of occupations, approximately 50% women	interview about worktime and domestic workload	musculoskeletal complaints	overtime more than doubled the risk of neck and shoulder complaints among women
Lipscomb et al., 2002	1163 U.S. nurses	one time questionnaire	musculoskeletal complaints	compared to 8 hour shifts 12 hours had more back disorders, and > 12 hours per day and 40 hours per week increased neck, shoulder and back complaints
Tucker et al., 1998	862 English male workers	one time questionnaire	musculoskeletal complaints	compared to 8 hour shifts, 12 hours had ore musculoskeletal complaints

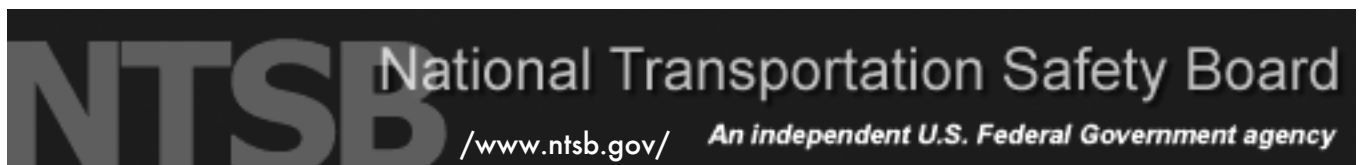
Section 2: The Transportation Industry and Sleep Deprivation

2.1 Introduction

Fatigue-associated accidents have long been concerns and challenges in the transportation industry. One of the earliest studies of human fatigue was among wagon drivers kept awake for three days at the University of Iowa in 1896 (Patrick and Gilbert, 1896). Economic pressures, society's demands for faster deliveries and increased vehicle and vessel size have made the impact of operator error, including fatigue, ever more prominent.

The U.S. National Transportation and Safety Board's (NTSB) (www.nts.gov/) was established in 1967 to promote safety in the aviation, rail, highway and marine transportation industries. Across all those transportation modes, approximately 30 percent of crashes and other accidents are fatigue related (NTSB, 1995). The link between long work hours compromising safety is clearly established in the transportation industry.

The reason for the tight link between incidents and fatigue is that operating any vehicle is a classical "tracking" task, which is the type of activity most sensitive to reduced alertness (Belenky et al., 2003). In many other industries much of production is taken over by machines and computers, and employees supervise the process. In those settings, lapses of attention infrequently cause accidents, which differs from the constant vigilance needed in transport work. In this Section, we present information on work hours and fatigue as they relate to the major transportation industries at sea, on land, and in the air.



2.2 Fatigue at Sea

A major impetus for increased attention to seafarers' fatigue came from the high profile grounding of the U.S. tankship Exxon Valdez (see text box next page). The NTSB found that "there were no rested deck officers on the Exxon Valdez available to stand the navigation watch when the vessel departed from the Alyeska Terminal," despite existing regulations mandating rest periods for those standing watch (NTSB, 1990).

Four years after the Exxon Valdez grounding, the International Maritime Organization (IMO) issued Resolution A.772(18), Fatigue Factors in Manning and Safety, which was a document dedicated to defining fatigue, identifying specific shipboard related fatigue factors and tasking shipboard management with specific responsibilities in mitigating these factors. The regulations that followed provided standards for shipboard work arrangements



Exxon Valdez

At 23:35 on March 23, 1989, the Exxon Valdez arrived at berth 5 of the Alyeska Marine Terminal to load its cargo before departing on its 24th voyage. At 05:05, it began loading its 52 million gallons of oil. About 10:30 AM, the captain (Joseph Hazelwood), chief engineer and the electronics officer went ashore. They ran errands and agreed to meet later in the afternoon at a town bar. At the bar, the men played darts and bought a round or two of drinks each. They left the bar about 19:00 and returned to the restaurant where they had eaten lunch and ordered two pizzas to take back to the ship. They had one drink while they waited, then took a cab to the ship.

The pilot taking the ship out of the terminal boarded the vessel at 20:20, and about 10 minutes later, the captain returned. The pilot stated he smelled alcohol on the captain's breath, but his behavior and speech were unimpaired. They shoved off, and the pilot was relieved by the captain and disembarked after about 90 minutes, as the tanker headed south through Prince William Sound. The captain radioed that he would be changing course to avoid some growlers, or small icebergs, which had drifted into the sound from the Columbia Glacier. The captain received permission to move into the northbound lane. Before retiring to his cabin, Captain Hazelwood instructed his third mate to start coming back into the lanes once the ship was abeam Busby Island Light, some two minutes ahead. At 23:43 the captain left the bridge. The third mate then ordered the helmsman to apply 10 degrees right rudder and informed the captain the turn had began. Two minutes after that, when he saw the vessel was not turning, he ordered 20 degrees right rudder. Again two minutes later, he ordered hard right rudder due to a radar reading that the ship was still traveling at a heading of 180 degrees and phoned the captain, saying, "I think we are in serious trouble." At the end of the telephone conversation the vessel contacted the bottom. The vessel grounded at 00:04 on the morning of March 24th, 1989. At approximately 00:05 the captain returned to the bridge after receiving a phone call from the third mate and feeling the ship ground. At 00:27, the captain notified authorities that the ship had grounded. At 03:35 the Executive Officer and the Senior Investigating Officer of the Coast Guard's Valdez Marine Safety Office boarded the vessel.

The Coast Guard mistakenly let the Valdez reduce its crew number, and the third mate and others on the bridge had been up long hours since docking and supervising loading the cargo. According to the NTSB report, the probable cause of the spill was failure of the third mate to properly maneuver the vessel because of fatigue and excessive work load. Other contributing factors were 1) the failure of the captain to provide a proper navigational watch because of impairment from alcohol, 2) the failure of the Exxon Shipping Company to provide sufficient crew and 3) the lack of an effective Vessel Traffic Service because of inadequate equipment and manning levels.

The spilled oil affected 1140 miles of Alaskan coastline. Resulting animal deaths included 250,000 sea birds, 2800 sea otters, 300 harbor seals, 250 bald eagles, 22 orcas and billions of salmon and herring. In 1994, an Anchorage jury awarded \$287 million for actual damages and \$5 billion for punitive damages.



and guidelines for monitoring compliance (https://www2.imo.org/b2c_imo/b2c/init.do). They included specific requirements, such as a minimum 10 hours rest in every 24 hours (which may be reduced to 6 hours every 24 hours for a period of not more than two days), and that those rest periods be enforced for watchkeeping personnel.

The International Maritime Organization was adopted in 1914, in response to the Titanic disaster, and it is a specialized branch of the United Nations responsible for measures related to international shipping safety and marine pollution. It currently has 163 Member States.

In the U.S., the Department of Transportation (DOT) (www.dot.gov/) sets limits on the hours worked aboard certain vessels, and those regulations are enforced by the U.S. Coast Guard. The DOT regulations are supported by the various American maritime unions (American Maritime Officers; the International Organization of Masters, Mates & Pilots; Seafarers International Union and Marine Engineers Beneficial Association). The current hours-of-service regulations vary depending on the type of vessel, and they are summarized in Table 2.1 (next page).

Although regulations exist, they are difficult to enforce, and industry practices rarely adhere to those rules, despite stipulated seafarer hours being much longer than most other occupations. Currently, it is acceptable for a seafarer to work 86 hours a week.

2.3 Seafarers' Work

Many factors influence fatigue among seafarers, including the type of vessel and job on those vessels (Allen et al., 2003). A 'vessel' usually is defined as greater than 55 meters (180 feet) in length, but that encompasses a wide range of categories: liners, tankers, cargo ships, livestock and car carriers, large fishing vessels, ferries, tugboats and offshore support vessels. For any vessel type, a variety of workers are needed for staffing, and job demands and hours of service vary.



When on board ship, being off work does not equate with being 'home,' and other factors contribute to fatigue besides lack of sleep, such as environmental issues, weather, noise, vibrations, poor sleeping quarters, ship-wide alarms and motion sickness (Meyer, 2005; Fatigue in the Maritime Industry report, 2003; International Transport Workers Federation Survey, 2003). Thus, having adequate sleep opportunities does not ensure being well rested.

2.3a Pilots

Pilots are highly skilled individuals who work bringing vessels in and out of ports or across hazardous sea lanes. There are approximately 1000 pilots who navigate large vessels through America's waterways. Generally, they have been ship captains (also known as masters or skippers) before becoming pilots, and it takes a minimum of 10 years at sea before being eligible to be a pilot. All begin in one- to three-year apprentice programs, in which trainees accompany licensed senior pilots. Before the end of training, a pilot is expected to be intimately familiar with all their waters and must pass extensive written exams. On average, pilots earn around \$200,000 per year.

Pilots have tours of duty, during which they are on call to perform assignments. After a tour is finished, an extended period is spent at home. For example, Columbia River bar pilots duty tours are three weeks, followed by three weeks off, and San Francisco Bay pilots work eight days on and six days off. The actual piloting assignments usually last two to six hours, depending on conditions; however, with travel to and from the ship, the assignments may last several days. Columbia River pilots average about five work assignments, each lasting approximately three days (Wadsworth, 2006), during a three week tour of duty. Pilots are transported to vessels on helicopters or station boats and get on and off ships by climbing a ladder of wood and rope called a Jacob's ladder.

Two seafarer job types are described to exemplify industry work schedules: 1) pilots and 2) captain and crew members. These also are the categories of positions for which programs to combat fatigue have been developed (pages 25 and 26).

While on a vessel, pilots are on call at all times, and there are no predetermined rest breaks. However, there are periods in a prolonged navigational passage when the pilot can go below to take a break. When surveyed, most pilots reported a maximum of four to six hours of sleep per day on duty (AMSA, 1999). In addition to reduced sleep, pilots reported that their sleep was of poor quality (ITWF Survey, 2003; Gillberg, 2005).

2.3b Captains and Crew

A vessel's captain or master oversees all operations at sea, in port and at anchor. They consult weather forecasts, make a voyage plan, direct the ship and ensure it runs safely, efficiently and economically. Most U.S. captains graduated from the U.S. Coast Guard, or from a naval or merchant marine academy, as licenced third mates. Training to become a ship's master is a lengthy process and requires experience as a deck officer and achieving progressively higher competency standards.

A typical pattern for a ship's master employed by an international shipping company is to work for three months at sea, followed by three months leave. While at sea, they are permanently on call. Not surprisingly, surveys of captains indicate that most report feeling fatigued when at sea, and half considered that fatigue often or always affected the performance of officers (Gander, 2005)

Table 2.1 Marine Regulations (46 U.S.C. 81D4; 46 CFR Parts 15.705 and 15.1111)
Officers must be off duty for 6 of the 12 hours before leaving port. Officers are to receive a minimum of 10 hours rest per day, divided into no more than two periods. Rest can be reduced to 6 hours for 2 days, while maintaining at least 70 hours rest per week.
Licenced individuals may not work more than 12 of 24 hours when at sea, and for tankers not more than 15 of 24 hours.
Licenced individuals and crew members will be divided into at least three watches. For certain circumstances, two watches are permitted, and watch requirements may vary depending on the type of vessel.
When a vessel is in a safe harbor, 8 hours is a day's work.

As with the captain, the crew also ships out for months at a time. They may be required to work irregular hours or full-time shifts, and they often remain on duty for long periods. A ship's work can be undertaken at any time of day, and night work is common; studies indicate that more than half of ship work is done between the hours of 18:30 and 05:30. Crew members' jobs vary widely, as implied by their titles, including deck hand, engineer, electricians, carpenters and mates. Deckhand positions aboard large vessels with international crews often are given to citizens of developing countries, and they do general maintenance duties. Mates direct the routine operation of the vessel for the captain during the shifts when they are 'on watch.' All mates stand watch for specified periods, usually either a four hours on and eight hours off pattern or a six hours on and six hours off rotation.

On smaller vessels, there may be only one mate who alternates watches with the captain. In those cases, when non-watch duties become prominent, such as when going in and out of ports, the captain and mates often work from start to finish of a port visit without sleep, a stretch of as long as 24 hours.

Surveys indicate that fatigue is frequent among crew members. A field study among 141 U.S. merchant marine personnel by means of logbooks documented that seafarers frequently experienced brief sleep durations, poor quality sleep and long work days. Of particular concern was that one-quarter of those standing watch in the early morning hours (04:00-08:00) reported getting less than four hours sleep a day (Sanquist, Raby & Forsythe, 1997).

Findings from a study of almost 2000 seafarers indicated that one in four said they had fallen asleep while on watch. Almost half reported working weeks of 85 hours or more, and approximately half said their working hours had increased over the past 10 years, despite new regulations intended to combat fatigue. Half considered their working hours a danger to their personal safety, and more than one-third indicated that their working hours sometimes posed a danger to the safe operations of their ship (Smith, Allen & Wadsworth, 2006).

The same study identified a number of risk factors for fatigue, including tour length, sleep quality, environmental factors, job demands, hours of work, nature of shift, and port frequency/turnaround time. The importance of these other factors is exemplified by what crews and captains refer to as dream and nightmare runs.

On dream runs, the ship is clean and comfortable; the weather is cooperative and calm; the pilot and crew get reasonable amounts of sleep; and fatigue usually is not an issue. On a nightmare run, the ship's living conditions are less than desirable; weather is difficult; as a result, the captain and mates will spend additional time on the bridge with little opportunity for rest or sleep. In a study of almost 200 seafarers over a complete tour-leave cycle, fatigue correlated with 'bad' runs. Following a bad run, crew members accumulated so much fatigue that recovery did not occur until the second week of leave (Sarke, 2001).

2.4 Effects of Work Hours and Fatigue in the Marine Industry

Captain and crew fatigue are recognized as major contributing factors to maritime accidents. The Great Britain Pilot Fatigue Risk Assessment Report (1999) indicated that fatigue was responsible for 20 percent of collisions and 25 percent of ship groundings. The U.S. Coast Guard data show higher numbers. They report that fatigue was the major factor in 25 percent of collisions and 36 percent of groundings, and they indicate it was responsible for 16 percent

of fatalities and 26 percent of injuries (NTSB paper/SR-99-01,1999). A Japanese study produced even higher values, with more than half of groundings attributable to fatigue (Kitsuama, 2001).

As suggested by the variability in seafarers' jobs, it is difficult to draw generalizations about how fatigue affects seafarers' personal safety and general health. As has been shown in many other occupational settings, seafarers' injury rates increase with the number of hours worked, especially for young seafarers and non-officers. That relationship is most linked after more than 70 hours of work per week, and for those with prolonged tours, i.e., being at sea for more than three months (Jensen et al., 2004).

Overall merchant seafarers have mortality rates higher than the general populations (Hansen & Pedersen, 1996). However, seafarers are a heterogeneous population, and they often have unhealthy lifestyles, such as poor diets, tobacco use, lack of regular exercise and excessive alcohol intake (Hansen et al., 2005).

In addition to lack of sleep, other factors at sea can adversely affect seafarers' health. Those include tour length, weather, circadian disruption, sleep quality, turnaround time and job demands. The likelihood of reporting impaired health increased geometrically with the occurrence of each risk factor, so that two doubled the risk but seven increased the risk 30 times (Smith, Allen & Wadsworth, 2006). These findings are made more remarkable because as investigators assessing seafarers often note, they are a group resistant to study, and those participating are a subset probably least likely to have problems.

Beyond injuries and impaired physical health, psychosocial problems are associated with working long hours at sea. Some studies indicate that it is the adaptation from life on board to life at home which presents "the most significant disturbance" faced by seafarers (Carter, 2005). Thomas, Sampson and Zhao (2003) conducted interviews with partners of seafarers concerning the interface between home and work. While seafarers may benefit financially from choosing a tour orientated lifestyle, the researchers concluded that the emotional cost to both seafarer and family outweighed any compensatory economic reward.

2.5 Countermeasures at Sea

Combating fatigue in the seafaring industry presents many challenges. Strong work traditions exist among individuals choosing that lifestyle, and economic demands are real. High level officer positions are relatively scarce, and individuals often are forced to work below their expertise.

Findings from the Fatigue at Sea Study provide an example of how difficult it is to conduct research with seafarers. In 2005, the Swedish World Maritime University began a two year project to assess mariners' fatigue (Lutzhof, 2005). The project sought to follow the two populations: 1) watchkeeping officers on merchant ships and 2) marine pilots. They planned to gather physiological data that would be cross checked

An example of watch-keeper fatigue occurred at 05:15 on a clear June morning when a general cargo vessel ran aground on the west coast of Scotland. The chief officer had been on watch since midnight and was suffering the cumulative effects of fatigue generated by the 6-on 6-off watchkeeping routine punctuated by regular port visits, where he was expected to oversee all cargo operations. The chief officer fell asleep standing at the controls between 04:05 and 04:15 and missed a planned course alteration. He woke an hour later, still standing, as the vessel grounded (MAIB Bridge Watchkeeping and Safety Study, 2004)

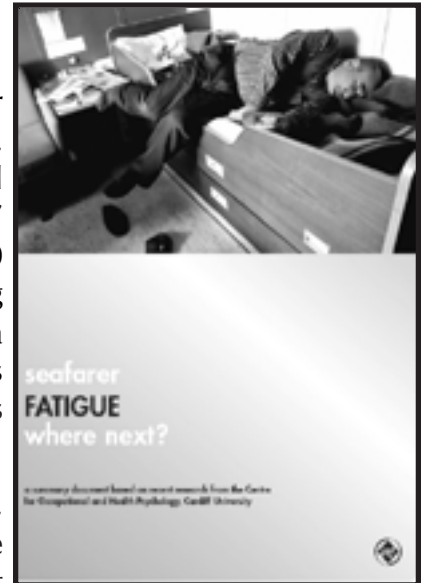
against fatigue-related injuries and accidents. They hoped to establish scientifically based hours-of-service regulations. It was an ambitious undertaking, and its disappointing midpoint report underscores the difficulty in assessing, and by extension, regulating and reforming seafarers' work. Despite the thoughtful plans, little was accomplished due to unpredictability of schedules, limited on board space and crews' unwillingness to participate (2007).

2.5a Cardiff Report

Researchers from Cardiff University have been studying seafarer fatigue for more than five years (Smith, Allen & Wadsworth, 2006). In January 2007, the Cardiff University group published findings as a report entitled, *Adequate Manning and Seafarers' Fatigue: the International Perspective*. They surveyed almost 2000 seafarers, collected diary reports and performed objective testing on board. In addition to the clear confirmation that fatigue is a problem, the studies also exposed a tendency of many seafarers to under-record their working hours. Importantly, researchers also made recommendations for managing fatigue.

The report calls for a holistic approach to maritime fatigue, encouraging the development of an on board safety culture underpinned by realistic staffing levels and a more robust approach to regulation. In addition to the general conclusions presented in Table 2.2 (page 27), certain observations concerning work force reform were felt relevant to seafarers. Inaction often appeared to be the consequence of misconceptions that reform necessitates excessive resources. Off-the-shelf health and safety plans generally do not work as well as those that are workplace specific, and business friendly approaches usually are more effective than harsh enforcement. However, in high hazard industries, external regulatory pressure may be needed for compliance.

John Bainbridge, Assistant Secretary of the International Transport Workers' Federation's Seafarers' section, said: "This report confirms what we already know. Seafarers are routinely working excessively long hours, endangering themselves and the marine environment. It's time to stop putting seafarers at risk and to learn from the examples of best practice in other industries."



2.5b Coast Guard Program for Crews

The United States Coast Guard developed a Crew Endurance Management (CEM) maritime program for fatigue (www.uscg.mil/hq/g-m/cems/i) (Comperatore & Rivera, 2003). The use of 'endurance' in its title reflected the principle that just as a ship's endurance is determined by how long it can support operations without replenishing supplies, a crew's endurance is determined by their ability to cope with job-related physiological, psychological and environmental challenges.

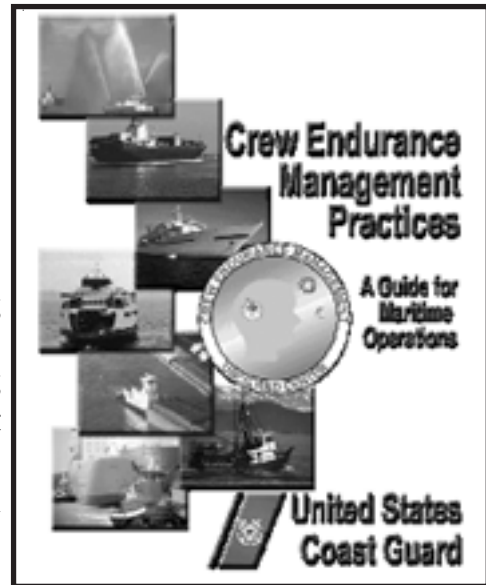
This program is research-based and oriented toward vessels with a structured routine (to the extent that this is achievable in any maritime operation). Its use requires training a local team of fatigue experts, who become the program advocates and fatigue management coaches. It has three sections. Section I introduces the concept of crew endurance management. Section II provides specific guidance on how to recognize endurance risk factors and the detrimental

effects of psychological, physiological, and environmental stress. Section III contains guidelines on how to assess crew endurance and implement improvements. The fatigue team enlists the entire crew's involvement and coaches them through the change process.

Examples of suggestions include striving for at least six hours of continuous sleep on all days, tuning into one's own fatigue level and adjusting sleeping when needed and changing ship policies to allow showering and meals at different times to match work schedules. It recommended on-watch napping in the early morning hours, when work is completed and at least one other crew member is awake on watch.

In 2002, the Coast Guard and the American Waterway Operators chartered a working group to implement CEM in the barge and towing vessel industry. A demonstration project showed improvement on a number of measures over a six-month period (United States Coast Guard, 2005). According to a 2005 report, more than 70 towing vessels were in some stage of documented CEM implementation.

The CEM website has many additional resources, including links to a newsletter, software to facilitate crew endurance risk factor assessment and information about training seminars held regionally to learn how to implement the system. However, this well designed program requires considerable investment of resources, which may restrict its use to larger vessels and interested companies (Gander, 2005).



2.5c Canadian Program for Pilots

Concerned with apparent fatigue related incidents involving marine pilots, Transport Canada reviewed the literature, collected data via questionnaires and on board observations and developed a Fatigue Management Plan for use in workshops with marine pilots (Transport Canada, 2002). Resources produced include a marine pilots' Fatigue Management Guide and Trainer's Handbook.



2.6 Fatigue on the Road

Crashes when driving a motor vehicle have a clear relationship to fatigue and other types of driver impairment, and commercial motor vehicle (CMV) transport (trucking) is the industry with the greatest number of studies relating long work hours to their impact on safety. Driving is a complex task that requires the coordination of physical, psychomotor and cognitive skills (Mayhew & Simpson, 1995). However, many driving situations are routine and monotonous, which can exacerbate driver impairment due to long work hours and other fatigue-promoting influences.

Table 2.2. Recommendations for Seafarer Fatigue Reform (Smith, Allen & Wadsworth, 2006)

Treat fatigue as a serious health and safety issue.	There are serious risks and consequences associated with fatigued seafarers, such as environmental disasters, economic losses and the health, safety and well being of seafarers. The first stage of dealing with fatigue is to get the relevant people to acknowledge that there is a problem to address.
Take a robust approach to regulation and staffing.	Staffing must consider more than the minimum level needed to operate a vessel and allow for maintenance, recovery time, redundancy and the paperwork and drills associated with security and environmental issues. More transparent regulatory models are needed to allow such an approach.
Enforce legislation, eliminate false record-keeping and provide better training and guidance.	It is essential that existing guidelines be enforced, supplemented with a serious attempt to promote a culture of safety, so that seafarers do not feel compelled to falsify records. Appropriate training and guidance regarding avoidance of fatigue and optimum working conditions is needed. All stakeholders must be involved in developing solutions. If nothing is done, the maritime industry may be compelled to respond to external drivers, such as environmental lobbies or those pushing security agendas.
Learn from best practices.	It is important to learn by example and adopt strategies that will lead to a culture of best practice and an elimination of worst case scenarios. This approach will require the collaborative efforts of all stakeholders.

Review of work hours and CMV operators allows insight into the difficulties of establishing clear thresholds for what constitutes safe practices. It also provides examples of means to monitor work hours and newer efforts to identify higher risk drivers. In addition, we discuss the relationship of fatigue to crashes among all drivers.

As early as 1917, a task force of scientists convened in Washington, D.C. to discuss the effects of fatigue on motor vehicle driver accidents (FMVCSA, 2005). The U.S. trucking regulations were developed in the 1930s by the Interstate Commerce Commission (ICC) to counteract perceived unsafe driver scheduling practices.

The rules were changed in 2003 to increase the work limit from 10 to 11 hours, and rather than just use the hours worked per week as a limit for total hours, a new 34 hour 'reset the weekly limit clock' provision was added. The stated reason for the change was to move toward a 24 hour schedule and allow more flexibility in scheduling, and in general CMV drivers prefer longer shifts, which allow more personal flexibility and driving at night when traffic is less (Wylie, 1996). Although a small change in shift length, the addition of the 34 hour rule increased the total hours that a driver could work per week. Table 2.3 presents a chronological listing of the regulations concerning CMV operation.

In response to the 2003 rule change and its longer hours, three advocacy groups; Public Citizen, Citizens for Reliable and Safe Highways (CRASH) and Parents Against Tired Truckers; filed a petition to review the new hours-of-service rule with the U.S. Court of Appeals. It cited a 1996 study that found a strong relationship between single-vehicle truck crashes and the length of consecutive hours spent driving, with the risk of a crash doubling after nine hours of continuous driving. They objected to effectively allowing 20 percent longer time behind the wheel; they also felt electronic monitoring of hours should have been required for all CMV operators. They pointed out that the new rules allowed a driver on an eight day rotation to accrue a total of 98 hours of both work and driving.



The resulting court dicta led to extensive considerations of each aspect of the rule. An expert panel reviewed the literature, convened study groups and heard testimony from sleep experts, occupational medicine consultants, the trucking industry, drivers and their representatives, the public and public advocacy groups. The findings were published in the Federal Register in August 2005, by the Federal Motor Carrier Safety Administration of the Department of Transportation as an almost 100 page document. Review of that report underscores how difficult it is to draw firm conclusions about work hour limits and job structures when so many variables influence outcomes, including economic realities and the potential for crash fatalities. Detailed abstracts of the extensive literature reviewed for the report was published as a separate document (http://www.trb.org/news/blurb_detail.asp?id=5198).

2.7 Commercial Motor Vehicle (CMV) Operators

There are almost three million U.S. truck drivers. Most commercial motor vehicle operators work in large metropolitan areas or along major interstate roadways where trucking, retail and wholesale companies have their distribution outlets. The truck transportation industry employs approximately one-quarter of these workers, and another quarter work for companies engaged in wholesale or retail trade. Approximately 10 percent are self employed. The remainder of CMV operators are distributed across many industries, including construction and manufacturing.

Table 2.3. Regulations Concerning Commercial Vehicle Operation

Year	Key Laws, Regulations and Hours of Service Mandates
1937: Interstate Commerce Commission (ICC) adopts hours of service	drivers are required to work on 24 hour cycle, with drive maximum 10 hours and rest minimum 8 hours; drivers can accrue up to 60 hours driving over 7 consecutive days
1938: Fair Labor Standards Act exemption	trucking industry exempted from overtime compensation, which creates incentive to drive long hours
1962: ICC eliminates requirement for 24 hour work/rest	drivers can alternate 10 hours of driving with minimum 8 hours of rest
1999: Motor Carrier Safety Improvement Act of 1999	new safety agency, the Federal Motor Carrier Safety Administration (FMCSA), emphasizes commercial motor vehicle safety as its highest priority
2003: FMCSA increasing maximum driving hours	increases consecutive driving time from 10 to 11 hours, maximum 14 hours on duty (11 hours driving) after 10 hours of consecutive rest; may not drive after 60/70 hours in 7/8 consecutive days, 7/8 rule restarts after 34 hours of duty
2005: FMCSA retains 2003 rules	keeps the 11 hour limit, adds the 34 hour off duty restart, eliminates the split sleeper berth exception by requiring 8 hours of consecutive anchor sleep

The rules and regulations presented in Table 2.3 refer to long-haul drivers. Short-haul drivers (within 150 mile radius of their base) have different rules, as they are less likely to fall asleep at the wheel. They are more likely to follow a more typical shift structure, and their driving is interrupted by the physical activity of loading and unloading, which improves alertness. In addition, short-haul driving generally occurs in urban settings requiring high levels of alertness, but also providing more stimuli to drivers. Similarly, regulations differ for drivers of passenger carrying vehicles, who have shorter work hour regulated limits.

As a group, truckers' lifestyles are unhealthy, even more so than the average American. For example, tobacco use among truck drivers is nearly double that of the U.S. population average (Roberts & York, 1997). Smoking substantially increases the risk of cardiovascular disease and causes about 30 percent of all cancer deaths. Truck drivers who smoke are perhaps at even greater risk, as they get a double dose of toxins breathing in secondhand smoke inside the cab.

Also on average, truckers are fatter than the already overweight average U.S. adult, and almost three-quarters are either overweight or obese [Roberts & York, 1997]. Being overweight or obese is a well-established risk factor for cardiovascular disease, hypertension, diabetes and certain malignancies. It exacerbates problems such as arthritis and back pain. And importantly it is a known association with obstructive sleep apnea, a condition which places individuals at a much higher risk for day time sleepiness and motor vehicle crashes.

In general, studies document that the majority of CMV drivers are chronically sleep deprived. In four major studies where sleep was verified using either an actigraph watch (wrist-worn monitoring device) or electroencephalogram (brain wave monitoring), CMV operators averaged from 3.8 to 5.3 hours of sleep per day (Dinges, et al., 2005; Balkin et al., 2000; Mitler et al., 1997; Wylie et al., 1996; Hanowski et al., 2000). When more than 500 truckers were surveyed at a highway stopping area, half reported that they reduced their sleep duration by getting up early when beginning a long distance journey, and 10 percent reported that they had not slept in the 24 hours before the interview.

The increased prevalence of sleep deprivation and driving among CMV operators may relate to several factors, including industry norms and cultural influences among drivers (Philip et al., 1996; Philip et al., 1999), economic rewards (Arnold et al., 1997) and an unawareness of the effects of sleep deprivation, both in general and for them personally when driving.

2.8 Drowsy Driving and Crashes

Crashes caused by fatigue are a problem among all drivers. The general reduction in sleep that has occurred in recent years, along with greater reliance on motor vehicles, have increased fatigue related crashes. In the U.S., the National Highway Traffic Safety Administration estimates that drowsy driving is responsible for 100,000 police-reported crashes and 40,000 injuries each year (NHTSA, 2000). Nine out of every 10 North American police officers report having stopped a driver who they believed was drunk, but turned out to be drowsy, according to the AAA Foundation for Traffic Safety survey (2004). Driving fatigued may be even more common than the alarming crash statistics suggest. When drivers were randomly surveyed, one in five said they had nodded off or fallen asleep at least once while driving in the past 12 months.

Sleep-related crashes have certain characteristics that set them apart. Typically there is no indication of braking or other attempts to avoid the crash, the driver is often alone, they occur

on higher-speed roadways and serious injuries are more common (NCSDR/NHTSA, 1998; Pack et al., 1995; Horne & Reyner, 1995; Stutts et al., 1999). Almost every crash timing study shows a peak in the middle of the night and a smaller peak in the middle of the afternoon, paralleling the normal daily cycle of alertness (Dinges, Napping Strategies, 1995).



Researchers in North Carolina compared drivers involved in crashes that were related to falling asleep with drivers from crashes that were not sleep-related. Employed drivers in sleep-related crashes were twice as likely to work two jobs, and they worked more total hours each week. In addition, 20 percent of sleep-related crash drivers had been awake for 20 or more hours when they crashed, compared to less than 5 percent of the other drivers in crashes. Importantly, half of the sleep-related crashers were not aware of their fatigue prior to the crash, and a third reported that they did not feel at all drowsy prior to their crash (Stutts et al., 1999).

Alcohol and other drugs (particularly antihistamines and narcotic pain killers) also contribute to driver impairment and fatigue-related accidents. All are central nervous system depressants and impair performance. For narcotic use, the risk of crashes doubles, and antihistamines increase risk three-fold (Howard et al., 2004). Alcohol directly results in impairment, and even small amounts below the legal limit exacerbate the effect of sleep loss, thus increasing the risk of crashes (Horne, 2004).



Although much of the research relating driver fatigue to crashes has been done in the U.S., Canada and Australia, the relation has been confirmed in many other countries, such as Greece (Tzamalouka et al., 2000), Yugoslavia (Milosevic, 1997); Peru (Rey de Castro et al., 2004); Israel (Sabbagh-Erich, 2005); and Norway (Sagberg, 1999).

2.9 CMV Operators, Work Hours and Crashes

According to the NTSB and other organizations that monitor traffic safety, more than 5,600 Americans die annually in fatigue associated CMV crashes. Although they are only 3 percent of the registered vehicles, CMVs are responsible for more than 10 percent of passenger vehicle occupant deaths. The excessive contribution to fatal crashes is a result of the CMVs' size, limited maneuverability and the usual involvement of more vehicles in truck crashes.

Some of the most clear examples of the effects of fatigue on performance are seen in major highway crashes involving truckers. A NTSB funded study of 182 truck crashes found that driver impairment due to fatigue was the most frequently cited etiology, causing 31 percent (FHA, 2003). While the majority of all fatigue related crashes do not involve CMVs, the latter are of particular concern due to their potential reduction with effective rules and enforcement and because the fatality rate of CMV crashes per mile traveled is four times that of other vehicles (FMCSA.dot.gov/facts; Federal Highway Administration, 2003).

Many of the factors related to fatigue and crashing in general have been confirmed as contributing influences for CMV drivers: working nights, getting less than 6 hours sleep per night, greater use

NTSB: Trucker had little sleep before crash that killed 7 kids

On Wednesday, January 25, 2006 at 3:25 PM a Union County, Florida school bus was transporting nine children home from school. The driver stopped at an approved stop going north, with lights flashing and stop arm extended. A Pontiac Bonneville was traveling behind the bus and carrying seven occupants. The Pontiac stopped behind the bus.



A 2004 Freightliner 18-wheel semi trailer truck loaded with bottled water was going northbound on the road and failed to stop. It struck the Pontiac,

over riding it, and both hit the bus. With the Pontiac still under the bus, both vehicles traveled through a ditch. The Pontiac became dislodged and engulfed in flames. The semi's cab separated from the truck and ended on its side. The school bus rotated counterclockwise and traveled in reverse northbound until its end collided with trees. The crash pushed the car 272 feet and the bus 328 feet. Three children in the bus were ejected onto the roadway. All the passengers in the Pontiac were killed, and the bus driver, truck driver and all nine students in the bus were transported to local hospitals.

The truck had an unobstructed view of the stopped vehicles, which were visible for 1400 feet on that stretch of road. The 31-year-old truck driver had been awake for 34 hours. He was a legally licensed driver, working for Crete Carrier based in Lincoln, Nebraska. Toxicology tests of the driver were negative. The driver had eight prior traffic violations, including speeding, driving with a suspended license and operating a motor vehicle in an unsafe condition.

All of the Pontiac's occupants were children or adolescents. Five of the seven killed passengers were children from one family. The oldest teenager was driving the car, and the youngest was 20 months old. The children's 62-year-old grandfather died of a heart attack after learning of their death. The two other children killed were from another family, cousins of the first. The parents of those two killed children are suing the driver and the trucking company. Approximately 10 months after the accident, the driver was charged with seven counts of vehicular homicide and seven counts of manslaughter by culpable negligence (www.news4jax.com/print/6721777/detail.html).

of sedating medications and longer duration drives (Stutts et al., 2003; McCartt et al., 2000). A NTSB study of fatal truck accidents found that one third of fatigued drivers also were impaired by alcohol and/or drugs. A comprehensive list of the alcohol and drug testing rules published by the Federal Motor Carrier Safety Administration's (FMCSA) and the Department of Transportation (DOT) applicable to CDL drivers and their employers is available online at the FMCSA website.

Although driver simulations can not reproduce all the unique considerations and tasks of driving, they allow study of specific variables and their impact on abilities. Simulations generally involve lane tracking, maintaining a constant speed and reaction time, along with monitoring brain waves for evidence of momentary brief episodes of sleep (Moller et al., 2006). Several studies have shown that sleep deprivation impairs alertness and results in more lateral deviations during driving (O'Hanlon & Volkerts, 1986; O'Hanlon et al., 1995; Ramaekers & O'Hanlon, 1994). This finding may explain the observation that sleep-related crashes frequently involve leaving the road or hitting an obstacle, with no corrective reaction from the driver (Horne & Reyner, 1995). When studied in driving simulators, the worst drivers among truckers are those who routinely got less than five hours of sleep per day (Pack et al., 2006).

In 2002 the National Sleep Foundation and a coalition of other organizations, federal agencies and corporations convened a national summit and initiated the drowsydriving.org website. Additional action items included research, public policy and educational programs to combat the problems of fatigued driver impairment.

Although it is well established that the longer CMV operators spend behind the wheel, the more likely they are to crash (Campbell, 2005; Jovanis, 2005), how long to allow behind the wheel is controversial. Beginning in the 1970s, the DOT conducted three multimillion dollar studies, and data from nearly 1,000 truck crashes were assessed. The risk of crashing increased as hours of driving increased, and there was a more than 15-fold increase in the risk after more than 13 hours awake, compared to the first hour of driving (US DOT, 2000). Recent studies have confirmed a 10 percent increase after driving 10 hours, and a 25 percent greater risk after driving 12 hours (Tucker 2000).

One of the contentious aspects of the 2003 rules was the eleventh hour of driving. As an example of how difficult it is to identify precise limits for long work hours, two expert investigator groups (the Virginia Tech Transportation Institute and the Pennsylvania Transportation Institute) reached different and incompatible conclusions about the eleventh hour. The Pennsylvania team found that the eleventh hour of driving posed a significant crash risk, while the Virginia Tech investigators could detect no statistical difference between the tenth and eleventh hours of driving. To help decide the issue, an economic perspective was added, and the FMCSA estimated that a ten hour driving limit would save no more than 9.3 lives per year compared to an 11 hour limit, but at an annualized net cost of \$526 million. In other words, a 10 hour driving limit would cost more than \$63 million per life saved.

2.10 Higher-Risk Drivers: Obstructive Sleep Apnea

As discussed in Section 5, one of the means to reduce fatigue-related incidents and work related accidents in general is to identify higher risk employees. Sleep disorders, such as obstructive sleep apnea (OSA), are a well accepted cause of increased daytime sleepiness, and importantly their presence increases the risk of crashing. In the early 1990s, Haraldsson and others (1990) published a study showing that those with untreated OSA had a seven-fold increase in single car crashes, and when controlled for miles driven, that number was almost 12 times greater than controls. Others have confirmed those findings (Teran-Santos et al., 1999).

Sleep apnea is assessed in a sleep laboratory by measuring breathing, airflow and brain waves while an individual sleeps (Figure 2.1). Among those with OSA, brief spells of apnea or times when breathing stops, may occur during sleep due to the temporary collapse of tissues at the

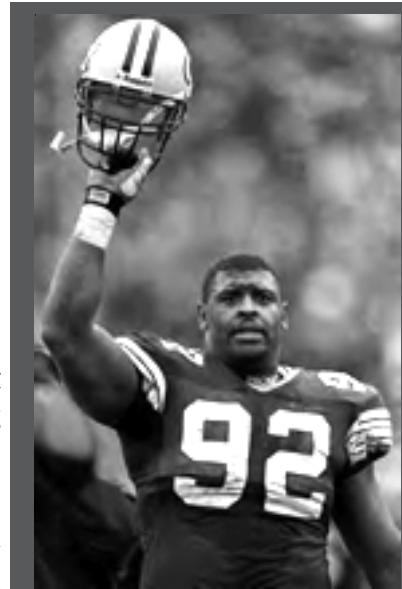
back of the throat. Due to this, the brain awakens, though the person might not be aware of their disturbed sleep. Mild to moderate sleep apnea is when these brief sleep interruptions occur 5 to 30 times an hour, while severe sleep apnea is when these interruptions occur more than 30 times an hour.

A recent study of CMV drivers found that sleep apnea is more common among them (18 percent mild, 6 percent moderate and 5 percent severe sleep apnea) than the general population where approximately 3 percent are believed to have severe sleep apnea. The increased prevalence among truckers may result from that profession's concentration of the risk factors for OSA including being male and overweight/obese, smoking and drinking alcohol.

The researchers also identified that for certain individuals, sleep apnea may have a multiplying effect on driver fatigue. They observed that the prevalence of sleep apnea depended on the average duration of sleep prior to the study. Short sleep duration, six hours or less per night, resulted in more sleep apnea. In addition, there was more sleep apnea when individuals awoke early in the morning, and since more than a third of CMV operators start their drives before 6:00 AM, that also could increase apnea and its associated risks. Although drivers generally were poor judges of their fatigue level, almost all objective tests of performance showed a clear relationship with the severity of sleep apnea and driver impairment.

Because the frequency of sleep disorders is increased among CMV operators and the consequences of increased fatigue potentially so catastrophic, there are regulations in place for screening CMV operators for sleep apnea and monitoring their adherence to therapy when it is detected (see page 58). Effective treatment of OSA reduces its daytime fatigue and significantly improves cognitive performance (McMahon et al., 2003). When treated, crash risk of apneic drivers is not different from normal individuals (George, 2001).

OSA has health consequences other than fatigue-associated crashes, such as an increased risk of hypertension, weight gain, sexual dysfunction, heart disease and sudden death. Although reduction in crashes is critical, treating OSA also is cost effective by other indices. Between January 2003 and December 2005, researchers from Texas, Wisconsin, and Minnesota analyzed 339 commercial truck drivers with newly diagnosed sleep apnea. All received a continuous positive airway pressure (CPAP) machine for treatment. Researchers found that after CPAP intervention, there was an average savings of \$538 per member per month or a 58 percent reduction in total health care costs. In addition, inpatient hospital admissions showed a reduction of 91 percent after CPAP was used. Researchers conclude that companies can reduce health care costs by identifying and treating employees with sleep apnea (Berger et al., 2006).



Obstructive sleep apnea (OSA) probably contributed to the untimely death of Reggie White, one of the greatest players in NFL history, who died at age 43. When severe, OSA can cause cardiac arrhythmias and sudden death. Mild sleep apnea may be as common as diabetes and asthma, and severe problems occur in two to five percent of adults, most of whom do not know that they have the disorder. Symptoms of OSA include loud snoring, choking during sleep, excessive daytime sleepiness and morning headaches. It can only be diagnosed in a sleep laboratory. More information is at www.sleepapneainfo.com/.

2.11 Documentation of CMV Operator Hours

Each trucker who drives in interstate commerce is required to keep accurate records of his/her duty status. Current rules allow truckers to use a log on an approved grid (Figure 2.2) or an automatic onboard recording device. As with other essentially voluntary enforcement schemes (such as the tax code), cheating is believed to occur. In the case of an accident, records can be checked against the expense receipts and other paperwork.

2.12 Countermeasures and Driving

The obvious countermeasure to drowsy driving is getting more restorative sleep. Countermeasures like cold air or a loud radio are not routinely effective (Reyner & Horne, 1998), and as described, drivers are poor judges of their fatigue levels. If they feel fatigued, they are, but those not feeling tired also may be significantly impaired. Caffeine and naps are discussed in Section 5.

Efforts are underway to develop devices for monitoring sleepiness in real-life conditions, but so far none have been proven effective (see text box next page). Driver monitoring systems that reliably wake up drowsy drivers, without providing too many false alarms, are not available, and even if they worked as expected from a technical point of view, there is concern that such systems may result in reliance on those devices at the expense of appropriate rest (Dinges & Mallis, 1998).

The American Transportation Research Institute (ATRI) encourages commercial drivers to adopt a personal lifestyle of wellness, health and fitness as a precursor to driver alertness and managing fatigue. ATRI's approach advocates that carriers encourage drivers to personalize their own wellness, health and fitness program and to obtain sufficient sleep. The ATRI endorses educating drivers on the effects of fatigue, the need for eight hours of uninterrupted sleep to decrease fatigue, using short planned naps to restore a fatigued individual's alertness and minimizing repeated sleep loss to prevent a chronic sleep debt which can negatively affect performance.

More recently, safety practices have focused on the higher-risk driver, based on findings that a relatively small percentage of individuals are responsible for an inordinate crash risk (Knipling et al., 2004). Surveys of fleet safety managers were used to identify those higher-risk individuals, and methods to avoid their hiring and means to monitor and modify their behavior have been published (<http://www.fmcsa.dot.gov/facts-research/research-technology/tech/high-risk-commercial-driver.pdf>). The Transportation Research Board of the National Academies prepared the report, Commercial Truck and Bus Safety Synthesis Program (CTBSSP) Synthesis 4: Individual

Figure 2.1. Sleep Laboratory Assessment



Commercial Truck and Bus Safety

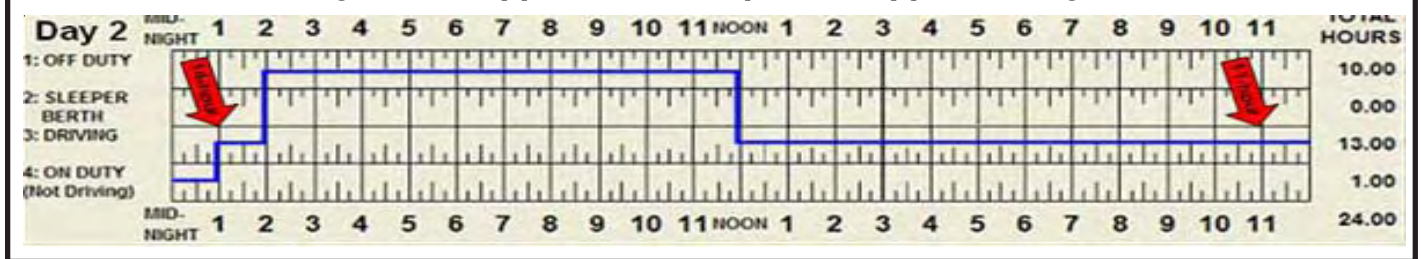
Synthesis 4

Individual Differences and the "High-Risk" Commercial Driver

A Synthesis of Safety Practice

Differences and the “High-Risk” Commercial Driver, which explores individual differences among commercial drivers, particularly as they relate to the higher-risk commercial driver. The synthesis identifies factors relating to commercial vehicle crash risk and assesses ways that the high-risk driver can be targeted by various safety programs and practices, at both fleet and industry-wide levels (http://www.trb.org/news/blurb_detail.asp?id=4295).

Figure 2.2. Approved CMV Operator Approved Log



The objective of FMCSA’s Advanced Driver Fatigue Alerting Technology research initiative is to increase driver alertness through a fatigue-alertness monitor. Driver fatigue-alerting technology is intended to monitor driver drowsiness, provide continual alertness level feedback to the driver, and provide alerts and warnings when the driver’s alertness level falls below a specified threshold. Currently, FMCSA in partnership with NHTSA, is conducting a proof-of-concept test of a drowsy-driver detection system based on the PERCLOS (percent of time the eyelids are closed over a given time period) concept. PERCLOS has been demonstrated to be the most valid measure of driver fatigue. The current infrared-based PERCLOS technology appears to work well at night, but not during daylight, limiting its utility to night driving. FMCSA plans to explore new technologies, such as means to monitor steering and lane tracking, which may be able to overcome these limitations and develop a more robust system. The objective is to identify and develop a relatively low-cost device to assure drivers are well rested.

2.13 Fatigue in the Air

Pilot fatigue has been recognized since early in aviation. In 1980, the NASA Ames Research Center was funded by Congress to study fatigue in air transport operations. They performed a series of short and long haul field studies and made observations in simulators at the Ames Research Center. Flight crew fatigue increases with progressive flying duty and reaches a critical level after 7 to 10 hours of flying (Samel, Wegmann & Vejvoda, 1997), and that time is decreased during night time flights. In addition to sleep debts and time zone changes, pilots are exposed to other fatigue contributing factors, such as hypoxia, low humidity and aircraft-specific noise and vibration. The Research Center also demonstrated that planned rests and naps resulted in improved alertness and performance (Rosekind et al., 1995; Naitoh, 1992; Dinges, 1992).



Figure 2.3. Military F-117 pilot in simulator being assessed in sleep deprivation study.

Once those fatigue issues were clearly documented, in 1999 the name of the Ames group was changed to the Fatigue Countermeasures Group to provide a greater emphasis on the development and evaluation of countermeasures and education concerning fatigue. They developed and conducted 90 minute presentations on fatigue and hosted an interactive website. Although they are no longer funded, they maintain the website, which is available at http://human-factors.arc.nasa.gov/zteam/webETM/GA_ETM/GA_ETM_premod.html. The module is entitled, "Alertness Management in Flight Operations," and it includes basic information about fatigue, sleep, sleepiness and circadian rhythms. It describes how flight operations affect physiological factors, identifies some of the misconceptions about fatigue in aviation and offers countermeasure recommendations.

The aviation industry is an example of the complexities in balancing competing interests of employees (who are paid on contracts and not with an hourly rate), safety experts, economic interests and federal regulatory agencies. Currently, conflicts exist between 1) existing regulations concerning duty hours and 2) scientific evidence and recommendations from the airline pilot organizations and the National Transportation Safety Board (Holley at al., 2003).

The Federal Aviation Administration, part of the Department of Transportation, establishes the Federal Aviation Regulations (FARs) governing flight and duty time, and those rules and regulations have remained largely unchanged since instituted in the 1930s. However, it is the National Transportation Safety Board (NTSB), an agency authorized by Congress, that investigates U.S. aviation accidents or those involving U.S.-built aircraft. The NTSB views generally align with those of the pilot unions, which maintain that the current scheduling system results in unsafe levels of alertness.

While the absolute number of commercial airline crashes is low, the percent fatigue-related is greater than that of commercial motor vehicles, where fatigue's effects have been well publicized. Both major U.S. pilots unions have posted extensive material on this issue on their websites (Air line Pilots Association [www.alpa.org] and Allied Pilots Association [www.alliedpilots.org]). In 2006, the NTSB Acting Chair Mark Rosenker characterized the FAA's past efforts as 'dismal' in failing to set appropriate duty time limits.

Because the FARs rules are perceived as inadequate, over the years they have been buttressed by collective bargaining agreements. However, those agreements affect only a part of the U.S. airline industry and do not result in uniform flight and duty time limits. Lack of mandated requirements, and economic demands have pressured carriers to reduce flight crew rest breaks to increase productivity and reduce costs. Those same airline economic forces and lobbying efforts also may have hampered Federal FARs reform.

The FAR regulations vary for different types of aircraft (domestic, commuter, on-demand) and with the number of pilots on the flight deck. The maximum duty hours for four member domestic flights is up to 18 hours, and a seven consecutive day flight hour maximum of 30 hours (100 hours in one month). The core principles sought by pilot groups and the NTSB include 1) minimum of 10 hours off duty in every 24 hour period to allow for adequate sleep, 2) maximum scheduled duty period of 14 hours and 3) flight limit of 8 hours between rest periods.



Additional reports on fatigue and scheduling issues can be found in the Aviation Safety Reporting System (ASRS) database. The air crashes captured on those sites corroborate the potential dire consequences of pilot fatigue demonstrated in research settings.

Pilot Fatigue Woven Through Circumstances of FedEx Crash

Fatigue can defeat pilots' proven performance records and progressive companies' policies. The object lesson comes from the July 26, 2002, collision with trees on final approach of a Federal Express B727 cargo jet at Tallahassee, Florida. The three pilots survived the crash, but their airplane was destroyed. The fatigue factor was woven throughout the National Transportation Safety Board (NTSB) final hearing on the case. "Much more work needs to be done on the fatigue issue, especially on the back side of the clock," said NTSB Member John Goglia. The "back side of the clock" is the expression often used to describe the time from midnight to about 6:00 AM, when the human body's natural demand for sleep is greatest. As one of his last official acts after nine years on the board, Goglia chaired the hearing. He noted with dismay that the accident occurred even though FedEx "is one of the more enlightened companies regarding the fatigue issue." Updating obsolescent flight time and duty time regulations has been on the NTSB "Most Wanted" list of aviation safety improvements since its inception in 1990. The FedEx crash case has focused attention on this issue, as it marks at least the third crash in which the safety board has cited pilot fatigue as a contributing factor. The two previous fatigue-related crashes were:

- * The Aug. 18, 1993, crash of American International Airways Flight 808, a DC-8 cargo jet, at Guantanamo Bay, Cuba, at the end of a long day involving a last-minute runway change as in the case of the FedEx accident, and

- * The June 1, 1999, crash of American Airlines [AMR] Flight 1420, an MD-82, at Little Rock, Ark., at the end of a long day involving a last-minute runway change, as in the case of the FedEx crash.

Air Safety Week, June 14, 2004 (http://findarticles.com/p/articles/mi_m0UBT/is_24_18/ai_n9911769).

2.14 Possible Implications for Fire Fighters and EMS Responders

Emergency services, long haul commercial vehicle operation and seafaring may seem divergent occupations. However, they are united by their each having long work hours.

Seafaring has overlap with emergency medical services responders because both involve working in teams or crews in unique circumstances. Also for both sites, workers rely on other members' performance, and their tasks often are accomplished under unpredictable environmental conditions. In addition, for both occupations, the effects of worker fatigue can have catastrophic consequences.

Seafarers' efforts to acknowledge, identify and deal with long work hours and fatigue, especially as they relate to the Cardiff recommendations (Table 2.2) and the U.S. Coast Guard efforts have touch points with fire fighters and EMS responders, and the conclusions about countermeasures presented in Table 2.2 also would apply for those workers. One aspect missing in marine worker reform efforts, which is discussed further in Section 5 (page 63), is the need to involve consideration of workers' families and other psychosocial components in planning and assessing work structures.

The information on commercial motor vehicle operators highlights the importance of ingrained occupational cultural norms and the difficulties and controversies of rule making when data are imperfect and influences such as economics and politics are realities. In addition, trucking demonstrates that regulations and enforcement can only go so far in remedying problems. Current efforts to minimize driver-related accidents by identifying higher-risk individuals are examples of means to work within an existing system to improve safety.

- For seafarers, long work hours are related to injuries, fatalities, collisions and groundings. Aspects identified as important in countering seafarers' fatigue-related problems include treating fatigue as a serious threat to health of workers and the industry, using realistic staffing patterns, enforcing regulations in conjunction with a culture of safety and involving all stakeholders in reform efforts.
- For all motor vehicle drivers, fatigue from too little sleep, long work hours and circadian disruption is a risk for motor vehicle crashes. The current CMV hours of service regulations are based on available evidence, the input of stakeholders and an economic analysis of the cost and benefit of the current work hour limits.
- Rather than altering the existing work structure, recent CMV driver safety efforts have been directed at making changes within the current work hours by focusing more on the higher-risk individual, such as those with obstructive sleep apnea or identified as at higher accident risk based on other criteria.
- The percentage of fatigue-related crashes may be highest in the aviation industry, and despite multiple pilots sharing tasks on the flight deck and existing hour limits, pilot unions argue that even stricter limits on pilot hours are needed.

Section 3: Postgraduate Medical Training and Sleep Deprivation

3.1 A Case Study in Mandated Reform: Emotions and an Adverse Event

Medical interns and residents have traditionally worked long hours, often spending every third or fourth night in the hospital, with minimal sleep during those times. Prior studies suggested that these long work hours impaired physicians' performance. Concerns were voiced that sleep-deprived interns, residents and other physicians working long hours were prone to errors when performing repetitive tasks and activities that required sustained vigilance (Samkoff & Jacques, 1991; Lingenfelser et al., 1994; Taffinder et al., 1998; Veasey et al., 2002). Importantly, some thought that the performance deficits associated with long hours could result in patient harm (Leape, Berwick & Bates, 2002). In addition to potentially hurting patients, these work patterns possibly were damaging physicians' health and well being (Shanafelt et al., 2002; Clever, 2002).

Despite those concerns, the system remained in place until a highly publicized adverse patient outcome led to legal actions (Brensilver, Smith & Lyttle, 1998) and public demand for reform (Kohn, Corrigan & Donaldson, 1999; Nagourney, 2003). A description of the Libby Zion case and the resultant book detailing its events is presented on page 43.

Following medical school graduation, M.D.s and D.O.s must complete a one year internship before being licensed to practice medicine. Most then become residents and spend two to six years in an accredited program to become board certified family medicine physicians, internists, surgeons, obstetrician/gynecologists, radiologists, pathologists or one of the many other medical fields. Some receive additional fellowship training following residency. Interns and residents are collectively known as housestaff or house officers. The term is a holdover from when they literally lived in the hospital or house throughout their training.

At the insistence of the consumer watch group Public Citizen and with the involvement of the Occupational Health and Safety Administration (Gurjala et al., 2001; Public Citizen Health Research Group, 2003), reform was initiated by the Accreditation Council for Graduate Medical Education (ACGME, 2003) (Philibert et al., 2002). The ACGME is the organization that sets standards for postgraduate medical education and makes the rules for the work structure of interns and residencies across the U.S. In 2003, the ACGME mandated a maximum 80 hour work week, restricted continuous work shifts to 30 hours and insisted that house officers have one day off per week. This reform sought to create a minimum standard for duty hours across all training programs.

Not all involved with medical graduate education were in favor of the changes. The 'downside' of resident work hour reform was a potential loss of continuity of care, reduction in trainee learning due to reduced patient exposure and disruption of the educational units that provide care in a teaching hospitals setting (Steinbrook, 2002; Charap, 2004).

The relationship among continuity of care, fatigued providers and patient safety is complex (Shojania et al., 2001). Efforts to reduce fatigue and sleep deprivation among residents can result in increased discontinuity of patient care, and just as with fatigued physicians, the result also can be harmful (Cook, Render & Woods, 2000). Even since implementation of the work hour reform, those house officers benefiting from the reduction in hours have noted potential negative impact on patient care and their education (Goitein et al., 2005). Three years after initiating the reform, the effect of this universal change in resident work hours on patient safety is not known. However, the sequence

of events provides insight into the complexities affecting work hours and their effects, even when the occupation has 'hard' outcomes, such as physician errors and negative patient outcomes. In addition, well designed efforts to study the impact of the reform illustrate the measures needed to examine altering the work environment.

3.2 Review of the Literature Was Inconclusive

'Evidence-based' is a term that refers to studies where review of the methodology, analyses and conclusions meets explicit criteria of scientific credibility. Many medical metanalysis and critical topic reviews apply those criteria, and that methodology was used with the available research concerning the effects of extended work hours on patient outcomes and doctor well being.

Because debate raged concerning the benefits and risks of reform, those involved critically analyzed an extensive existing literature for evidence concerning the current (prior to reform) system. Fletcher and colleagues (2004) searched the English-language literature for the last 40 years to identify articles that related physician work hours and patient safety, and beginning with more than 1200 citations, carefully reviewed 343 articles. As they pointed out, the many simulation studies showing decreased house officer performance were not 'real' patient encounters. The reviewers concluded that "evidence on patient safety is insufficient to inform the process of reducing resident work hours" (Fletcher et al., 2004).

The same group of investigators, funded by a grant from the Agency for Healthcare Research and Quality, undertook a review of the literature as it related to work hours and residents' lives (Fletcher et al., 2005). Again looking at 40 years of publications, they reviewed more than 500 articles. Their conclusions were similar to that of their review of hours and patient safety. The work hours and shift lengths of interns and residents are extreme and in general, much longer than physicians in practice or other professions. Although the reviewers found that some evidence suggested residents' quality of life would improve with work hour limitations, they wrote that interpreting the "outcomes of these studies is hampered by suboptimal study design and the use of non-validated instruments." Thus despite the many published articles addressing the issue, their critical review of data was inconclusive.

3.3 Web-based Nationwide Survey and a Prospective Trial

Coincident with changes in housestaff training hours, the Harvard Work Hours Health and Safety Group began a series of investigations to study the effects of work hour reform (Barger et al., 2006; Lockley et al., 2006; Landrigan et al., 2004). They aimed to test the hypotheses that extended work hours have a negative effect on patient safety and residents' sleep, performance and health. Those efforts illustrate study design features needed to document worker events, potential confounding variables and means to validate outcomes.

A web-based survey was used to collect individual data from almost 3000 interns, from different geographic regions and a wide variety of training programs. More than 17,000 monthly reports were filed by intern participants. The surveys asked about their time distribution and sleeping and waking hours, along with more than 60 other questions. Although the web is a convenient means to collect self-reported data, it also can be biased and inaccurate. Accordingly, the investigators validated the interns' self-reported measures by having a random sample also keep daily diaries.

The Accreditation Council for Graduate Medical Education (ACGME) is responsible for the accreditation of post-M.D. medical training programs within the U.S. Their website (http://www.acgme.org/acWebsite/dutyHours/dh_index.asp) has extensive information of work hour issues, including pdf files of their reports and updates, annotated bibliographies and position papers of other medical societies.

Diaries or activity logs correlate with direct observation of individuals, and the diaries were used to validate the self reported information.

Data on patient errors was collected, and the researchers found that extended-duration work shifts were associated with an increased risk of significant medical errors and adverse events. However, self reports of errors are subject to recall bias and are difficult to validate. For those outcomes, it also was problematic to control for the many potential confounding factors, such as level of supervision and other work-related issues. A more firm outcome was motor vehicle crashes when driving home from work. For these events, intern fatigue was a primary variable, and those crashes were substantiated with accident reports, insurance claims, photographs or other documentation.

The investigators found that interns who had worked 24 hours or longer were 2.3 times more likely to have a motor vehicle crash driving home from work. In addition to an adverse impact from one long day of work, repeated prolonged work days also had a detrimental effect. An almost linear relationship was observed between the number of extended shifts per month and car crashes; on the typical longer work schedule (every third night), the risk of a crash on the commute from work was increased 162 percent.

The same researchers who did the web-based intern survey also conducted a small prospective randomized crossover trial among interns working in the Medical Intensive Care Unit and the Coronary Care Unit at the Brigham and Women's Hospital in Boston. Each intern served as his or her own control as they worked in random order for three weeks under two different work hour situations: 1) a traditional schedule of approximately 80 hours per week and 2) a 60 hour schedule, which also eliminated shifts longer than 24 hours. Again, the interns' habits were closely monitored, and they completed daily sleep and work hour diaries and underwent continuous ambulatory recordings for three or four days a week. In this situation the patient care outcomes could be directly assessed using direct observation by other physicians, regular chart reviews by two highly-trained nurses, voluntary intern self-reports and computerized event-detection monitoring systems.

The investigators found that interns working a traditional schedule made 36 percent more serious medical errors and five times more serious diagnostic errors, both of which were highly significant differences. Even though there was less continuity of care and more transferring management among interns, errors still were fewer among the interns with more rest.

Collectively, the findings from the studies demonstrated an increased risk to both residents and patients of continuing to permit long work hours and extended duration work shifts. When working long hours, physicians were at a higher risk of lapses of vigilance and committing serious medical errors, and they were more than twice as likely to crash their cars while driving home. Other medical providers also are adversely affected by long work hours. For nurses, the risk of needle stick injury significantly increases after extended work hours (Ayas et al., 2006), and the risk of nursing errors is greater when working more than 12 continuous hours or more than 40 hours per week (Buss-Frank, 2005).

3.4 Possible Implications for Fire Fighters and EMS Responders

Emergency medical services and medical graduate training are each unique. And the long work hours of housestaff training (80 hours per week) are less than the typical hours worked by most EMS responders. However, both circumstances can involve 24 hour shifts and the need to perform under conditions where one's actions can have life and death consequences. Unlike medical trainees, fire fighters and EMS responders may work under conditions where environmental demands place additional burdens on workers. Despite those limitations, the analogies between medical graduate training and fire fighting and EMS response work result in certain potential implications for understanding the advantages and disadvantages of particular work structures:

- Review of extensive existing information suggest that long work hours may be hazardous to worker health and result in reduced performance. However, the many variables and unique situations prevent drawing firm conclusions from the many published studies. While performance on simulation exercises and alertness measures can reflect worker abilities, the most compelling evidence comes from real world outcomes, such as job performance, patient safety and crashes (Taffinder et al., 1998; Storer et al., 1989).
- One adverse outcome and the resultant public examination of conditions lead to events that mandated reform.
- If possible, assessment of new conditions should be accompanied by well designed, prospective randomized trials. And if cross-sectional study results are to be generalized across sites, those studies should include a broad range of locales, conditions and personnel, and they require appropriate means to validate the collected data.
- Interns and residents only participate in graduate training for one to five years, after which they assume their subsequent roles. Although their involvement in work hour reform is important, it is even more critical when considering changing work structure among employees already engaged in their professions, such as fire fighters and EMS responders. Because work schedules are such an integral component of people's lives, workers' full participation in scheduling issues is mandatory.

The United Kingdom also is in the process of reforming postgraduate medical training to reduce working hours, using a phased reduction aimed to reduce weekly work hours to 48 by 2112. An explicit component is acknowledging the economic and work force consequences of reduced hours, and the gradual reduction allows expanding medical student numbers to cover the additional duties (Beecham, 1999).

A Case That Shook Medicine by BH Lerner, The Washington Post, November 28, 2006.

Many people have vowed to avenge the untimely death of a relative. Lawyer and journalist Sidney Zion actually did – to the benefit of patients and doctors-in-training nationwide. After his 18-year-old daughter Libby died within 24 hours of an emergency hospital admission in 1984, Zion learned that her chief doctors had been medical residents covering dozens of patients and receiving relatively little supervision. His anger set in motion a series of reforms, most notably a series of work hour limitations instituted by the Accreditation Council on Graduate Medical Education (ACGME), which have revolutionized modern medical education.

Just about everyone involved in the Libby Zion case – her father, her doctors and the people who testified at the trial that eventually resulted – has a different account of what happened. But there are some undisputed facts. Libby was a college freshman with a history of depression who came to New York Hospital in Manhattan on the evening of Oct. 4, 1984, with a fever, agitation and strange jerking motions of her body. She also seemed disoriented at times.

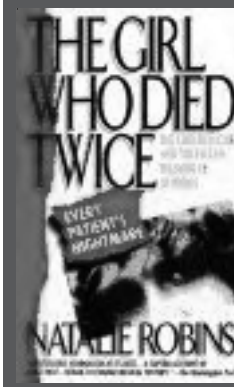
Unable to diagnose her condition definitively, the emergency room physicians admitted her for hydration and observation. As the physician of record, Raymond Sherman, a senior clinician who had treated several members of the Zion family, approved the decision by phone. On the hospital ward where she was sent, Libby was evaluated by two residents: Luise Weinstein, an intern eight months out of medical school, and Gregg Stone, who had one additional year of training. They, too, were not certain of Libby's diagnosis. Stone termed it a "viral syndrome with hysterical symptoms," suggesting that Libby was overreacting to a relatively mild illness. The doctors prescribed a shot of meperidine, a painkiller and sedative, to control her shaking. Sherman approved the plan by phone.

The events of the next several hours remain controversial. At about 3 AM, Weinstein went off to care for some of the 40 other patients she was covering. Stone went to sleep in an adjacent building, where he would be available, if necessary, by beeper. After the doctors left, Libby became more agitated. The nurses contacted Weinstein at least twice. Weinstein ordered physical restraints to hold the patient down and prevent her from hurting herself. She also prescribed an injection of haloperidol, another medication aimed at calming the patient. Busy with other patients, Weinstein did not reevaluate Libby. Libby finally fell asleep, according to the nurses, but when an aide took her temperature at 6:30 AM, it was 107 degrees, dangerously high. Weinstein was called, and emergency measures were tried to lower the temperature. But Libby Zion suffered a cardiac arrest and died. Weinstein called her parents, telling them doctors had done everything they could. To the doctors at the hospital, the case was an inexplicable "bad outcome" in which a healthy young woman had died of a mysterious infection.

But the more Sidney Zion learned of the circumstances of Libby's death, the more he rejected this assertion. He became convinced his daughter's death was due to inadequate staffing at the teaching hospital. And he grew determined to ensure that others not fall victim to the same gaps in the teaching hospital system that he blamed for his daughter's death. First, there was a question as to whether the meperidine (Demerol), known to cause fatal interactions with the MAO inhibitor phenelzine (Nardil), Libby Zion's antidepressant, had produced the high fever. Second, Sidney Zion questioned the use of restraints and shots for an increasingly agitated patient. To the distress of his daughter's doctors, Zion began to refer to her death as a "murder."

Zion's anger was exacerbated by what he learned about the hospital's staffing on the night Libby died. "You don't need kindergarten," he wrote in a New York Times op-ed piece, "to know that a resident working a 36-hour shift is in no condition to make any kind of judgment call – forget about

life-and-death." As a columnist for the New York Daily News and a friend and confidante of many journalists and power brokers in the city, Zion vented his outrage about the state of medical education widely and loudly. Over time, the image of the bedraggled, unsupervised intern wreaking damage in hospitals would be featured in the pages of The Washington Post, the New York Times and Newsweek. One overtired intern, interviewed on TV's "60 Minutes," obligingly forgot one of Mike Wallace's questions.



The book begins as a narrative of the weekend of Libby Zion's death and then weaves its way through her background before returning to the complex legal entanglements faced by her physicians and the New York Medical Center. It provides a sobering perspective for all who practice or are cared for in U.S. teaching hospitals.

In May 1986 Manhattan District Attorney Robert Morgenthau agreed to let a grand jury consider murder charges. Although it declined to indict, the jury issued a report strongly criticizing "the supervision of interns and junior residents at a hospital in New York County." In response, New York State Health Commissioner David Axelrod established a blue-ribbon panel of experts headed by Bertrand M. Bell, an outspoken primary care physician at the Albert Einstein College of Medicine in the Bronx, to evaluate the training and supervision of doctors in the state. Bell had long criticized the lack of supervision of physicians-in-training. In 1989, New York state adopted the Bell Commission's recommendations that residents could not work more than 80 hours a week or more than 24 consecutive hours.

Still, some physicians resisted work hour reform efforts, and they argued one simply could not become a qualified doctor without experiencing firsthand what happened during the often unpredictable first 36 hours of a patient's illness. Until 2003. In that year, the ACGME made reduced work hours mandatory for the accreditation of residency training programs across the country. The new ACGME standards look remarkably similar to those of the Bell Commission. As might be expected, the new requirements are a work in progress. A study published in the Sept. 6, 2006, issue of the Journal of the American Medical Association found that 80 percent of interns nationwide still sometimes work excessive hours.

Historians these days tend to distrust the idea that the actions of specific people truly cause large-scale change. Rather, many argue, change more commonly results from a complex interplay of cultural and political factors. In the case of Libby Zion, however, it is possible to trace a straight line from her death to Sidney Zion's campaign to the Bell Commission to the ACGME regulations. To be sure, it took the social changes of the 1960s and 1970s to make graduate medical education susceptible to reform from the outside. But Sidney Zion sped things up considerably, ensuring that Libby had not died in vain.

In the winter of 1994, *Zion v. New York Hospital* finally went to trial. Court TV avidly covered the proceedings, which were full of vitriol on both sides. In presenting its case, the hospital introduced a claim, unsupported by toxicology testing and vigorously disputed by the plaintiffs, that Libby Zion had died as a result of cocaine ingestion that she had concealed from her doctors. The jury hedged, attributing responsibility to both the doctors and the patient. Throughout his crusade, Sidney Zion's anger was paramount. Indeed, it is quite possible that without this rage, he might not have accomplished what he did. Zion was "aggressive, narcissistic, self-indulgent, pushy, persistent and paranoid," psychiatrist Willard Gaylin memorably wrote in the Nation, "but that is precisely the stuff successful reformers are made of." (http://www.washingtonpost.com/wp-dyn/content/article/2006/11/24/AR2006112400985_pf.html)

Section 4: Fire Fighters, EMS Responders and Sleep Deprivation

4.1 Introduction and Descriptions of Work Settings

In the past few decades, the U.S. has become increasingly dependent upon shift workers to meet the economic demands of globalization and our 24 hour society. From a productivity standpoint, shift work is an effective means to increase efficiency and customer service without major increases in infrastructure, and it is a necessity when providing 24/7 emergency medical services. However, because it deviates from our biologically preferred daily rhythm and sleep schedule, it also has inherent potential risks (as described in Section 1).

The term fire fighter includes career, volunteer and wildland fire fighters. According to the National Volunteer Fire Council, approximately 73 percent of the 1.1 million U.S. fire fighters are volunteers (National Volunteer Fire Council, 2006). Issues concerning work hours and fatigue-related health effects are presented as they relate to both career and volunteer fire fighters. Among fire fighters, job specifics vary. For example, fire fighters include individuals assigned to engines, trucks and special response units; those with paramedic training; and officers and employees assigned to the Fire Inspector office, training division and other specialized units. Superimposed on the variability in job descriptions are the unique characteristics of different fire departments/bureaus/districts and stations within those organizations.

Wildland fire fighters' job structures differ from other fire fighters, in that they usually are deployed to sites for two weeks of intense work. The effects of their long work hours relate to physical exhaustion, in addition to sleep loss. Those issues are discussed on page 54.

We and others have documented that fire fighters are a high-risk group, with an increased prevalence of obesity, hypertension, high cholesterol levels, certain malignancies and chronic musculoskeletal complaints (Elliot et al., 2004 & 2007; Aronson, Tomlinson & Smith, 1994; Guidotti, 1995, Reichelt & Conrad, 1995; Gledhill & Jamnik, 1992). Fire fighters' cardiovascular risks, combined with episodic intense physical exertion involving extreme heat and life-threatening situations, may account for heart attacks causing half of on-the-job deaths (Kales et al., 2003 & 2007), compared to approximately 10 percent for EMS personnel (Maguire, 2002).

Much less data are available on work-related morbidity and mortality for other groups of first responders. Among all occupations, the highest risk of cardiovascular disease is with law enforcement officers (Calvert, Merling & Burnett, 1999), whose life expectancies are 15 years less than the average American's. They have a higher prevalence of cardiovascular risks, heart disease and certain malignancies (Franke, Collins & Shelley, 2002; Richmond et al., 1998).

EMS responders can include paramedics, other emergency medical technicians (EMTs), and those involved in medical air transport. Fire fighters can be full time career employees, volunteers or wildland fire fighters. Many fire fighters also have EMS training. In this Section, each of those categories is discussed as it relates to sleep deprivation.

Management strategies have been developed to minimize the adverse health consequences of the sleep loss and circadian disruption of shift work and extended work hours. Those are presented in Section 5.

EMS responders include a range of job descriptions. In general, they are employed for pre-hospital care by private companies, public municipalities and hospitals. Paramedics have the highest level of training and are able to perform more duties than EMT-First Responders, EMT-Basics and EMT-Intermediates. Because many fire departments answer medical calls, fire fighters often are cross-trained in EMS skills. Other EMS responders work within clinic systems, hospitals or other administrative structures. The National Association of Emergency Medical Technicians estimates that there are approximately 142,000 paramedics and 600,000 EMTs in the U.S. The category of EMS responder also includes those involved in air medical transport.



When assessing the effects of long work hours, many other variables must be considered. Specifics of the job description, work structure and its context and characteristics of the individual employee all may affect outcomes. Accordingly, those issues must be taken into account when generalizing study findings and applying any conclusions to other settings. As a result, in presenting information, we have tried to provide specifics concerning the study group and methodology when describing information.

4.2 Fire Fighter and EMS Responders' Unique Shift Structures

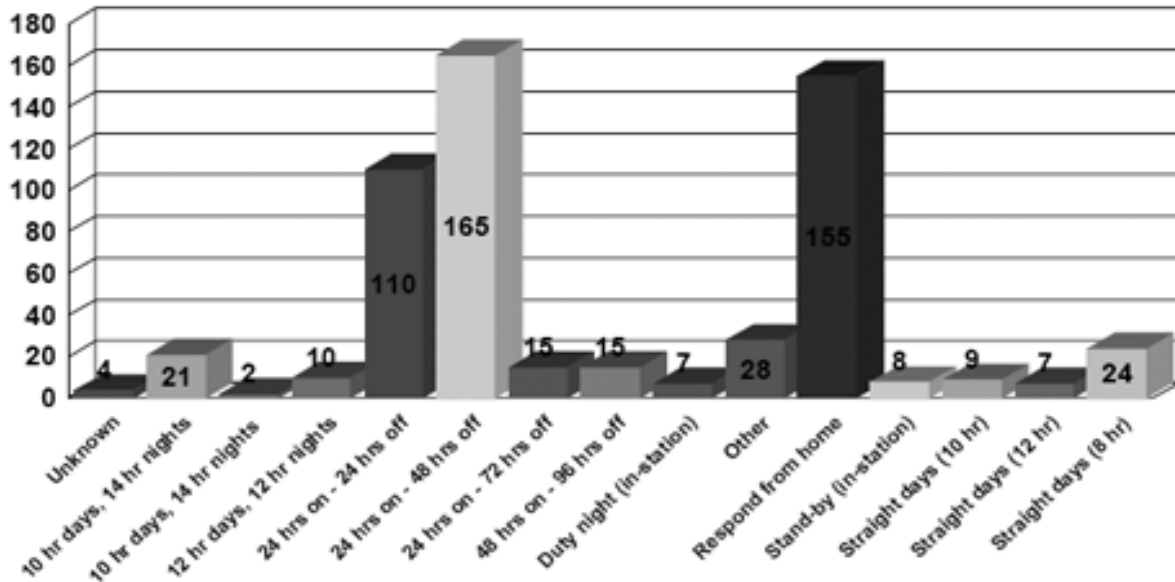
In any fire department, the shift schedules are based on local needs and preferences. The National Fire Fighter Near-Miss Reporting System is a voluntary, non-punitive means to capture and learn from incidents and near-incidents, and its 2006 summary report provides a convenience sample of the many different shift structures of fire fighters (Figure 4.1) (<http://www.firefighternearmiss.com>). Among reports submitted to the Near-Miss Reporting System, 12 percent indicated that their department had 2 shifts (days and nights) of 10 to 14 hours length. The majority of reports were from departments using three platoons or shifts deployed in rotations. Thirty percent reported 24-on/48-off formats, and 23 percent indicated alternative 24 hour rotations. The latter usually is an on-off-on-off-on then 4 off schedule (depending on nuances, called 3/4, modified Detroit or modified Berkeley). More than 19 variations on those basic three platoon rotation patterns are in use. Most departments have a Kelly or off day every 8th shift to reduce the number of hours worked from becoming overtime. Some departments maintain a fourth smaller platoon to staff Kelly days and leaves. The result is a work week that for most fire fighters averages 48 to 56 hours, not counting overtime.

In the last few years, a 48 hours on and 96 hours off schedule has become more popular. In the Near-Miss reports, 3 percent of departments listed the newer 48-on/96-off schedule. The format originated in Southern California, because fire fighters were unable to afford local housing and faced long commutes, which were reduced in half with that schedule. Because it represents a new work format, descriptive information is available from departments adopting that schedule, which is summarized in Section 4.3.

EMS responders' shift structures vary even more widely than fire fighters, because they often work for agencies smaller than fire departments. Shift duration, even within one worksite, includes lengths of 8, 10, 12, 14, 16 and 24 hours. In general,



Figure 4.1. Distribution of Work Schedules in 2006 Near-Miss Accident Reports*



*The Near-Miss Reporting System is a convenience sample and may under represent volunteer fire fighters. Only approximately one-third of reports are from volunteer departments, when nationwide volunteer departments represent 71 percent of fire departments.

the total hours worked per week averages approximately 54 hours but often reaches higher totals. For example, a staffing pattern might be 12 hour shifts, with a maximum of three in a row, with a guarantee of 48 hours per week and an attempt to provide employees 60 hours each week. Within organizations, efforts are made to distribute the workload, so that shifts at busy locations are 12 hours, with longer shifts reserved for those with fewer calls, where the EMS responders are likely to get 4 to 6 hours of sleep during a night. The staffing patterns are complex, and web-services are available to aid in meeting those demands, such as <http://www.emsmanager.net>.

Medical air transport personnel also work long shifts. Among those workers, because of helicopters and fixed-wing craft pilot regulations, which limit work hours, staffing patterns for pilots and medical personnel differ; pilots generally work 10 to 14 hour shifts, while the medical teams are approximately equally divided as working either 10 to 12 hour shifts or 24 hour schedules. There is scheduling diversity among air medical transport work sites, depending on work load, whether privately operated or hospital-based and other factors (Frakes & Kelly, 2004).

4.3 Anecdotal Effects of Work Hours

Internet sites, such as FireEngineering.com and firehouse.com, contain discussion forums that occasionally involve schedules, sleep and fatigue issues contributed by fire fighters and other EMS responders. In general, fire fighters have an established tradition of working 24 hour shifts, and few complaints are registered about that pattern. Those who question the wisdom of that scheduling format, on the grounds of either safety or economics (Philpot, 2005), have received harsh criticism from fire fighters submitting comments (Firehouse Forum, 2003).

The National Fire Fighter Near-Miss Reporting system (National Fire Fighter Near-miss Reporting System, 2007), described in the previous section, allows searching of their database for particular types or categories of incidents. One of the available search terms is 'fatigue.' When the 35 reports identified with that term were reviewed, only 18 appeared potentially related to sleep deprivation or a particular long work structure, and with closer inspection, only seven of more than 1000 total reports appeared relevant. Pertinent issues included responding to events when on duty for more than 15 hours, driving home from busy 24 hour shifts and fatigue when awoken for early morning calls. The near-miss records have a place for incident time, but summary reports indicate that for most submissions, that information is not included, and specifics concerning the relationship between time of day and near-misses is not available.

Among paramedics, a tragic fatigue-related death was highly publicized. That crash involving post-shift fatigue and the public concern that followed resulted in a policy change in one EMS organization. Brian Gould, a 42-year-old paramedic, died when driving home from an overnight shift when his car crossed lanes and struck a semi head-on. Drugs, alcohol and weather were not factors. Because of the incident, the ambulance service, which previously had moved from 24 to 12 hour shifts due to paramedic fatigue issues, instituted a policy that if a crew gets less than four hours of uninterrupted sleep during a 24 hour shift, colleagues were to take them and their vehicles home after work (Erich, 2007). A similar incident, when a San Francisco Fire Department paramedic died when she fell asleep while driving home after a long, busy shift, was one of the factors leading to that department's replacing 24 hour ambulances with 10 hour crews, as the call volume had become too exhausting to function with the longer work hours (Garza, 2007).

With restructuring from 24 hour shifts to 48-on/96-off formats, departments have done assessments of that change, and findings have been posted to the internet to assist other departments considering making similar changes. In general, fire fighters, their union, management and budgetary officials have collaborated on designing the new format, with all agreeing on a specific trial plan. Follow up reports, 6 to 12 months after the change, generally have indicated parties' satisfaction with the extended 48 hour schedule, and most report a decrease in sick leave (www.sjff.org/items/L230_48-96.ZIP). Whether reduced sick leave indicates improved health is unclear, as sick-time is known to be influenced by 'not-illness' factors, such as employee morale and seasonal variables.

West Metro Fire Protection District in suburban Denver did a thoughtful review of outcomes after switching to the 48-on/96-off schedule, including a consultant's report, work-related findings and focus group information (www.westmetrofire.org/docs/2006/ops/west%20metro4896final.doc). The department has 15 stations and 310 uniformed personnel. Calls per station varied from approximately 3500 calls (busiest) to 300 calls (least busy) per year.

They found that the fire fighters slept more while on shift with the 48 hour format. Prior to the change, fire fighters reported getting 5.6 hours of sleep per night, compared to 6.4 hours after the change. When not at work, hours slept also increased after the change; individuals reported an average of 7.1 and 7.4 hours sleep per night (before and after, respectively). The average number of times awakened at the station was 1.9 before and 1.6 after instituting the longer shifts. Making the change did not appear to adversely impact citizen complaints, damage reports, turnout times, injuries or overall vehicle accidents. However, when the first

Additional information from fire fighter fatality, wildfire incidents, ambulance crashes and EMS incident/death reporting systems is included in those specific sections.

and second day of the 48 hours were compared, during day two, there was a significant increase in injuries and a trend toward increased EMS-related complaints (3 vs. 8 and 16 vs. 26, respectively). Sick leave decreased with the longer format, which also was reflected in decreased need for overtime.

The majority of fire fighters and their families liked the 48-on/96-off schedule. Fire fighters felt that it interfered significantly less with family, leisure and social activities. And although fire fighters reported that their spouses were less supportive of the 48 hour schedule, when families directly were asked, they reported general satisfaction with the longer format. Findings from an internet survey of citizen feedback were positive concerning the fire department performance both before and after the change. Importantly, the percentage of fire fighters supporting the change went from 64 percent before the switch to 86 percent after the 6 month trial interval.

Commuting home following a prolonged shift may be a vulnerable time, with an increased risk of motor vehicle crashes (see page 29). No departments have reported systematic information relating to fatigue on commutes home following the extended hours of either the 24 or 48 hour shift format.

4.4 Work Hours and Fire Fighters

The general effects of long work hours are reviewed in Section 1. For fire fighters, longer work hours have been related specifically to stress and injury rate. The concept of 'stress' is complex, and current worksite models consider stress affected by several factors in addition to work hours, such as the job context and organization, relationships among workers and management and features of the work itself (Salazar & Beaton, 2000). Among fire fighters, work stress is compounded by critical incidents and life threatening events, and in general, those latter issues are reported as the greatest sources of fire fighter stress (Beaton et al., 1999).

Disrupted sleep patterns are a recognized source of occupational stress, and fire fighters are not immune from those adverse consequences. A survey of more than 700 fire fighters assessed job stressors and found that sleep disturbances (disruption, poor quality of sleep, not enough) were ranked as an important cause of stress by approximately one-third of fire fighters (Murphy et al., 1994). The participants were professional fire fighters from the Pacific Northwest who responded to an anonymous mailed survey that used a standard instrument indexing occupational stress. Most were male, and on average, they had been fire fighters for 12 years. Other studies also have noted fire fighters' work structure as a source of stress (Murphy et al., 2002; Murphy et al., 1999; Oginska-Bulik, 2005).



Fire fighters and EMS responders may be called upon to work long hours with disasters or other unforeseen occurrences. For example, the headlines in the September 2, 2005 Times-Picayune read, "Katrina Doesn't Stop Fire Fighters from Working Around the Clock," and the article reported that "men and women of the fire service along the Gulf Coast have truly put themselves on the frontline to protect their communities by working endless shifts, throughout the day and night, before, during and now after this horrendous storm."

Extended work hours refers to shifts longer than the typical eight hours. Additional information about the advantages and disadvantages of long work hours is found in Section 5.

One study used a biological marker for increased stress of fire fighters. Serum cortisol is a hormone produced by the adrenal gland, and its level increases in response to stress (Munck, 1984). Elevated levels have been associated with feelings of depression, impaired memory and suppression of immunity (Plotsky, Owens & Nemeroff, 1998; Lupien et al., 1997). When Welch fire fighters' morning cortisol levels were assessed, those younger than age 45 had significantly higher cortisol levels compared to normal individuals. The fire fighters' specific work schedules were not reported. The researchers termed the finding the "neuro-endocrinological price paid for fire fighting work." Older fire fighters did not have elevated cortisol levels, and it was not clear whether that represented selection or adaptation to fire fighting work (Brody et al., 2006).

Although they disrupt sleep and increase fatigue, calls during the night appeared to have a positive effect on fire fighters' mood (Paley & Tepas, 1994).

The effects of night work among fire fighters appear comparable to others working nights. Bos and colleagues (2004) compared Dutch fire fighters working a 24-on/48-off schedule to Dutch industrial shift workers, and they found that the fire fighters' self reported sleep disturbances and recovery needs were not increased above the industrial night shift workers.

For fire fighters, the night work varies and is unpredictable, in that they may be answering calls, performing other duties or sleeping. That format differs from typical shift workers with fixed job routines. Among stations, the number and type of calls varies widely. Intuitively, greater station call volume might be anticipated to relate to higher stress levels. Paradoxically, rather than sustained higher call volumes causing stress, some have found that alarms after periods of inactivity are more stressful (James & Wright, 1991; Beaton & Murphy, 1993).

The effects of fire fighting on the spouse and family are becoming better recognized (Pfefferbaum et al., 2002; Menendez, Molley & Magaldi, 2006). For fire fighters, family impact usually relates to critical incidents, and only a single study has reported the effect of shift work (Regehr et al., 2005). Wives of Toronto fire fighters reported that while they valued their husbands' traits that led their spouses to be fire fighters, shift work was a stressor. The long work hours contributed to disruptions in family routine, and wives often noted feelings of loneliness and being a single parent.

The wives reported missing their husbands due to physical absences of work and fire fighter camaraderie to the exclusion of families, with the perception that home needs came second. This study also mentioned that most of the fire fighters had second jobs during their time off from the fire station. The potential impact of second jobs has not been examined in other studies. A study limitation was that it involved a relatively small number of participants from a single site, and researchers did not quantify established dimensions of family life, such as intimacy, conflict and parenting styles (Shakespeare-Finch, Smith & Obst, 2002).

Outside employment or a second job is an acknowledged occurrence among fire fighters and other workers. The overall prevalence of second jobs in the U.S. is uncertain, because of the difficulty in defining jobs as they relate to household duties, care-giving in the home and personal entrepreneur activities. However, estimates by the Families and Work Institute are that more than 15 percent of workers have two paychecks.

Measures of fire fighter alertness during their work hours parallel those found in other studies: alertness falls after 10 to 12 hours of work and during nighttime hours. Dormrachev, Savchenkov and Mikhailova (2004) studied 120 Russian fire fighters working a 24 hour work, 72 hour

rest schedule. They used self reported fatigue and also measured retinal sensitivity as an objective index of alertness. Both self reported energy level and retinal electrical sensitivity threshold indicated progressive fatigue after 12 hours on duty.

Knauth (1995) conducted a study of 29 U.K. fire fighters to assess the effect of a 24 hour workday on performance, mood, sleep and circadian rhythm. As expected, during the night, fire fighters' body temperature and alertness decreased, while reaction time increased. The authors proposed a two hour nap during each night due to the documented decrements in alertness.

Fire fighters' night work is episodic and unpredictable. More night calls and the associated fragmented sleep increase overall fire fighter fatigue. In a small study of 11 fire fighters in Japan, timing of calls and their impact were assessed. Investigators found that fire fighters disturbed from 01:00 to 05:00 had the greatest reduction in sleep quality, felt more fatigue and experienced the greatest change in their measured reaction time (Takeyama et al., 2005). The authors concluded that a night shift schedule ensuring undisturbed naps would be beneficial in reducing fire fighter fatigue.

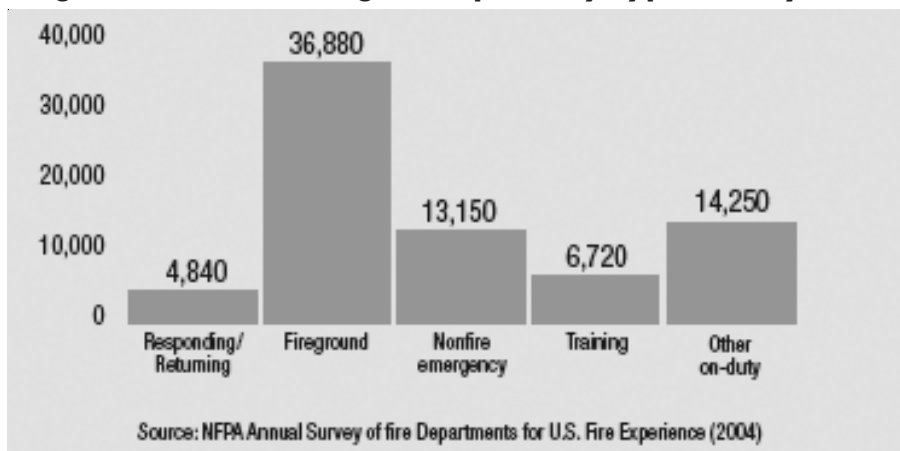
In other settings, long work hours and night shift work increase the rates of occupational accidents (see Section 1). Figure 4.2 shows the National Fire Protection



Association (NFPA) 2004 data concerning injuries by duty type among fire fighters. The majority of injuries occur on firegrounds. In 2003, the NFPA analyzed those fireground injuries using findings from the United States Fire Administration's National Fire Data Center's National Fire Incident Reporting System (NFIRS) to examine factors relating to possible causes of fireground accidents, including nature of injury, fire fighter age and importantly, time of day.

The peak period for structure fires attended by fire departments was noon to midnight (62.6%), and the fewest occurred in the early morning hours of midnight to 6:00 AM (16.4%) (Figure 4.3). As expected, the majority of fireground injuries occurred during the peak fire hours of noon to midnight. However, an unexpected finding was that a disproportionate increase in injuries happened during the midnight to 6:00 AM interval (25.7% injuries for 16.4% fires, Figure 4.3). This point is made more apparent when fireground injuries per 100 structure fires are examined (Figure 4.4).

Figure 4.2. U.S. Fire Fighter Injuries by Type of Duty 2004

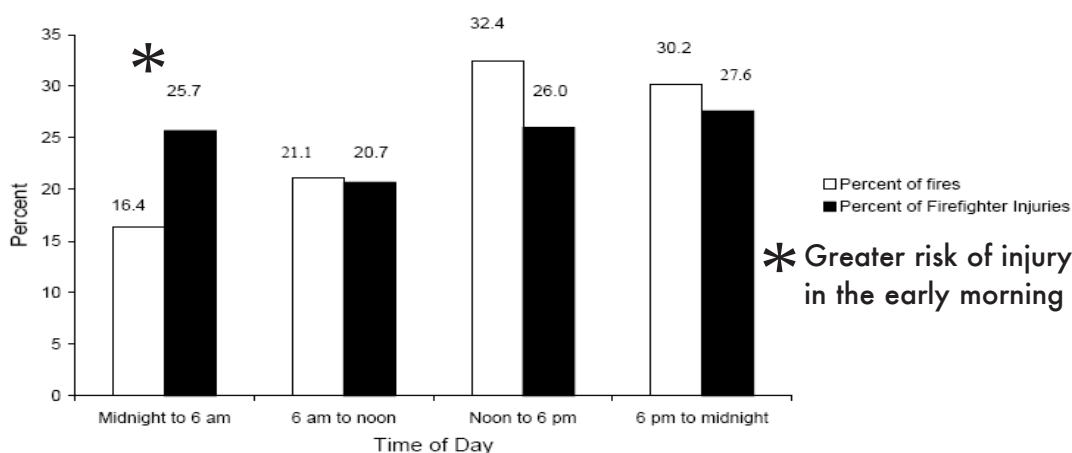


The highest injury rates per 100 fires occurred in the midnight to 6:00 AM times, when about 3.9 injuries occurred per 100 structure fires attended. The report author speculated that finding a higher injury rate during the nighttime hours could relate to lack of visibility, cold temperatures and lower alertness of fire fighters.

Any increase in accidents with extended work hours might relate to decreased alertness, and it also might be due to physical fatigue. To investigate the latter possibility, Sobeih and colleagues (2006) studied the effects of working long shifts and wearing turnout gear, including self-contained breathing apparatus, on fire fighters' postural stability. They measured strength, balance, and postural stability with a force plate system at the beginning of the shift and repeatedly over 12 hours among 16 healthy Cincinnati fire fighters. For each assessment, fire fighters changed into their gear and were assessed performing different activities, in their uniforms and when wearing personal protective equipment.

Perhaps because of the anchoring effect of their gear, researchers found that postural sway (an indicator of muscle fatigue and/or weakness) decreased when fire fighters wore their personal protective equipment. They reported a trend for decreased postural stability over the 12 hour work shift. One fire fighter was measured over a 48 hour shift, and he showed even greater loss of stability near the end of that shift. Approximately 20 percent of moderate and 10 percent of severe

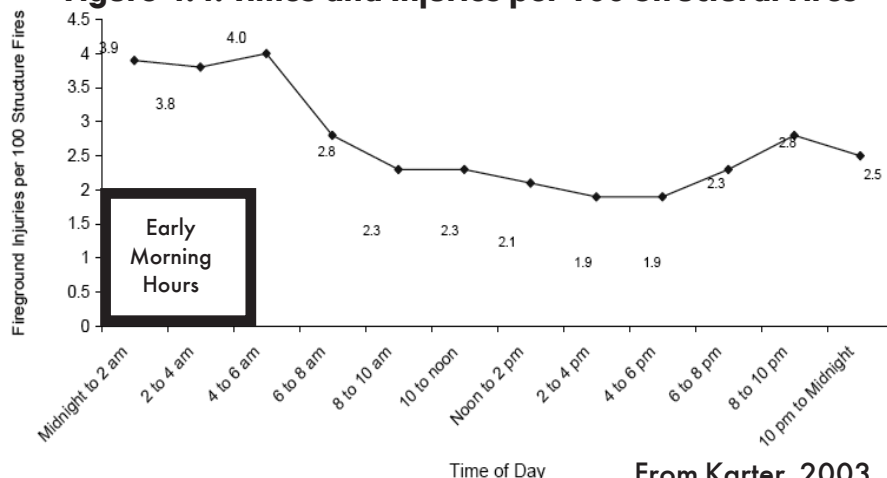
Figure 4.3. Comparison Times of Injuries and Times of Fires



Source: 1994-98 NFIRS

From Karter, 2003.

Figure 4.4. Times and Injuries per 100 Structural Fires



Source: 1994-98 NFIRS

From Karter, 2003.

Rates of injuries from midnight to 6 AM more than doubled those of mid-afternoon.

fire fighter injuries are due to slips (Karter, 2003). The authors felt that their findings indicated that prolonged shifts may contribute to the high prevalence of slips and falls among fire fighters. They also noted that their study was at risk for the “healthy worker effect,” which tends to minimize findings as volunteer subjects often are least likely to be affected by the test conditions.

4.5 Work Hours and Volunteer Fire Fighters

According to the National Volunteer Fire Council (NVFC) approximately 800,000 U.S. fire fighters are volunteers (National Volunteer Fire Council, 2006). Volunteers must meet physical ability requirements, undergo reference/background checks and complete training requirements. Volunteers primarily serve communities with fewer than 25,000 inhabitants, and others work as part of a combination system, where career fire fighters provide the majority of emergency services (NFPA, www.nfpa.org/index.asp?cookie%5Ftest=1). The term volunteer also may be used in reference to part-time or on-call fire fighters who may have other occupations. Although they volunteer to respond, they are compensated as employees when working. Volunteer fire fighters are supported by national organizations, and many resources are available, such as the National Volunteer Fire Council’s Retention and Recruitment Guide for the Volunteer Emergency Services: Challenges and Solutions (2005).



Data from the Firefighter Fatality Investigation and Prevention Program compares fatalities among volunteer and career fire fighters (Centers for Disease Control and Prevention, 2006). Fifty-three percent (610 of 1,141) of U.S. fire fighters who died while on duty during 1994-2004 were volunteers, and 32 percent were career fire fighters. The remaining 15 percent were among other fire fighters (e.g., wildland, paid on call, and part-time fire fighters). Although the overall death rates were roughly comparable among career and volunteer fire fighters, their causes of death differed. For both career and volunteer fire fighters, cardiac events were the leading cause of death (i.e., deaths from myocardial infarction or arrhythmias). However, for volunteers, motor vehicle crashes were the second leading cause of death.

In general, volunteers live within a specified distance of the fire department, and they often use their personal vehicles to respond to a fire alarm. The majority of volunteer fire fighter crashes were on route to a call. The reporting system is limited by only tabulating fatalities; other non-fatal crashes are not indexed. Review of motor vehicle-related fatalities, based on available information concerning circumstances and time of day, revealed only one (in 1999) that appeared clearly fatigue-related. That incident occurred early in the morning (0655), when a volunteer on route to a fire may have been driving immediately after awakening (FACE Investigative Report #99F-44, Fire Fighter Fatality Investigation and Prevention Program, 2007).

As mentioned, family stress from extended work shifts can be significant, and that factor may be even greater given the unpredictability of volunteer fire fighters’ schedule. As a result, the NVFC has proposed means to involve families in the activity of its volunteer members, such as creating a family auxiliary open to all, inviting family members to help out around the station and with public education and by holding social functions (NVFC Retention and Recruitment Guide, 2005).

Since the late 1990s, all fire fighter fatalities have been investigated, compiled and analyzed in the Firefighter Fatality Investigation and Prevention Program (<http://www.cdc.gov/niosh/fire/>). This has provided an important source of information concerning health hazards (Centers for Disease Control and Prevention, 2006). While reporting of on duty deaths is complete, the system does not capture nonfatal events. Importantly there is no data on crashes that occur during the commute home following a shift, which may be a vulnerable time for fatigued employees.

4.6 Work Hours and Wildland Fire Fighters

Wildland fire fighters generally are employed by the Forest Service and the Department of the Interior to control, extinguish, manage and prevent wildland fires. Most wildland fire fighters work on a seasonal basis. They stay at a base camp during off-duty hours and work at the fire sites for shifts that extend beyond the typical eight hours and involve physical demands well above those of even the most vigorous of other occupations. Because different organizations employ wildland fire fighters, the National Wildfire Coordinating Group (NWCG) (2004) helps coordinate programs and provide more effective execution of each agency's fire management program.



The NWCG recommends 14 day duty assignments, excluding travel, and during those times, a work to rest ratio of 2:1, (that is, for every 2 hours of work or travel, provide 1 hour of sleep and/or rest). Generally, crews are deployed as two shifts, working 10 to 12 hours per shift. Work shifts that exceed 16 hours and/or consecutive days that do not meet the 2:1 work/rest ratio should be the exception, and no work shift should exceed 24 hours. After completion of a 14 day assignment and return to the home unit, two mandatory days off should be provided. In additions, no driver may drive more than 10 hours during any duty day.

Crew leaders must allow appropriate rest for their crew and monitor members for signs of fatigue. The crew leaders especially must get enough rest, as long shifts and lack of sleep impair cognitive function more quickly than physical abilities, and they are responsible for organizing the work to minimize crew member fatigue, such as changing assignments to help maintain interest.

Wildland fire fighting is extremely physically demanding. Studies of energy expenditure during this arduous work indicate that daily energy expenditure approximates that of running a marathon and is more than twice that of recreationally active college students (Heil, 2002; Ruby et al., 2003). Because of that physical drain, along with long hours and lack of sleep, researchers have looked for physiological manifestations of work stress, such as depressed immune function. For example, investigators studied wildfire crews by obtaining saliva samples just prior to and immediately after shifts of different lengths, and they found that after working 12 hours, there was a fall in immunoglobulins (disease fighting antibody levels). When fire fighters worked longer than 12 hours, the immune response did not recover by the following day and remained depressed for five additional work days. Based on their findings, the researchers noted the importance of being well rested prior to deployment, obtaining seven to eight hours of sleep each night and using short (less than 20 minutes) or long (more than 90 minute) naps when possible (Childress, 2004).

Wildland fire fighters have the Wildland Fire Safety & Health Reporting Network, SAFENET, which is a method for reporting and resolving safety concerns encountered in wildland fires. Reviewing the last three years of reported events (2003 to 2006), communication issues were the leading category contributing to reported incidents. Of 494 incidents (2003 to 2006), 38 appeared related to human perceptual errors, including fatigue (Bailey, 2007). Fatigue was a clear contributor in six of the serious accidents, three of which resulted in rollover vehicle crashes. Fatigue when driving can lead to poor judgement, inattention, vehicle wandering and falling asleep at the wheel. Wildland fire fighters often travel to and from worksites in 15 passenger vans, which when loaded with occupants become top heavy and prone to rollovers.

The most notable fatigue-related incident was when eight crew members were killed in a traffic accident after spending the previous 11 days fighting a forest fire. The crew had been demobilized the previous evening. Weather was sunny and dry, and the crew had been on the road about three hours when the crew driver attempted to pass a semitrailer on a downhill left-hand curve, in a marked no-passing zone. The van struck an oncoming semitrailer head on. This particular patch of road is known for frequent accidents. Alcohol may have played a role in the incident (<http://www.ohsu.edu/croet/face/incidents.cfm>).



SAFENET (<http://safenet.nifc.gov/>) was developed on the recommendations of the Wildland Firefighter Safety Awareness Study. SAFENET is a component of the National Interagency Fire Center and reports can be submitted anonymously by anyone, although it is recommended that the first line supervisor complete the SAFENET form. It is a tool and format to identify and remedy safety concerns of wildland fire fighters.

4.7 Work Hours and EMS Responders

As mentioned, EMS responders' work a wide variety of types of jobs with different work structures. As demands for emergency medical services have accelerated, increases in work load and employee dissatisfaction have resulted in changes in shift structure. Those occurrences have allowed prospective assessment of different work formats. At one site, EMS personnel changed from 24 to 12 hour shifts, using a rotation with 3 days of 12 hour shifts, 2 days off, 2 days of 12 hour shifts, 3 days off. With the 12 hour schedule, both at 2 months and at 1 year, employees perceived that they were more productive and felt better, with less family and social disruption from their work. Interestingly, an index of emotional exhaustion decreased immediately after the change, and although other indices remained improved with the reduction in shift duration, the emotional exhaustion dimension returned to baseline after one year (Boudraux et al., 1997).

The city of Austin changed EMS staffing to distribute shorter shifts to the busiest sites. They reported their staff survey findings that led to the change. Prior to the change when 24 hour staffing still was in effect, most paramedics felt the demands for overtime were excessive, and one-third reported working more than 24 hours without sleep in a single week. The majority felt that 24 hour shifts resulted in a decrement in their abilities, and most (72%) reported that 12 hours was the maximum time that it was safe to take calls at the busiest stations (<http://www.austinchronicle.com/gyrobase/Issue/story?oid=oid%3A388475>).

The relationship between sleep deprivation and decreased performance is well established (Jewett, 1997). Being awake for 18 hours produces impairment equal to a blood alcohol concentration (BAC) of 0.05 (Dawson 1997; Falletti 2003). A recent analysis of U.S. workers involving more than 110,000 job records over 12 years, controlled for age and occupation, revealed an almost linear increase in injuries with the number of hours worker per day (or per week) (Dembe et al., 2005). Working 12 hours per day was associated with a 37 percent increased hazard rate, and 60 hours per week increased injuries 23 percent.

Fatigue-related ambulance crashes may be a means to identify effects of long work hours among EMS responders. Although no complete national count of ground ambulance crashes exists, the number can be approached using the National Highway Traffic Safety Administration Fatality Analysis Reporting System. Over a ten year period (1991 to 2002), the factor most related to EMS crash fatalities was not wearing a restraint, and most crashes occurred during emergency runs when arousal and vigilance would be anticipated to be high (CDC, 2003). Thus, with those data, unlike vehicle crashes in general, fatigue did not appear to be a major factor in crashes.

Obtaining work-related injury information on paramedics/EMTs is problematic. The Census of Fatal Occupational Injuries is the repository for information on fatal work-related injuries. However, that database does not have a specific listing for EMS personnel. There is a website memorializing EMS personnel (National EMS Memorial Service at www.nemsms.org/honorees/) who have died in the line of duty, but that record is not complete. Review of entries from the last two years revealed 34 deaths, with the majority (21) relating to helicopter and plane crashes. Of the 17 surface vehicle crashes, 5 related to commuting to or from work, but details relating to time of day and fatigue were not reported. A death not listed in that site, which appear related to fatigue and resulted in a policy change, is presented on page 48.

The pre-hospital EMS continuum includes the emergency room. Discussions of emergency room staffing patterns generally compare 8 versus 12 hour work lengths, as busy shifts longer than 12 hours are associated with unacceptable fatigue and recognized decrements in performance (Joffe, 2006). The 12 hour threshold for declining performance of critical tasks has been confirmed in other studies of medical personnel (see Section 3). Twelve consecutive hours also is the maximum duration that the Institute of Medicine recommends nurses work during a 24 hour period (Scott et al., 2006).

Medical air transport teams include a pilot(s) and EMS personnel. Flight regulations require 12 hour shifts for pilots, and both 12 and 24 hour shifts are common staffing patterns for non-pilots in the air medical community. During certain times, pilots may be called into longer service. German medical transport helicopter pilots' physiological profiles were studied during prolonged shifts, necessitated by longer summer daylight hours and more motor vehicle crashes with victims needing air transport. Findings indicated that pilots working longer hours accumulated significant fatigue, and the results led to an enforced eight hour uninterrupted sleep opportunity each day (Samel, Vejvoda & Maass, 2004).



Anonymous surveys (Frakes & Kelly, 2004, 2005 & 2007) and small studies have assessed the impact of different work schedules for EMS flight nurses. Surveys of flight EMS personnel indicated that as anticipated, crew members reported significant sleep debts. Interestingly, the investigators found that 80 percent of 24 hour and 50 percent of 12 hour non-pilot crew members had outside employment (Frakes & Kelly, 2005 & 2007), and of concern, more than half reported having arrived to work within eight hours of leaving their other job. Employers differed on whether they allowed sleeping at work. Some did not allow naps, because they felt it might encourage arriving at work fatigued. However, pre-shift sleep did not vary with that variable. In a small study of 10 EMS flight nurses, 12 and 18 hour shifts were compared. The investigators could find no decrement in performance with the longer work hours in that short term study, and 18 hour shifts were preferred by the nurses due to lifestyle issues (Thomas et al., 2006).

4.8 Summary of Studies of Work Hours, Fire Fighters and EMS Responders

The reports concerning long work hours and fire fighters and EMS responders presented in this Section are summarized in Table 4.1 (next page). As stated in this Section's outset, there is a paucity of available well done studies, and many of investigations have been done in countries other than the U.S. Despite those limitations, certain potential implications are apparent.

- Fire fighters have documented increases in their risks for cardiac disease and malignancies, which are also illnesses that may be promoted by the chronic sleep deprivation associated with long work hours.
- Fire fighters and EMS responders are at risk for the decrements in mental and physical performance that have been well documented among others working long hours and during the night.
- Fatigue among fire fighters may relate to the disproportionately higher fireground injury rates observed for the early morning hours.
- Fatigue when driving may increase the risk of crashes when driving following long work hours. Long commutes following work may be a particular hazard.

Table 4.1. Summary of Study Findings about Work Hours, Fire Fighters and EMS Responders

Source	EMS Responder Group	Outcomes
anecdotal reports from websites and the near-miss reporting systems	fire fighters	only a complaints about long work hours; only 7 of more than 1000 near-miss reports were identified as fatigue-related
anecdotal	fire fighter, paramedic	2 reported deaths commuting home due to fatigue
San Jose and West Metro, Denver switch to 48/96 schedule	fire fighters	change reported satisfactory for fire fighters and their family and both supported the change; no identified adverse effects; crashes commuting not reported
Murphy et al., 1994	fire fighter survey	sleep disturbances were among causes of stress for NW career fire fighters
Brody et al., 2006	Welch fire fighters	elevated cortisol (stress hormone) levels among fire fighters
Bos et al., 2004	Dutch fire fighters	sleep disturbance among fire fighters were comparable to those of other night shift workers
Dormrachev et al., 2004	Russian fire fighters	alertness levels fell over a 12 hour shift
Knauth, 1995	U.K. fire fighters	alertness levels were lower at night
Takeyama et al., 2005	Japanese fire fighters	calls in the middle of the night were most disruptive to sleep
Sobeith et al., 2002	Cincinnati fire fighters	reduced postural stability over a 12 hour shift
Karter, 2003	NFPA and NFIRS U.S. fire fighters	increased rate of injury per 100 fires from midnight to 6 AM to twice that of mid-afternoon injury rates
Childress, 2004	wildland fire fighters	decreased immunoglobulin levels working longer than 12 hour shift
Bailey, 2006	wildland fire fighters	fatigue associated crashes when driving from work sites
Boudraux et al., 1997	EMS responders	switch from 24 to 12 hour shift more productive and less socially disruptive

Section 5: Measures to Effectively Manage Work Hours

5.1 Introduction

One in five U.S. workers or more than 15 million Americans work evenings, nights, rotating shifts or other irregular schedules. It is estimated that fatigue costs U.S. employers \$136.4 billion annually in health-related costs and lost worker productivity (Ricci et al., 2007). The health consequences of long work hours, inadequate sleep and disruption in daily rhythms are discussed in Section 1. For the majority of sleep deprived individuals, the problem develops insidiously, and while they might acknowledge their fatigue, they tend to discount its personal impact and consider it an issue for others, not themselves (Jones et al., 2006). The concept of adapting to sleep deprivation or training oneself to require less sleep is a myth. Although a person can learn to sleep less, no one can learn to need less sleep.

Better understanding of sleep and circadian physiology, plus the interest of researchers (Rosa et al., 1990; Horowitz & Tanigawa, 2002; Goh, Tong & Lee, 2000), occupational specialists and health promoting organizations have generated a range of options and suggestions to improve the lives and productivity of shift workers. Examples of the products and services that they offer are presented on pages 69 and 70.

In general, methods to minimize and cope with long work hours are divided into categories of employment-related issues and those adaptations that individuals personally can make in their working and non-working lives. Although organized into those domains, in reality, all strategies require collaboration among workers and employers. Topics presented in this Section are organized as they relate to workers, including screening, worker habits outside of work (sleep hygiene and other lifestyle behaviors), stimulant use, family issues and commuting. Job structural issues presented include worker environment, physical activity, naps, work hour structure, behavior-based fatigue management and regulations.

5.2 Identifying At-Risk Workers

5.2a Sleep Apnea (see also Section 1, page 10 and Section 2, page 32)

Commercial motor vehicle operators (CMVO), truckers, are a group who work long hours and whose alertness can have life threatening consequences. As discussed previously, obstructive sleep apnea (OSA) is a disorder associated with increased daytime sleepiness. OSA is more common among CMVOs, and because the consequences of increased sleepiness are so great in trucking, regulations are in place to screen all CMVOs for the disorder (Hartenbaum et al., 2006). A simplified version of the recommendations used to identify individuals in need of specialized sleep laboratory studies to assess for OSA is presented in Table 5.1. Although OSA may be suggested by history and certain physical findings (higher body mass index, greater neck circumference and hypertension), it can only be diagnosed by an overnight study in a specialized sleep laboratory. Once diagnosed, appropriate management, such as using nighttime continuous positive pressure breathing apparatus or other measures, can correct the day time fatigue (Hartenbaum et al., 2006). Those identified CMVOs with OSA are required to provide documentation of appropriate treatment and be closely followed to insure that their illness is being managed or they will not be licensed to drive.

Table 5.1. Components Used to Identify Commercial Motor Vehicle Operators Needing Formal Sleep Studies for Obstructive Sleep Apnea

1. Sleep history suggestive of OSA (snoring, excessive daytime sleepiness, witnessed apneas).
2. Observed unexplained excessive daytime sleepiness or confessed excessive sleepiness.
3. Motor vehicle accident (run off road, at fault, rear-end collision) likely related to sleepiness.
4. Two or more of the following (1) body mass index > 35 kg/m ² ; (2) neck circumference > 17 inches in men and 16 inches in women; (3) hypertension (new or uncontrolled).
5. Epworth sleepiness scale score > 10, no driving until assessed if Epworth sleepiness scale score $\geq$ 16 (see page 6 for Epworth scale).
6. Previously diagnosed sleep disorder but no recent medical visits or compliance data available for immediate review.

5.2b Individual Differences in the Effects of Sleep Loss

Individuals differ in their ability to tolerate night work and adjust to shift work. Studies indicate that after a single night of work, approximately half of adults can perform at acceptable levels. One third have a moderate amount of impairment, and the remaining individuals will have moderate to marked decrement in performance (Dinges, 1992). Even the same individual's ability to tolerate night work may vary over time, unassociated with any identifiable factor.

An area of current research, which has not yet reached practical applications, is the recognition of individual variability in the effects of sleep deprivation (Lammers-van der Holst et al., 2006; Van Dongen et al., 2004). Van Dongen and colleagues (2004) have identified trait-like differences in susceptibility to fatigue and performance decrements due to sleep deprivation, with up to six-fold differences in how individuals responded to the same amount of sleep loss, when controlling for other factors. The researchers concluded that "neurobehavioral deficits from sleep loss constitute a differential vulnerability trait."

Perhaps fire fighters and EMS responders are a select group, which might imply that they are more able to deal with the stress of longer work hours. However, investigation of other unique workers, such as active duty F-117 pilots, revealed that they were not all equally able to tolerate sleep deprivation and demonstrated significant variability in their susceptibility to impairment from sleep loss (Van Dongen et al., 2006). Future work may identify individuals more suited for shift work and allow stratifying coping strategies based on a worker's innate predisposition toward problems from sleep deprivation and circadian disruption.

5.2c Day-Night Preference and Age

In addition to the individual differences described in Section 5.2b, people vary in their natural tendency to be an early bird or a night owl. Survey instruments (Table 5.2) are available to assess the natural ability to work evenings, and questionnaires also can determine how well workers are tolerating their current work structure (Menna-Barreto et al., 1993; Folkard et al., 1995).

In general, the ability to adjust to night work and work long hours diminishes with aging (Reid & Dawson, 2001), and some have proposed specific age limits for night and/or shift work (Baker et al., 2004). However, examination of commercial driver crash risk as it relates to age, found the opposite findings. Older drivers were most likely to limit their exposure to risky driving situations, and age was not a predictor of job performance (Knipling et al., 2004).

5.3 Sleep Habits and Lifestyles

Workers' ability to tolerate long hours is affected by their general health and how they spend their non-working hours. Shift work may be a risk factor for a number of health harming effects (Section 1). To counter those effects, maintaining a healthy lifestyle and achieving the Healthy People 2010 objectives is especially important (Table 5.3, next page). Those health behaviors are known to result in an increased life expectancy and improved quality of life (DHHS, 2005).

For shift workers, first among those lifestyle issues is their sleep habits. In general, adverse effects of irregular shift schedules and long work hours are minimized when people establish some regularity in their bedtime and waking schedule, even on weekends, so that an anchor of fixed sleeping times is maintained.

As described in Section 1, all sleep hours are not equal, daytime sleeping is more difficult, and those hours are not as restorative as nighttime sleeping. Shift workers who are up during the night are encouraged to develop good sleep hygiene practices to facilitate falling asleep during the day, after their work ends early in the morning. A light meal should be eaten before bed if the person is hungry. Breakfast foods such as toast, bagels or cereal are recommended. Caffeinated and alcoholic beverages should not be consumed before going to bed. Because bright sun light can heighten the normal tendency for daytime alertness and make it more difficult to sleep, individuals intending to sleep after arriving home often are advised to wear sun glasses when traveling home.

Table 5.2. Early Bird or Night Owl Preference

Answer 1=never, 3=sometimes or 5=always, and total your score.

- _____ I have a good appetite 20 minutes after waking in the morning.
 - _____ I would have a great workout from 7 to 8 AM
 - _____ I find it easy to get out of bed in the mornings.
 - _____ I wake up without an alarm clock on workdays.
 - _____ If I worked 4 AM to 6 AM, I would sleep before rather than after.
 - _____ I am at my very best when I start my day.
 - _____ If I had to take an important test, I would prefer to take it at: 8-10 AM (5 pts), 3-5 PM (3 pts), 7-9 PM (1 pt).
 - _____ If I could choose my schedule, my core working hours would be: 5-10 AM (5 pts), 10 AM-3 PM (3 pts), 5-10 PM (1 pt).
 - _____ TOTAL (compare to the scale below)
- 35-40 Extreme Early Bird: Among the 10 percent who naturally are early risers, are most productive during the first half of your day and often fade beginning mid afternoon.
- 27-34 Moderate Early Bird: Still set your alarm clock or sleep in on days off. Nights are not off limits, but you don't often stay out late.
- 22-26 Hummingbird: Flexible and tend to be ready for action both morning and night.
- 14-21 Moderate Owl: Prefer evenings. Your mood increases throughout the day.
- 8-13 Definite Owl: You skip breakfast and arrive at work at the last minute. At night you find yourself busy, perhaps surfing the Internet, doing the laundry or socializing.

Healthy People 2010 is a statement of U.S. health objectives designed to identify the most significant preventable health threats and establish national goals to reduce those threats. It is available at www.healthypeople.gov/.

Even if the worker is not aware of being awakened by outside light and noise, sleep quality may be compromised during the daylight hours. To maximize the benefits from and ability to sleep during the day, it is important to eliminate noise and light from the sleep environment. Specific suggestions include acoustical and light insulation with eye masks, ear plugs and room darkening shades or drapes; the telephone should not ring into the bedroom during the daytime. During hot weather, a window air conditioner can be used to provide background noise, as well as maintain a cool temperature recommended for sleeping. Shift workers may need to explain to friends and family the importance of restorative sleep and enlist their support. Cooperative neighbors who are aware that there is a night worker sleeping can avoid engaging in noisy activities outside the worker's bedroom.

Sometimes people use night work to allow them to work a second job or provide care for their children during the day. However, the resulting chronic sleep deprivation may increase their risk for accidents and cause mental and physical problems.

5.4 Caffeine and Other Stimulants

Caffeine is a recognized stimulant, and drinking a caffeinated beverage (coffee, tea, cola) can help maintain alertness. Individuals may choose to use caffeine or other stimulants to maintain alertness either on or off work. Caffeine has a duration of action of three to five hours, but effects can last up to 10 hours in sensitive individuals. Thus, although a limited amount of caffeinated beverages (two to three cups of coffee) during the first half of the night shift enhances alertness, caffeine consumed during the last half of the shift may interfere with falling asleep after the worker gets home.

The 'dose' of caffeine needed to improve alertness is approximately 250 mg (two cups of average strength brewed coffee), and higher doses are not more beneficial and increase side effects (van Duinen, Lorist & Zijdewind, 2005). Comparison of caffeine in different products is shown in Table 5.4.

Recently prescription medications have been developed to reverse the sleepiness associated with some types of sleep pathology, such as narcolepsy. One of those agents, modafinil, was approved by the U.S. Food and Drug Administration for treatment of the extreme sleepiness of individuals with shift work sleep disorder (SWSD) (described on

Table 5.3. Healthy People 2010 Objectives

1. **Daily physical activity**
2. **Healthy diet (> 5 servings of fruits and vegetables/day, low in saturated and trans fats)**
3. **Maintain healthy body weight**
4. **Do not smoke**

Table 5.4. Caffeine Content

No-Doz (max strength)	200 mg
Brewed coffee	135 mg
Instant coffee	100 mg
Espresso (2 oz.)	100 mg
Red Bull (8.2 oz.)	80 mg
Mountain Dew	55 mg
Brewed tea	50 mg
Coke Classic	35 mg
Green tea	30 mg
Hot cocoa	15 mg

Caffeine and modafinil are two of a number of countermeasures or *chronobiotic interventions*, along with light exposure and melatonin, used to reset or counteract the body's normal circadian rhythm (Schwartz & Roth, 2006). Most studies of these drugs and other measures are with simulations of night shift work. However, these interventions are not a substitute for more comprehensive strategies to minimize disruption of sleep schedules and allow for adequate restorative sleep (Basner, 2005).

page 8). When studied, use of the drug reduced sleepiness and produced a small but significant improvement in performance (Czeisler et al., 2005).

However, it is important not to take that finding as meaning that the drug would be useful for all individuals performing shift work. To do the study, the U.S. Modafinil in Shift Work Sleep Disorder Study Group screened 4533 shift workers to identify the approximately 10 percent of individuals with diagnosable SWSD and eligible for study, and only about three-quarters of those completed the protocol. Thus, the results are not applicable for the majority of shift workers, and in that small subset of workers who took the drug, although their performance was improved, it did not reach a normal level.

More recent work assessed use of modafinil with emergency room physicians working 24 hour shifts. Investigators found that while the agent increased certain aspects of measured alertness, it also made it more difficult for participants to fall asleep when opportunities for sleep arose (Gill et al., 2006). Overall, for the average worker, the effects of modafinil are relatively modest and comparable to those of repeated low doses of caffeine (Dagan & Doljansky, 2006).

5.5 Education of Workers' Families

Sleep habits and organizing non-working hours requires social coping strategies to facilitate interactions with family and friends. Involving workers' families in any job reform is increasingly recognized as important. Wilson and colleagues examined the effects of involving families by using the natural experiment of worksites that did and did not include families in shift work strategy discussions. They found that shift work reform focusing on physiological issues only, without family involvement, was counterproductive and increased family conflict (Wilson et al., 2007).

Involvement of families can encompass education about the effects of shift work and information about effective countermeasures. Organizing support groups for the workers and their families also can provide a mechanism for recognizing ongoing work-related problems and providing solutions to remedy them.

5.6 Commuting Issues (see also Section 2, page 29)

Fatigue is a major factor in crashes, and the National Highway Traffic Safety Administration estimates that drowsiness is the primary cause for 100,000 crashes each year (Lyznicki et al., 1998). When the causes for motor vehicle crashes were reviewed, drivers at high risk for sleep-related crashes included 1) younger drivers lacking sleep due to demands of school and jobs, late socializing and poor sleep habits; 2) shift workers; 3) drivers using alcohol or other drugs and 4) those with sleep disorders.

Simulation studies have confirmed that workers' driving is impaired after working night shifts. Ten night shift workers were studied using a driving simulator, and researchers compared performance after their typical night shift and following a normal night's sleep. Despite the few subjects, significant differences were found. After their night shift, workers demonstrated almost three times as many wheels outside the lines and more than twice the lateral deviations (Akerstedt et al., 2005). Confirming the simulator findings, study of medical interns found that driving home from long work shifts more than doubled the risk of crashes (Barger et al., 2006; Lockley et al., 2006; Landrigan et al., 2004).

Disruption of circadian rhythm and the fatigue that can accompany working nights potentially is compounded when work ends in the morning because in general, the recommendation is that workers go to bed directly following those types of shifts. In that setting, the need for alertness commuting may be in conflict with the need to go directly to bed once arriving home. The usual measures to increase alertness, such as caffeine or exercise, might make sleeping once home more difficult. Suggested means to reduce commuting risk include educating workers to the risks, assisting workers with alternative means of getting home besides driving, and providing a place for workers to nap before driving home.

5.7 Work-Related Issues: Environment and Physical Activity

Though listed as work-related issues, most strategies require the collaboration of employer and workers. For example, the availability of exercise facilities to use during break times are only helpful if used by the workers. In fact, when workers are involved in designing their schedules, the outcomes are better than plans arrived at by management mandates (Ala-Mursula, 2002). In unionized facilities, the cooperation of trade union representatives also adds to the success (Sakai, 1993). In fact, the participation of workers and their representatives in formatting work structures that maximize alertness appears as important as the schedule itself for programmatic success (Kogi, 1998).

Environmental conditions can be adjusted to maximize alertness by controlling lighting and temperature. Bright lighting enhances alertness. Keeping the temperature at a setting where a light sweater is comfortable also helps to counteract drowsiness. Organizing work tasks to have the most tedious activities early in a shift, allowing for social interchange and providing patterns of non-monotonous sounds also will contribute to an attention-stimulating environment.

In general, moderate physical activity will increase alertness, and exercise during a night or long shift can reduce feelings of fatigue. Providing equipment such as exercise bicycles or a ping-pong table in the break room may make physical activity more enjoyable and realistic for employees. Simple measures, such as walking up and down stairs instead of taking the elevator, and using software programs that cues workers to move around and stretch at intervals can be helpful.

Exercise is not a substitute for sleep. While exercise increases alertness in the short term, when assessed in a cross over study, in the long run, individuals who exercised during sleep deprivation had worse performance and felt more fatigue than when sleep deprived without exercising (Scott, McNaughton & Polman et al., 2006). Because of its potential energizing effect, vigorous exercise should be avoided near the end of a shift, if the worker plans on sleeping following the shift, and conversely physical activity prior to beginning work may enhance alertness.

5.8 Naps

Napping is a strategy that can be used on and off work. Naps can be taken in anticipation of a long night or during prolonged work times, and used in that way, they can attenuate fatigue. Particularly when starting a series of night shifts, a two hour nap taken in the evening before the work can improve alertness.

A nap is sleep that lasts less than half of the typical daily major sleep episode. Resting without sleeping is not a nap. Environmental conditions that promote sleep, such as a cool, quiet environment and reclining more than 45 degrees from vertical, enhance the quality of sleep obtained during a nap.

Naps as short as 20 minutes can be effective in restoring mental abilities, and naps of two hour during long work shifts can be highly restorative. Based on the disproportionate recovery potential of relatively short (less than 45 minutes) periods, these “power naps” have been investigated as a strategy to attenuate performance deficits during and following periods of sleep deprivation (Gillberg, Kecklund & Axelsson, 1996). Studies by NASA showed that planned naps by pilots on long-haul flights improved alertness when landing.

For most types of night work, nap breaks are generally not an option, despite their potential for suppressing sleepiness. However, some industrial organizations have begun promoting napping as a means to improve conditions, work performance and safety (Takeyama, Kubo & Itani, 2005). Stanford researchers (Smith-Coggins et al., 2006) examined emergency room doctors and found that short naps during a 12 hour night shift resulted in better performance on written memory tests, a simulated car drive and simulated intravenous line insertion. As a result, their hospital instituted a sanctioned napping program. Suggestions for emergency room staffing patterns have included recommendations to allow strategic napping prior to work and following 12 hour shifts before driving home (Joffe, 2006).

Studies performed among flight crews by NASA and the Federal Aeronautics Administration also revealed information about ‘planned naps.’ They found that naps could be scheduled in anticipation of fatigue, and they did not need to wait until an individual was so fatigued that involuntary napping occurred. Most people could fall asleep during planned naps in a reasonable time (i.e., five to ten minutes) (Rosekind et al., 1994).

A potential adverse effect of napping is the grogginess or sleep inertial experienced upon awakening (see page 2). Naps longer than 45 minutes can result in awakening during the deeper stages of sleep and greater grogginess and reduced cognitive performance than if awoken from Stage 1 or 2 of non-rapid eye movement (NREM) or from REM sleep (Dinges & Orne, 1987; Takeyama et al., 2004). Immediately upon awakening, a person’s ability to make decisions may be half that of the ability when rested and fully awake, and even 30 minutes later, decision making may not be back to normal. In addition to the duration of a nap, the circumstances of awakening affect sleep inertia. Paradoxically, abrupt awakening, such as might occur with a fire alarm, may result in longer persistence of grogginess. In addition, those with chronic sleep deprivation are more affected by sleep inertia.

Thus, if an individual is required to be alert upon awakening, naps are best when either short or approximately two hours in duration, when the individual would be expected to be dreaming or in the early phases of the next sleep cycle. Also when possible, getting started upon awakening by washing one’s face, drinking coffee or tea, using bright lights or being physically active, can help with feeling more alert, although performance still can take more than 20 minutes to return to normal levels.

5.9 Structuring Work Hours

Shift duration, patterns and sequencing are components of the science of industrial hygiene. Determining work structure for a specific site is complex and requires consideration of many factors, full participation of labor and management and often, the services of consultants. The following paragraphs present some of the considerations relating to shift patterns. Because of the wide variability in work structures and staffing demands, making generalizations or specific

recommendations is not possible. However, principles from studies in other settings can be used when assessing existing fire fighter and EMS responders' work structures.

In general, fixed shifts cause the least disruption to circadian rhythms, provided that workers maintain the same sleep and wake cycle on their rest and work days. For example, fixed shift patterns are popular with police officers, where officers bid for a shift. In those and other settings with fixed shifts, the most senior workers often obtain their preferences. As a result, those working nights are newly hired or those who prefer nights due to second jobs or other daytime activities, such as care giving duties. For the latter group, their daytime commitments and nighttime work make adequate restorative sleep almost impossible.

Rotating shifts are a means to deter workers from combining fixed daytime commitments with their nighttime shift work. Studies on shift workers have shown it takes about 21 consecutive days for circadian rhythms to fully adjust to night shift. Most rotating shift schedules make changes too rapidly to allow circadian adjustment to the new work pattern. The direction for a rotating shift is most physiological when it is forward, (early/late/nights), because the internal bodily clock naturally tends to run slow (i.e., every 25 hours). That is why it is easier to delay sleep than it is to advance it and why people experience less jet lag going from east to west than from west to east. Despite that rationale, some workers prefer a backward rotation (nights/late/early), because it affords more time to recover lost sleep and prepare for the next night shift.

When to begin daytime shifts also has been examined, and as a rule, early starts to morning shift should be avoided. While there is no optimum starting time, 0700 is better than 0600 which is better than 0500. Early starts reduce sleep, as by choice or by family circumstances, most workers go to bed around their normal time the prior evening, despite the early shift. Reduced sleep because of early shift starts leads to fatigue, which can increase the risk of errors and accidents on morning shifts.

Extended shifts is the term used for shifts lasting longer than the typical eight hours. Available information indicates that jobs not requiring a high degree of physical exertion or that have natural resting periods may be most suitable for the extended workday schedule (Canadian Centre for Occupational Health and Safety, 1999). For example, a machinist who has cycle time between setups that allows reduced attention while the machine is running can probably work a longer day. On the other hand, a data entry operator who must continually enter data while sitting in one position and concentrating for long periods would find the extended workday more difficult.

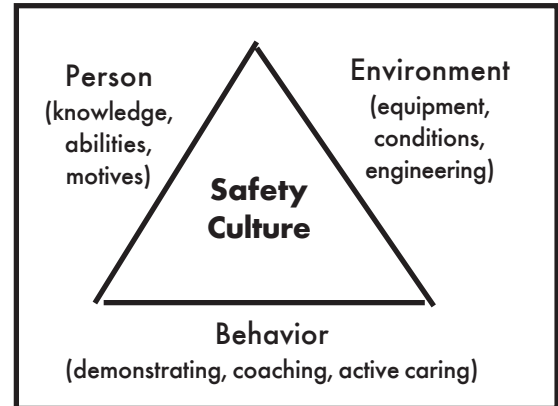
The potential advantage and disadvantages of properly designed extended workdays are that longer periods off can compensate for longer workdays. On the other hand, with longer shifts, workers have little time for anything other than their jobs, eating and sleeping, during their working days. Workers with other responsibilities, such as child care and other family responsibilities, may find the extended workdays especially tiring. Time spent travelling to and from work is often viewed by workers as lost time. The extended workday means fewer commuting trips and, therefore, less wasted time. When supported by the workers, extended shifts may enhance worker morale and job satisfaction, which must be balanced with a need for more breaks and a slower work pace with extended shifts (Canadian Centre for Occupational Health and Safety, 1999).

5.10 Behavior-Based Work Hour Management

In organizations, the development of a *esprit de corps* among workers and a culture of safety may be a critical component for effectively dealing with worker fatigue (Knippling et al., 2004). Rather than a top-down change, behavior-based safety systems have been used to effectively alter the culture of workers (Geller, 2005). These programs have been used in settings as varied as pizza delivery (Ludwig & Geller, 1997), mining (Fox, 1987) and manufacturing (Reber & Wallin, 1984).

Behavior-based programs include components at multiple levels. Senior leadership demonstrates a commitment to core values embedded into strategic priorities, and employees are involved at each step. Local control is established to manage the process and communicate issues among workers and across the organization. In addition, all participants demonstrate a willingness to learn and try successful techniques from high-reliability organizations. Geller (2001) has described three dynamic, interactive factors relating to cultural change in organizations, and he points out that successful programs include attention to each domain (Figure 5.1).

Figure 5.1. Safety Triad (from Geller, 2001)



A review of occupational health and safety studies found that behavior-based systems were most effective in promoting healthier actions, and their effects were greater than technological interventions, government action, near-miss reporting systems and poster campaigns (Guastello, 1993). Sulzer-Azaroff and Austin (2000) reviewed behavior-based reports and found that 32 of 33 showed reduced work-related injuries. Of particular relevance to fire fighters and EMS responders is that, because behavior-based organizational change emphasizes peers helping peers, it is most applicable to settings where employees work in groups rather than alone.

The same principles of management were components of the Crew Endurance Management maritime program developed by the Coast Guard (page 25), and others have converged on similar principles. For example Rhodes (2005) writes that effective fatigue management programs should have the following key components: organizational commitment, an explicit fatigue management policy and process, involvement of stakeholders at all levels, subjective (opinions and beliefs) and objective measures of the programmatic outcomes, and ongoing monitoring and improvement.

5.11 Rules and Regulations

We have presented information about the existing rules and regulations as it relates to fire fighters, other emergency medical services responders, the transportation industry and postgraduate medical training in Sections 2 to 4. However, in this report, we attempted to focus on the issues pertaining to workers' health and job effectiveness, rather than the political and economic issues relating to formal regulations. The sometimes contentious regulation issues are compounded by the difficulties in monitoring and enforcing those rules. Even in domains as well publicized as medical graduate training work hour reform, follow-up of mandated work hour reform reveals change has been slow (Landrigan et al., 2006; Surani et al., 2007).

Commercial vehicle safety is an arena where rules and regulations are prominent (Federal Registrar, 2006). However, publications concerning that industry point out the general ineffectiveness of regulatory measures (Knipling et al., 2004). For instance, they cite the example of a worksite that used docking pay for safety rule violations. Rather than increasing the desired behavior, they found that there was a paradoxical decrease in the actions with punitive measures. Only positive feedback for compliance, not penalties for violations, resulted in a significant increase in the health promoting behavior (Zohar, Cohan & Azar, 1980).

Recommendations of occupational experts and available evidence are clear that any effective work structure system involves workers and their families, employee representatives, local administrators, regulatory bodies and often expert consultants in designing programs that maximize physical and psychosocial health, safety and productivity outcomes.

5.12 Summary of Studies on Work Hour Management

Fire fighting and EMS response work cover a wide spectrum of activities and conditions, and generalizing recommendations is difficult. Principles that apply across the range of worksites include becoming educated about the performance and health effects of fatigue and assessing work structures and job demands. Involving emergency medical services personnel and their families, management, representatives from labor organizations and national administrative bodies, and sometimes outside consultants is important in the success of any fatigue management program. Sleep science and the information contained in this report are resources for fire fighters and EMS responders in those efforts.

- Those working long duration shifts can improve their well being by leading healthy lifestyles. Chronic sleep deprivation may not be recognized, and it is important for workers to acknowledge their need for and maximize their ability to achieve adequate restorative sleep.
- Coping with long work hours may be facilitated by identifying workers at higher risk for difficulties in adjusting , such as those with sleep disorders.
- Fatigue is a risk for motor vehicle crashes, and commuting home following long duration shifts may be an especially vulnerable time for workers.
- Personnel, their families, management and consultants, working in collaboration, are best able to structure work hours and circumstances to meet the needs of professional excellence and employee well being that typify fire fighting and EMS work.

Table 5. 5. Resources for Information on Managing Work Hours

Organization	Description	Contact Information
Alert@work	Source of information about and resources for shift work, sleep and circadian rhythm sleep disorders.	www.alertatwork.com/component/option,com_frontpage-/Itemid,1
American Lung Association	Information about shift work, especially drivers and sleep apnea issues.	www.lung.ca/diseases-maladies/apnea-apnee/drivers-ca-mionneures/index_e.php
Circadian Technologies, Inc.	Founded in 1983, international research and consulting firm that assists companies with their extended hour and shift work operations.	http://www.circadian.com/media/about_circadian.html
Division of Sleep Medicine @ Harvard University	Well known group involved in public education; policy, clinical and basic research, and education of medical personnel.	www.sleep.med.harvard.edu/
The Napping Company	Products on the benefits and strategies of napping and its positive effects on productivity and mood.	http://www.napping.com
National Institute for Occupational Safety and Health.	Plain Language about Shiftwork is a well written and referenced 47 page lay document about shift work, including work schedules, health and safety issues and management strategies.	DHHS (NIOSH) Publication No. 97-145 @ www.cdc.gov/niosh/pdfs/97-145.pdf
National Sleep Foundation	Dedicated to improving public health and safety by achieving understanding of sleep and sleep disorders. (See specific informational offerings on page __.)	www.sleepfoundation.org/hottopics/index.php?secid=8-tid=85
Shiftwork Solutions LLC.	International organization that assists with schedules.	http://www.shift-work.com/ .
Stanford Center for Human Sleep Research	Involved in design and conduct of studies of sleep disorders, including newer drug therapies to maintain alertness.	www.med.stanford.edu/school/psychiatry/humansleep/
Working Time Society	Scientific Committee on shift work and working time of the International Commission on Occupational Health and links to the International Symposiums on shift work and work time.	About">www.workingtime.org/index.php/WorkingTimeSociety>About

Table 5. 6. Additional Resources on Managing Work Hours

Resource	Description
Sleep strategies for shift workers (brochure). Available at www.sleepfoundation.org/Merchant2/merchant.mvc?Screen=PROD&Store_Code=NSF&Product_Code=139&Category_Code=PEB . (\$.50)	This brochure outlines the common effects of shift work on health, workplace alertness and productivity and offers tips about diet, sleep environment, medications, light therapy and sleep hygiene.
When "9 to 5" Isn't an Option Available at www.sleepfoundation.org/Merchant2/merchant.mvc?Screen=PROD&Store_Code=NSF&Product_Code=183-&Category_Code=PEBp://www.sleepfoundation.org/sleepionary/index.php?id=20&subsection=coping . (\$5.00)	Public education poster.
Speed kills, so does fatigue (videotape). Available at www.sleepfoundation.org/Merchant2/merchant.mvc?Screen=PROD&Store_Code=NSF&Product_Code=151-&Category_Code=PEB (\$19.95)	An in-depth look at the causes and consequences of drowsy driving through the use of graphics, personal testimonials, and expert interviews. Explains proper sleep habits, common sleep disorders, the "biological clock," and the use of caffeine and naps. Excellent for shift workers, and commercial drivers and non-commercial drivers alike.
Day/Night Sleep Strategies for Shift Workers Videotape (videotape). Available at www.sleepfoundation.org/Merchant2/merchant.mvc?Screen=PROD&Store_Code=NSF&Product_Code=138-&Category_Code=PEB . (\$19.95)	This 11 minute educational video builds on the knowledge of its companion brochure regarding sleep, health, and nontraditional work schedules. This video is for workplace viewing for employees and management.
Working with Stress (Pub. No. 2003-114D). First NIOAH training and educational educational video available 1-800-35-NIOSH	Describes workplace factors that can create or exacerbate stress and suggests practical measures to reduce stress.
Overtime and Extended Work Shifts: Recent Findings on Illness, Injuries and Health Behaviors, DHHS (NIOSH) Publication No. 2004-143	Presents a review of the methods and findings from 52 studies that examined the relationship between long work hours and selected health outcomes. Also provides recommendations on issues and priorities to consider in future research.
Work-related Roadway Crashes - Who 's at Risk? DHHS (NIOSH) Publication No. 2004-137	Companion fact sheets provide information that employers and others can use for assessing risks for motor vehicle injuries and deaths in their work setting and for taking effective steps to reduce those risks.
Plain Language about Shiftwork. DHHS (NIOSH) Publication No. 1997-145	Provides basic facts about shiftwork and talks about ways to make shiftwork life easier.
The Practical Guide to Managing 24-Hour Operations from www.circadian.com	Guide to aspects to assess in any 24-hour worksite and suggested dimensions for safe, effective work and employee well being.

Appendix 6.1: Legal Considerations

As the impacts of sleep deprivation are becoming better identified and understood, the legal system is reacting with new laws.

Particular attention has been drawn to fatigued drivers, who face both civil and possible criminal penalties when they fall asleep behind the wheel. Such drivers may be charged with causing injury or death by criminally negligent operation of a motor vehicle. One state, New Jersey, has even gone so far as to create a new law, known as Maggie's law (next page), which specifically provides that a "knowingly fatigued" driver who causes a fatal accident can be convicted of vehicular homicide. "Fatigued" is defined as having been without sleep for a period in excess of 24 consecutive hours. Even in those states where no specific law relating to fatigued drivers has been enacted, criminal penalties may still be involved. The decision to pursue criminal charges rests with the criminal prosecutor in that jurisdiction. However, there seems to be a nationwide trend toward greater use of criminal negligence charges which has become apparent, for instance, in other contexts such as training injuries and deaths. Conviction could result in imprisonment, fines, supervision by the criminal justice system, and other penalties.

Regardless of whether a fatigued driver suffers imposition of criminal penalties, he or she may still be held liable under civil law for actual damages. This means that the person may be sued, and money judgments can be collected from income and personal assets, subject to certain exemptions. Furthermore, there may be no absolute right for the person to insist that the judgment be collected from his or her employer. If personal liability insurance coverage is inadequate, he or she may be in financial peril.

Fatigued personnel may also present a risk for their employers. While criminal penalties for employers are unlikely, except in the most egregious cases, employers are probably going to be included in any civil suit against an employee for money damages. Under the doctrine of respondeat superior, employers are liable to the public for damages caused by their employees. Moreover, if the employer has knowledge of the employee's fatigued state, the employer is at risk for a claim that it has negligently allowed its fatigued employee to cause an accident. A successful plaintiff is more likely to collect his or her judgment against the employer rather than the employee because the employer is more likely to have substantial financial assets.

Regarding injury of co-workers, the employee is frequently not personally liable for payment to the injured co-worker because of a provision in many state Workers' Compensation laws that prevents one co-employee from suing another for workplace injuries. In this situation, the injured employee would be covered under Workers' Compensation laws.

A review of employment practices with the appropriate risk managers and insurers to minimize this exposure is prudent.

Maggie's Law

Maggie's Law was named after Maggie McDonnell, a 20-year-old college student from New Jersey who was killed by a drowsy driver on July 20, 1997 at 11:30 AM when the car she was driving was hit head-on by a van that had crossed three lanes of traffic. The driver of the van told police that he had not slept in 30 hours. Since the jury was not allowed to consider driver fatigue as a factor, he was only convicted of careless driving and fined \$200. The events led to the signing of a New Jersey statute (http://www.njleg.state.nj.us/2002/Bills/A1500/1347_R2.HTM). Under the law, a sleep deprived driver who causes a crash after being awake for more than 24 hours can be convicted of vehicular homicide. The law also raised the specter of corporate liability in cases of drowsy employees who work long hours, high amounts of overtime, double-shifts, or even 24-hour on-call periods at their employer's request.

"For extended hours employers in New Jersey and surrounding states, Maggie's Law increases the risk of corporate liability should an employee cause a fatal drowsy driving accident," said Dr. Martin Moore-Ede, chairman and CEO of Circadian Technologies, Inc. "We are seeing a steep increase in driver fatigue accident litigation. In fact, the US Department of Transportation identifies fatigue as the number one safety problem in transportation operations, with a cost in excess of \$12 billion a year." According to Dr. Moore-Ede, "Employers must consider options for mitigating this risk, such as educating employees on the danger of drowsy driving and controlling long work hours, and developing policies that minimize this potential new legal liability."

The first federal bill focusing on drowsy driving was introduced in the House of Representatives in October 2002 by Rep. Robert Andrews (D-NJ). The bill, HR 5543, titled "Maggie's Law: National Drowsy Driving Act of 2002" (www.theorator.com/bills108/hr968.html), calls for incentives for states and communities to develop traffic safety programs to reduce crashes related to driver fatigue and sleep deprivation. The legislation also calls for training for police officers, the creation of driver education curriculum, standardized reporting of fatigue-related crashes on police report forms, and the promotion of countermeasures such as continuous shoulder rumble strips and rest areas.

Appendix 6.2: Recommendations

As briefly presented in the Executive Summary, this document serves as a resource for fire fighters and EMS responders as they assess the dynamic demands of their work and adjust its staffing structure and deployment characteristics to meet their performance standards and maintain the health and well being of workers. Potential future directions apparent from this report are presented in the domains of education and potential future studies.

6.2a Education

This document, presentation of its findings and the accompanying education tools will assist fire fighters and EMS responders in understanding the performance and health effects of sleep deprivation. However, as noted in the Section on behavior-based work hour management and as exemplified by the U.S. Coast Guard's Crew Endurance Management program, knowledge is only the first step in an educational program. A culture of awareness and support is needed. As presented in Figure 5.1, page 67, this will require ongoing reinforcement of education activates and translation of that knowledge into attitudes and behaviors that promote appropriate work hour management.

6.2b Future Assessments

Fire fighters and EMS responders are in the forefront of compiling information and open access to findings related to effective training and work-related injuries, deaths and near-misses. Parallel strategies, using national web-based systems, could obtain information concerning department schedules and work structures. Similarly, as was done with medical interns, carefully designed and validated data collection formats could be used to gather job structure, performance and health characteristics of individual workers, including sleeping habits and other fatigue-related indices.

The departmental and work setting findings would provide resources for sites/organizations considering different work structures, especially as two competing trends appear to be developing. On one hand, for some sites (e.g., San Francisco and Austin) workloads and the scope of services have increased, and with recognition that alertness and abilities decline after approximately 12 hours, shift lengths have been shortened. Alternatively, other departments are following the trend toward longer shifts and switching to 48-hours-on/96-hours-off structures. Although each locale must determine the specifics of scheduling, a systematic database could help inform those decisions.

With assembly of a large database, fire fighters and EMS responders in different settings and health services analysts could better assess relationships among work hours, sleep habits, lifestyle practices, health conditions and costs of injuries and work-related illnesses. Those health-related outcomes could be accompanied by work-performance metrics, such as response times, compliance with accepted and applicable work-related standards and economic outcomes.

Five areas appear especially appropriate for further study, and they are elaborated in the following paragraphs: 1) better identification of the impact of fire fighting and EMS response work on the family, 2) monitoring crashes during commuting, 3) utility of strategic napping, 4) the prevalence of sleep disorders among fire fighters and EMS responders and 5) cardiovascular risks and other lifestyle issues and their relationship to work hours. In addition, available technologies, such as measures of vigilance and simulations, could be used to index whether performance is affected by the prolonged but discontinuous work that can characterize the work of fire fighters and EMS responders.

Information suggests that long work hours may have adverse psychological and social consequences (Section 1). Those issues, compounded by the camaraderie of fire fighting and EMS work, and the extended work absences that can attend those occupations, may have an unintended negative impact on families. Assessing these dimensions and the social consequences of work structures are important areas for future research, and the need to involve families when considering job and work hour restructuring has been emphasized repeatedly.

Driver fatigue increases the risk of motor vehicle crashes, and fire fighter and EMS responder databases do not systematically collect information on events immediately after leaving work, such as crashes commuting. One of the factors leading to the 48-hours-on/96-hours-off work structure is a reduction in the number of commutes. Ironically, those commutes, although fewer in number, may be more hazardous. In general, shift workers are twice as likely to fall asleep behind the wheel, and as was shown with medical trainees and documented anecdotally among fire fighters and emergency medical services responders, the commute home is a particularly vulnerable time for fatigued workers. Special efforts are needed to gather data on crashes during commuting and to educate fire fighters and EMS responders on that risk and means to reduce its potential. Vigilance testing and driver simulations with end of shift personnel could be added as a component of assessing work structures.

The utility of naps has been mentioned several times in this report. They have been advocated by the U.S. Coast Guard, the American Transportation Research Institute, and the aviation industry and among emergency room physicians. Researchers who have investigated work habits among fire fighters and EMS responders have suggested naps as a means to manage fatigue, and they are discussed in Section 5. For those needing to work long hours, sanctioned and/or scheduled naps may be effective means to achieve optimal performance during the later work hours, and those formats should be studied for their utility and efficacy in attenuating fatigue. While work performance outcomes are the optimum endpoints, surrogate endpoints, such as measures of alertness, simulations and physical measures, could be used to assess naps or other scheduling modifications. Scheduled naps also might allow timelier implementation and evaluation of work place structural features, such as sleep space location, means for awakening and acoustic shielding, designed to facilitate individuals' obtaining restorative sleep in the midst of a busy fire station or other worksite.

Fire fighters and EMS workers may have a higher prevalence of sleep disorders, and untreated, those problems increase morbidity/mortality and impair performance. Focused screening could define the prevalence and severity of these problems and determine whether and how assessment for sleep disorders might be added to the IAFF/IAFC Wellness-Fitness Initiative's annual assessments.

Cardiovascular health is of particular concern, as it is a leading cause of work-related death in certain sectors. Newer markers of inflammation relating to cardiovascular risk have been linked to sleep deprivation. The work hour structure of fire fighting and EMS responders may be a setting to gather important information about this association. Prospective assessment of these and additional sleep-related mental and physical correlates could be coupled with naturally occurring work hour restructuring to better define and understand the risks of different occupational formats.

The health profile of most fire fighters and EMS responders is similar to the majority of adult Americans, less than 10 percent of whom eat healthy, exercise regularly and have optimal body weights (Reeves & Rafferty, 2005). Add to that the recommendation for six to eight hours of sleep

a night, and the percentage achieving those health objectives is even lower. We are grateful for the assistance of the IAFF/IAFC in studying the implementation, effectiveness and dissemination of science-based health promotion programs among career fire fighters (Elliot et al., 2007). Continuing to assess health promotion methods and their potential mental, physical and economic benefits are critical areas for ongoing research.

The IAFF/IAFC Wellness-Fitness Initiative, as well as the National Fire Protection Association Standard 1582 (medical program) and 1583 (fitness program), set standards and priorities for fire fighters and EMS responders' well being. Currently, the IAFF/IAFC Wellness-Fitness Initiative does not include sleep hygiene in its behavioral health sections, nor does the NFPA 1582 include any specific examinations to assess for sleep disorder risk and/or status. Information from this report would be appropriate for inclusion in the next edition of the IAFF/IAFC Wellness-Fitness Initiative. Fire fighting and EMS departments spend considerable resources on preventive maintenance of their apparatus and durable equipment. However, that is not a cost effective and efficient use of resources if similar efforts are not allocated to having the healthiest and most qualified personnel responding to these emergency situations.

From a Near-Miss Report: As a probationary fire fighter in many departments, it is customary for rookies to be involved in all activities in the station where they are assigned. The night before the event, which could have killed me, my partner and I ran 38 calls in 24 hours, with a 3 hour fire around midnight. At 2 AM, we responded to an auto accident in front of a local night club, this was call 30 of 38, shots were fired in our general direction, and we were only 80 feet from the shooter. No one was hit or injured. We never even made our beds. Here is the problem, when I was driving home in the morning, I had been on duty from 06:30 one day to 08:00 the next, no sleep and involved in everything in the house, cook, clean, shop, calls, reports, station tours, and all. I fell asleep at the wheel on the 19th mile of a 23 mile trip on the highway. My vehicle struck a wall. Had I left the road 100 yards earlier, I would have plummeted off of a bridge. In our department, new hires took quite a bit of ribbing and criticism. The members of the shark tank were coming in the next day, and there was no way it would have been acceptable for me to stay and sleep in the dorms while the on coming shift was doing their normal routine. The rest is a necessary piece of life. In hindsight, I should have tried to speak with a company officer about getting some sleep before heading home. Be careful and do not over do it trying to impress the senior guys.

Appendix 6.3: Data Collection Methodology

Information for this review was gathered from three primary sources: database searches, internet searches and consultation with experts in fire fighting and EMS personnel issues and those knowledgeable concerning sleep and chronobiology. The English language literature was reviewed for papers and other works published from 1996 onwards.

The databases searched were Ovid, MEDLINE and PUBMED using the Medical Subject Heading (MeSH) terms and keywords: emergency services personnel, emergency medicine technician, paramedic, fire fighter/firefighter, fire service, first responder, emergency medical services (EMS), shift work, shift, sleep, sleep deprivation, stress, workload, work schedule tolerance, circadian rhythm, chronobiology and personnel staffing. Papers were selected based on their content, relevancy, author, and research validity. Additional articles were selected by reviewing citations and reference lists of already accessed literature. For information in the Sections on the transportation industry and postgraduate medical training, analogous search strategies were applied with the use of terms related to those workers.

A similar strategy was used for the internet search, and potentially relevant sites were accessed and explored for information. Those sites are cited and listed in the references and where appropriate, in the text. Compilation of the most useful sites is listed below.

As is typical for evidence-based reviews, our goal was to provide a critical appraisal of the evidence. Because this involved a range of materials and perspectives, synthesizing the findings was sometimes challenging, but necessary to assist readers in using the information. Our objective was for the information to serve as a resource for fire fighters and EMS responders.

Accreditation Council for Graduate Medical Education (www.acgme.org)
 American Transportation Research Institute (www.atri-online.org/)
 Canadian Centre for Occupational Health and Safety (www.ccohs.ca/)
 Canadian Marine Pilots fatigue management of Transport Canada (www.tc.gc.ca/tdc/publication/pdf/13900/13958e.pdf)
 Cardiff University's Seafarer fatigue report (www.itfglobal.org/files/seealsodocs/3165/fatigue%5Fwhere%5Fnext.pdf)
 Department of Health and Human Services. Healthy people 2010: Understanding and improving health (www.healthypeople.gov/)
 Department of Transportation (DOT) (www.dot.gov/)
 Emergency Medical Services Resources (www.jems.com/)*
 Federal Motor Carrier Safety Administration of the DOT (www.fmcsa.dot.gov)
 Fire Fighter Fatality Investigation and Prevention Program of NIOSH (www.cdc.gov/niosh/fire/)
 International Association of Fire Chiefs (www.iafc.org/)*
 International Association of Fire Fighters (www.iaff.org/)*
 Firehouse Forums (www.forums.firehouse.com)
 National Association of Emergency Medical Technicians (www.naemt.org)
 National Fire Fighter Near-Miss Reporting System (www.firefighternearmiss.com)
 National Fire Protection Agency (www.nfpa.org)
 National Highway Traffic Safety Administration (www.nhtsa.gov)
 National Sleep Foundation (www.sleepfoundation.org)
 National Transportation Safety Board (www.nts.gov)
 National Volunteer Fire Council (www.nvfc.org/)
 National Wildfire Coordinating Group (www.nwcg.gov)
 Road Safety Monitor (trafficinjuryresearch.com/whatNew/newsItemPDFs/RSM_Drowsy_Driving_2004.pdf)
 Seafarer fatigues: the Cardiff Research Programme (www.socp.org/Cardiff%20research_report.pdf)
 Truck Safety Coalition (www.trucksafety.org/Hours_FAQ.php)
 United States Coast Guard Crew Endurance Management (www.uscg.mil/hq/g-m/cems/i)
 United States Fire Administration (www.usfa.dhs.gov/)*
 Wildland Fire Safety & Health Reporting Network (safenet.nifc.gov/safenet.nsf)
 Wildland Firefighter Health & Safety Report (www.fs.fed.us/fire/safety/h_s_rpts/spring_2002/shiftlen.htm)
 Wildland Firefighter Magazine (www.firerescue1.com)

*These and other sites listed have extensive links to additional related sites and resources.

Appendix 6.4: References

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